INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 10, No. 6, p. 293-304, 2017
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Investigate of bio-mechanical method on carbon sequestration and macro-element concentration in soil and plant

Shahin Aghamirzadeh*, **Elina Heydarpour**

Soil Conservation and Watershed Management Research Department , Kerman,

Agricultural and Natural Resources Research and Education Center, AREEO, Kerman, Iran

Article published on June 30, 2017

Key words: Carbon sequestration (CS), Adsorption phosphorus, Total nitrogen (TN), *Agropyron desertorum,* Construction broad-base terrace, The pit-seeding method, Depth soil

Abstract

Biological management and mechanical practice are available for controlling soil erosion, therefore, soil management practice, which accretion of organic carbon, nitrogen and phosphorus and it can help in improving soil carbon, nitrogen and phosphorus over time. This study investigated that the potential of carbon sequestration, total nitrogen and phosphorus stock in soil and biomass of *Agropyron desertorum* as construction broad-base terrace by the pit-seeding method (bio-mechanical method) for improving capture of organic carbon, nitrogen and phosphorus. This study, conducted in split-plots based on completely block randomized design with three replication. Soil sampling were collected from 0 to 10, 10 to 20 and 20 to 40cm depth and Walkley and Black's methods were used for measuring of soil organic carbon. The amount of aboveground and underground biomass of plant sample were calculated by cutting and weighing the aerial parts (leaves, stem) and roots. Stock of carbon in plant was determined by using the ash method. The results of this research show that application of construction broad-base terrace by the pit-seeding method in carbon sequestration (CS), soil organic carbon (SOC) and total nitrogen (TN) and adsorption phosphorous (AP) are effective. In addition, CS, SOC, TN and AP in soil surface (0 to 10cm) is higher than depth of soil specially, when construction broad-base terrace by the pit-seeding method was applied. Based on the results, it appeared that the largest percentage of distribution total organic carbon, total nitrogen and adsorption phosphorous had been reserved in parts of plant and soil, respectively. The result of this research reveal the paying more attention to the role of bio-mechanical method was conservation method in reducing the rate of increase in atmospheric CO_2 and increasing productivity of soil, particularly in many areas with degraded soils.

***Corresponding Author:** Shahin Aghamirzadeh ✉ sh.aghamirzadeh@areo.ir

Introduction

Management and conservation of soil and water resources are critical to human well-being (Young *et al*., 2014; Olson & Al-Kaisi., 2015). Their prudent use and management are more important now than ever before to meet the high demands for food production and satisfy the needs of an increasing world population (Blanco–Conquie *et al*., 2007; Thelen *et al*., 2010; Philips *et al*., 2015).

Managing soils under intensive use and restoring eroded/degraded soils are top priorities to a sustained agronomic and forestry production while conserving soil and water resource (Bhattacharyya *et al*., 2007; Thelen *et al*., 2010). Management must come before conservation for the restoration and improvement of vast area of world's eroded and degraded soils and ecosystems.

Shirani *et al*. (2002), Thelen *et al*. (2010) and Dou *et al*. (2013) reported that a number of biological, agronomic management and mechanical practice are available for controlling soil erosion. There are differences among these biological and mechanical in relation practices to their mechanisms of erosion control. Standing vegetation (e.g., cover crops) and construction broad-base terrace reduced soil erosion.

Soils are major resource of carbon, with soil carbon storage dependent on environmental, bio-geochemical and land management factors. Changing in land use with biological management (cover crop) and mechanical practice (construction broad-base terrace) can have effect on soil carbon contents (ASAE, 2003). Such changes are important the soil fertility and long-term sustainability and for their influence on stock of carbon and atmospheric CO_2 concentrations and global warming (Wardle *et al*., 2002; Bonanomi *et al*., 2013; Qiu *et al*., 2015).

Biological management (cover crop) and mechanical practice (construction broad-base terrace) can improved soil structure, increasing water retention and replenishing plant nutrients. In addition, these are useful in soil erosion control, nutrient replenishment, soil structural improvement and soil organic carbon sequestration and reduced atmospheric CO_2 concentrations and global warming.

Increasing the amount of organic carbon (OC) sequestrated in soil through improved agricultural management has become an important part of strategy to mitigate CO_2 emission to the atmosphere (Wardle *et al*., 2002; Bonanomi *et al*., 2013). Therefore, the use of biological management (cover crop) and mechanical practice (construction broad-base terrace) are being considering as part of strategy to reduce C loss from the soil and plant.

Increasing terrestrial carbon storage focusing upon the goals of increasing the carbon in plant as well as carbon in the soil. Fixing an increased amount of carbon can be most readily accomplished by increasing the biomass produced by increasing the plants growing at a site (Knops *et al*., 2010; Thelen *et al*., 2010). The largest potential for sequestration was through the conversion of land, with even greater carbon mitigation if some of the area was used for bioenergy crops (Ameri & Sanadgol., 2010).

The management practices that either increase or decrease soil organic carbon (SOC) content by using biological method and mechanical practice, can increase water infiltration, water-holding capacity and aggregate stability (Kuligowski, 2010). This is particularly important for agricultural soils deficient in OM. Also, by supplying nutrients, particularly N (Mkhabela and Warman, 2005), P (Krogstad *et al*., 2005) and K. In addition, this methods can improve the mineral nutrient status and growth of plants grown in such soils.

The effect of biological operating system and mechanical practice on phosphorus (P) adsorption and desorption, P transformation in soil and P availability have not been investigated intensively. Most of studies have been mainly focused on the inorganic P but organic P can constitute a significant portion of total P and can contribute substantially to plant-available P through process of mineralization (Reddy *et al*., 2000).

Phosphorus is one of the most limiting nutrients for plant growth in soil (Zohar *et al*., 2010). It is an essential, irreplaceable element in the nutrition of both aquatic and terrestrial species of plants and animals. Its availability depends on soil characteristics and contents of labile P fraction (Ohno *et al*., 2005). It is estimated that P availability to plant roots is limited in two thirds of the cultivated soil in the world. Phosphorus is essential to minimize yield loss on the soil (Walker *et al*., 2008).

However, most of the P applied to soil can be converted into unavailable forms that cannot be easily utilized by plants (Dierberg *et al*., 2011). Phosphorus is required nutrient for all living organisms and low P availability could limit growth and productivity. Specifically, P limitation may impact agricultural yield (Dierberg *et al*., 2011).

The main objective of this study was to investigate capture of carbon, phosphorus and nitrogen by effect of biological management (cover crop by pit-seeding method) and mechanical practice (construction broad-base terrace) in three depths as affected by *Agropyron desertorum* application.

Method and material

For this experimental, watershed of Dare-Morid with broad-base terrace was selected that is located 40km from city of Baft (29°22 58N, 56°36 00E, 230m above the sea level). The soil experiment is classified as typic haplo xerept. The long-term mean precipitation of area is 145mm per annum, which mainly occurs in winter. The average annual temperature for this region 9°C and varies from -20 to 38°C. This work was initiated in summer of 2010 and it was finished in winter of 2013.

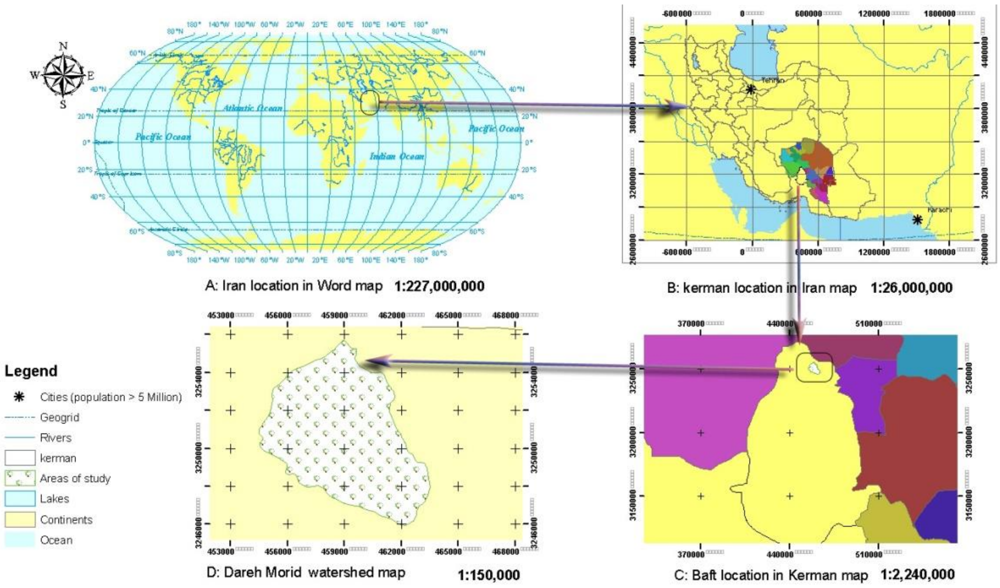


Fig.1. geographical location of studied sites, Dareh Morid, Kerman, Iran.

Experimental method

In this experiment, for realizing that how many sample plots are needed for an accurate determination of cover, were used to minimal area method. The first, 10 plots were measured and then average and variance were calculated.

According to the following formula, minimum plot number was calculated:

$$N = \frac{t^2 \left(\frac{S\bar{x}}{\bar{x}}\right)^2}{p^2}$$

Where "N" is minimum plot number, "t" is t-test with proportion at level of 5%, "p" is the error is usually equal to about 0.05 mean, "$\bar{x}$" sample mean and "$S\bar{x}$" is sample stdev. The field experiment consisted of 6 plots (1m²). In the experimental plots, *Agropyron desertorum* were cultivated by pit-seeding method.

Sample of plant

Agropyron desertorum is one of the most common plant species of the Tibetan plateau and the Trans-Himalayan grasslands. It usually occurs in loose sandy soil, and can be found growing up to 5399m. The plant has small wooly hairs and thick root stock that are its adaptation to the cold arid condition therefore, *Agropyron desertorum* was used in this work. In this experiment, the plant was cultivated by pit-seeding method. This method is an easy and can be applied on flat slope with rough surface to steep slope (25 to 45%). When plant growth in area, one composite sample, take from at least 10 widely scattered areas in field. After a plant sample has been collected, they were ground to pass 20-mesh sieve before performing the element analysis. The surface and subsurface biomasses were floured after drying in oven under 40 degree Celsius. Obtain ash, after exiting from oven, set up in desiccator to cool and then it was weighted. The rate of organic carbon (OC) for each biomass was calculated by ash weight, primary weight, and ratio of organic carbon to organic material (OM).

Soil sampling

Soil sample were taken from 0-10, 10-20 and 20-40cm depth, crushed to pass through a 2mm sieve and, finally, selected physical and chemical properties were measured (Table 1). Soil textured for was determined by hydrometer method (Gee and Bander, 1986). SOC concentration was determined by a titration method after oxidation with $K_2Cr_2O_7$ (Black, 1965). Total nitrogen was measured Kjeldahl method. Soil pH and EC were measured in saturated paste extract, respectively (Page *et al*., 1992).

Table 1. Initial soil properties at 0 to 40cm soil.

Sand (%)	Silt (%)	Clay (%)	pH	EC (dS m^{-1})	OC (%)
76.00	20.00	8.00	7.70	0.50	0.50

EC: Electrical conductivity; OC: Organic carbon.

Computation of Carbon Sequestration in soil

Organic carbon was determined by wet oxidation. Carbon Sequestration (CS) was calculated according to following equation:

CS: 10000*SOC*BD*D

Where "CS" is carbon sequestration (kg.h^{-1}), "SOC" is soil organic carbon (%), "BD" is bulk density (kg.cm^{-3}) and "D" is depth of soil (cm).

Computation of Organic Carbon in part of plant

Organic Carbon (OC) in different part of plant was computed according to following equation (Mac Dicken, 1997):

A: (a-100)*0.5

B: (A/100)* weight of biomass

C: B/100

Where "A" is organic carbon (%), "a" is amount of plant ash (gr), "B" is organic carbon (g.m^{-2}) and "C" is organic carbon (ton.he^{-1}).

Computation of adsorption Phosphorous in soil

In Phosphorus analysis, distilled water blank must be run with every batch of samples tested. It is used both to zero the spectrophotometer and to show that the glassware and reagents are not contaminated with phosphates. At least one check standard must also be run with each batch. If a variety of samples are being tested with results expected to cover a wide range of concentrations, test two or more standards. The absorbencies of the standards must agree closely with the true value or a new curve must be drawn. Spike samples are run by adding the 5.0mg/L Phosphate standard to a sample. To simplify the calculation, use the same amount of standard in the spike sample as you are using in your check standard.

Tissue analysis

Computation of Phosphorous concentration in part of plant

Plant samples (root, shoot and litter) of *Agropyron desertorum* were collected, dried and digest in a tri-acid mixture (HNO_3:$HClO_4$:H_2SO_4 3:1:1 ratio) and P concentration in the digest was determined color metrically using Vanado-molybdate-yellow color method (Jackson, 1973).

Computation of total nitrogen in plant tissue

Put 100 to 300mg. of finely ground, well averaged, dry tissue or 500- 1500mg. of green tissue into a 200-cc. Erlenmeyer flask.

There should be at least 0.5 mg. of nitrogen in the sample used. Add 1 gm. of sodium chlorate for each 100 mg. of dry sample or each 500mg. of green sample. Add 25 cc. of 50 percent by volume sulphuric acid and attach the flask to a water-cooled reflux condenser. Heat with a high flame until the oxidation is complete and all chlorine color has disappeared from the solution (usually 3 to 5 minutes). Remove the flame, flush out the condenser with 10-15 cc. of 50 percent. sulphuric acid, cool somewhat (a cold water bath may be used), detach from the condenser and make the solution to 50 cc. with 50percent sulphuric acid. Immediately put exactly 1 or 2 cc. of the solution into a suitable graduated flask, add 3 or 6 cc. of phenoldisulphonic acid, mix well, add about 20 cc. of water, make alkaline with 40 percent NaOH solution, adding it until the maximum yellow color is produced and make to volume.

After thorough mixing, the clear solution is compared with a standard in a colorimeter. The volume of the solution should be such that the color is fairly close to that of the standard.

Statistical analysis

This pattern had a split-plot based on completely block randomized. All statistical analysis were performed in the SPSS system.

Result

Distribution of total organic carbon

Data were analyzed following analysis of variance and means were compared based on Duncan at the 0.05 probability level. It was found that almost all of the considered treatments significantly affected the distribution of total organic carbon, total nitrogen and adsorption phosphorous (Table 2).

Table 2. Analysis of variance (F values) for distribution of organic carbon (DOC), total nitrogen (TN) and adsorption phosphorous (AP).

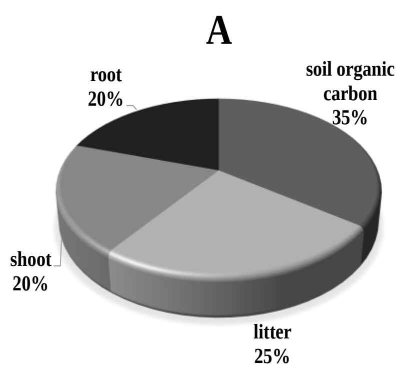
Source of variance	df	DOC	TN	AP
Repetition	2	413003.13*	0.00010*	0.00020*
Treatment	1	111322133.30**	0.002**	0.001**
error (a)	2	412002.12	0.0000210	0.000010
Depth	2	1351235.40**	0.000032**	0.000022**
depth×treatment	2	82028.20**	0.000013**	0.000011**
error (b)	8	5000.20	0.0000017	0.0000015
CV	-	1.13	1.35	2.35

Level of significance indicated; ns= not significant; *= significant at p<0.05; **= significant at p<0.01.

Fig. 1, 2 and 3 show that percentage of total organic carbon distribution in soil and plant. The results show that distribution of total carbon under construction broad-base terrace by the pit-seeding method was significantly increased compared with control soil. It was compared in the 0 to 10, 10 to 20 and 20 to 40 cm depth with control soil. In this study, distribution of carbon differed among different depth of soil. Being this tendency more evident in top soil and less in the bottom layer. Based on the results, it appeared that the largest percentage of total carbon had been reserved in parts of plant (Fig. 2, 3 and 4).

Total nitrogen

The results show that total nitrogen was significantly increased under construction broad-base terrace by the pit-seeding method compared with control soil. Comparing total nitrogen in the 0 to 10, 10 to 20 and 20 to 40 cm depth with control soil. It is clear that the largest percentage of total nitrogen had been reserved in top of soil and construction broad-base terrace by the pit-seeding method (Fig. 5, 6 and 7).



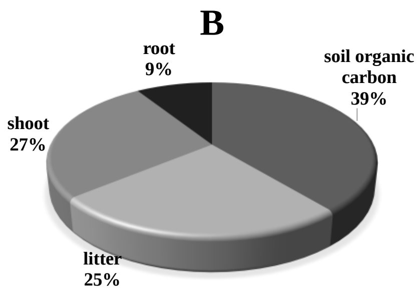


Fig. 2. Comparing carbon sequestration at depth of 0 to 10cm between control soil (A) and construction broad-base terrace by the pit-seeding method (B).

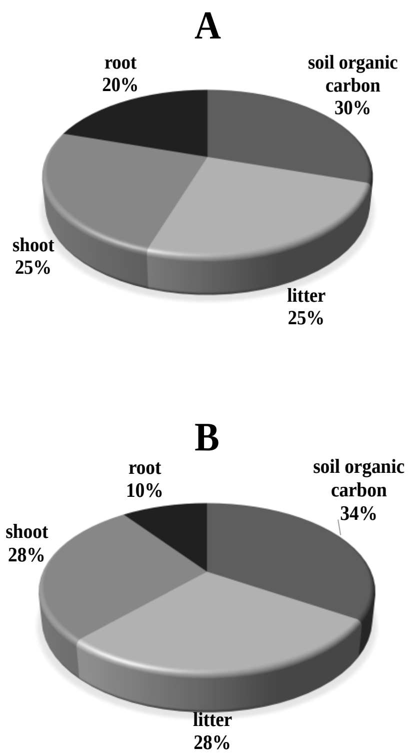
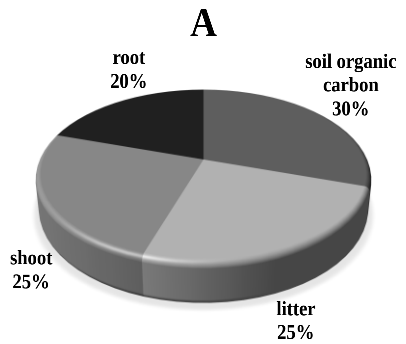


Fig. 3. Comparing carbon sequestration at depth of 10 to 20cm between control soil (A) and construction broad-base terrace by the pit-seeding method (B).



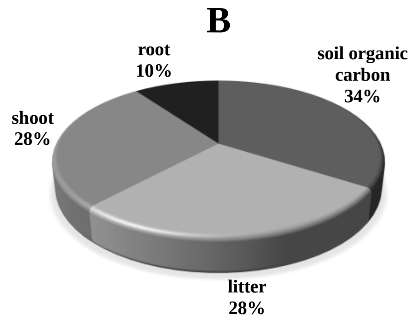


Fig. 4. Comparing carbon sequestration at depth of 20 to 40cm between control soil (A) and construction broad-base terrace by the pit-seeding method (B).

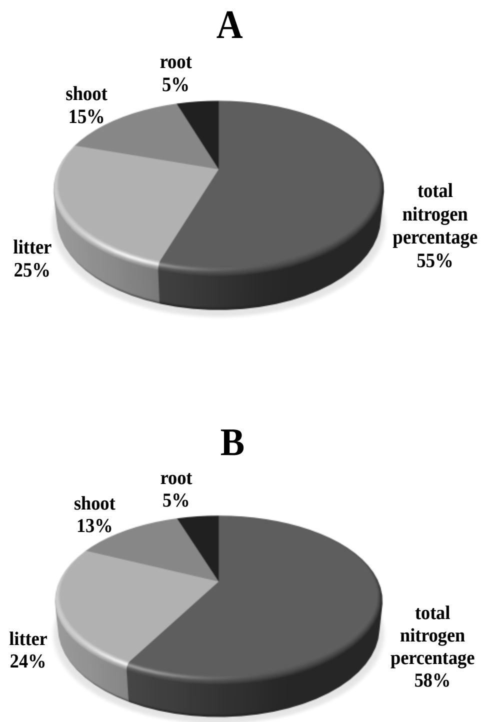
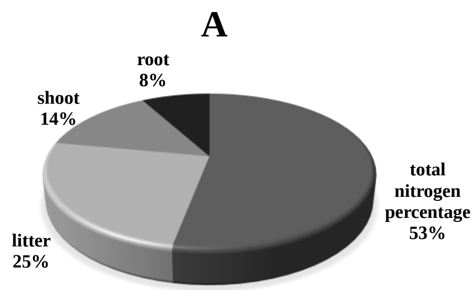


Fig. 5. Comparing total nitrogen percentage at depth of 0 to 10cm between control soil (A) and construction broad-base terrace by the pit-seeding method (B).



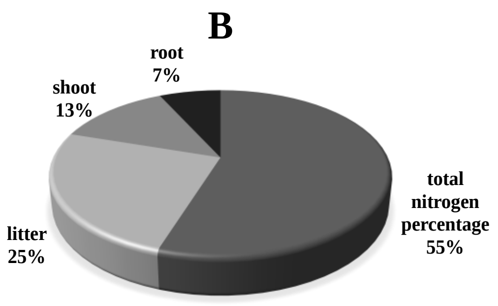


Fig. 6. Comparing total nitrogen percentage at depth of 10 to 20cm between control soil (A) and construction broad-base terrace by the pit-seeding method (B).

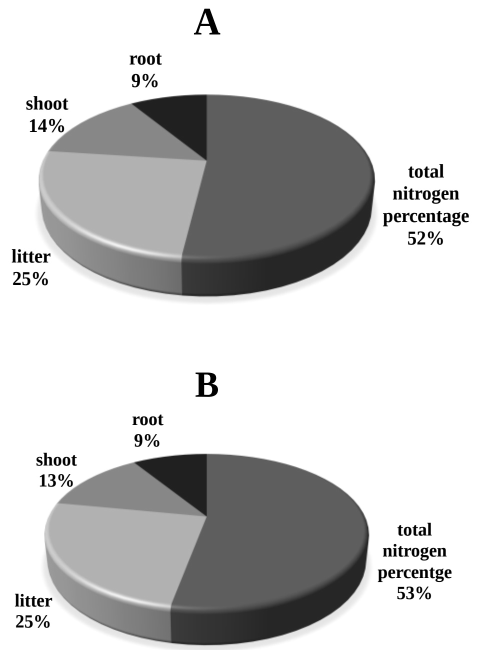


Fig. 7. Comparing total nitrogen percentage at depth of 20 to 40cm between control soil (A) and construction broad-base terrace by the pit-seeding method (B).

Adsorption phosphorous

In this study, adsorption phosphorous under construction broad-base terrace by the pit-seeding method was significantly increased compared with control soil. Comparing the adsorption phosphorous concentration in the 0 to 10, 10 to 20 and 20 to 40 cm depth with control soil. It is clear that the largest percentage of adsorption phosphorous had been reserved in soil (Fig. 8, 9 and 10).

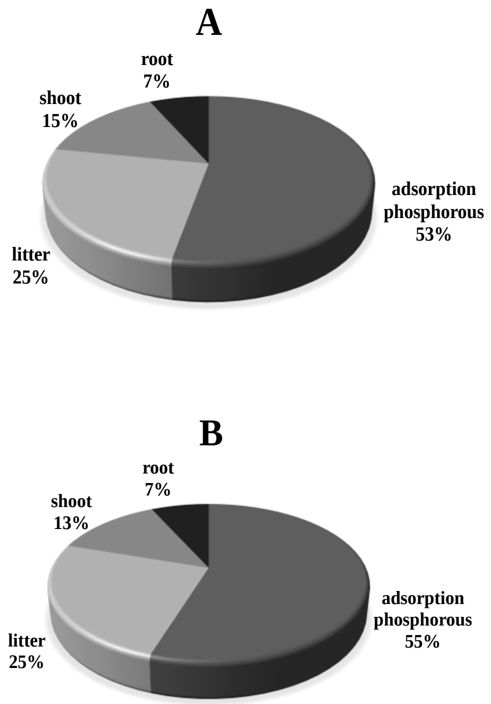


Fig. 8. Comparing adsorption phosphorous at depth of 0 to 10cm between control soil (A) and construction broad-base terrace by the pit-seeding method (B).

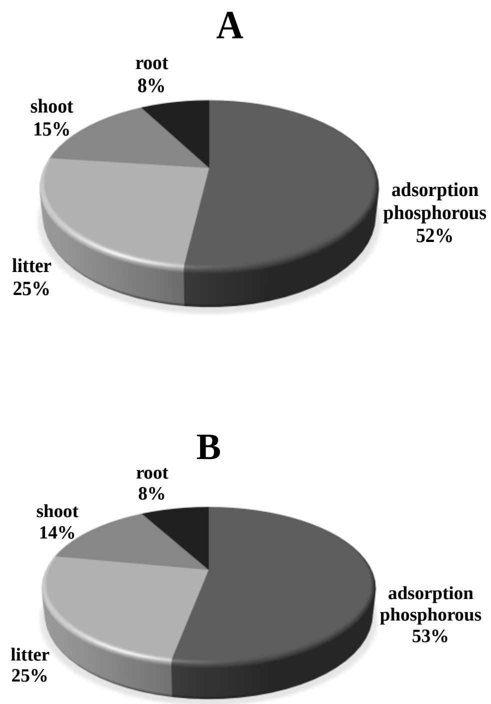
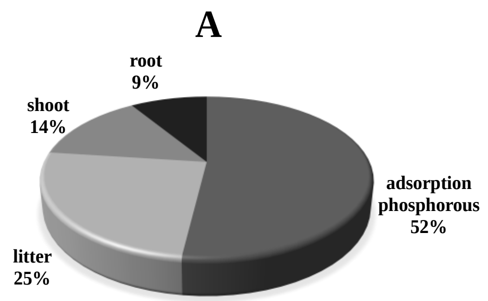


Fig. 9. Comparing adsorption phosphorous at depth of 10 to 20cm between control soil (A) and construction broad-base terrace by the pit-seeding method (B).



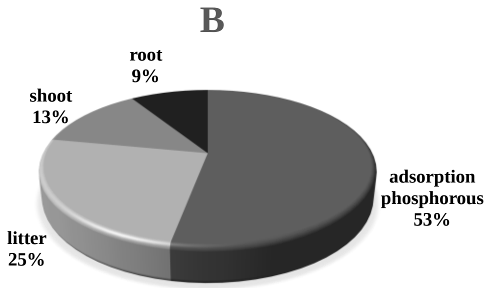


Fig. 10. Comparing adsorption phosphorous at depth of 20 to 40cm between control soil (A) and construction broad-base terrace by the pit-seeding method (B).

Discussion

Distribution of total organic carbon in soil and plant

Biological management and mechanical practice (bio-mechanical method) are available for controlling soil organic carbon. There are differences among these biological management and mechanical practices in relation to their mechanisms of erosion control and it can effect on carbon stored in soil and plant. Biological management such as pit-seeding method are in direct contact with the soil surface and thus serve as buffers layer protecting the soil (Young *et al.*, 2014; Olson & Al-Kaisi., 2015). In addition, mechanical practice such as construction bankette generally decresed runoff, increasing water retention and replenishing plant nutrient.

It is provides innumerable benefits including reduction of soil erosion and improvement in soil physical, chemical and biological properties, therefore, biological management and mechanical practice can effect on organic carbon and carbon sequestration in soil and plant.

In recent decades it has been recognized that the quantity of carbon (C) stored in soils is significant on a global scale so that management practices (biological management and mechanical practice) that either increase or decrease soil organic carbon (SOC) content (Shirani *et al.*, 2002), can have a global positive or negative impact (Powlson *et al.*, 2008). The management practice of this research (pit-seeding method) available to organic carbon include increased use of bioenergy crops. Shirani *et al.* (2002), Bronick *et al.* (2005), Thelen *et al.* (2010) reported that application of cover plant generally had lower soil temperatures higher soil moisture and increased organic matter in soil. The result of other researches show that using of crop protects the soil surface from the direct impact of raindrops and reduce excessive fluctuation of freezing and thawing cycles of surface soil (Thelen *et al.*, 2010) also, the application of crop produced a buffer zone between the soil surface and sun protecting the soil from direct sunlight therefore it may have slowed mineralization of organic carbon and, therefore, higher amount of organic carbon can be stored in the soils (Bhattacharyya *et al.*, 2007; Thelen *et al.*, 2010).

SOC concentration was greater in top soil and generally decreased with soil depth. The magnitude and trends of change in soil physical properties depend on soil depth changes. Thus, Shirani *et al.* (2002), Thelen *et al.* (2010) reported that increasing soil depth lead to soil compaction, low organic matter (OM) and weak structure of the soil. Application of pit-seeding method can effect on hydrophobic properties can be more pronounced and result in lower rewetting of aggregates (Denef *et al.*, 2001).

Consequently, hydrophobicity may be due to the presence of humic acids, which serve as strong binding agents of soil particles into aggregate (Shirani *et al.*, 2002; Thelen *et al.*, 2010). This method can beneficially or adversely affect by influencing soil temperature and soil moisture (Bhattacharyya *et al.*, 2007). It would sequester carbon, off-set atmospheric CO_2 levels, and improved soil and environmental quality (Jonasson *et al.*, 2004; Thelen *et al.*, 2010).

We recognized that the carbon sequestration in soil is significant so that management practice and mechanical practice increase or decrease it. This method (pit-seeding method and construction broad-base terrace) improved soil physical environment for better uptake of water and nutrients from the soil. This sequestration of carbon was likely a result of higher humification rate constant (Bhattacharyya *et al*., 2007; Thelen *et al*., 2010) and the direct application of organic carbon through *Agropyron desertorum*. SOC concentration was greater in top soil and generally decreased with soil depth. The large difference in SOC concentration strongly influenced soil physical properties (Blanco–Conquie *et al*., 2007). Increasing soil depth lead to soil compaction, low OM and weak structure of the soil. Therefore, low in OM connect consequently have weak structural stabilities and decreased carbon sequestration (Blanco Conquie *et al*., 2007; Thelen *et al*., 2010).

Total nitrogen percentage

Nitrogen fixation refer to the conversion of atmospheric N_2 to ammonia and then to N-containing organic compounds that can become available to all forms of life. Biological N fixation is the most common N fixation process. Management decisions related to biological and mechanical can greatly impact the actual amount of N fixed. In this research, biological N fixation is carried out by biological management and mechanical method (bio-mechanical method). Distribution of total nitrogen was obviously under construction broad-base terrace by the pit-seeding method due to its different N mineralization potential. We simulated a change in the TN retained in the SOM by keeping the proportion of litter stabilized as SOC constant of *Agropyron desertorum*. In addition, the responses in the plants seem to be a consequence of responses in the microbial and soil inorganic N pools (Knops *et al*., 2010; Youjin *et al*., 2011).

Adsorption phosphorous

Comparing adsorption phosphorous concentration in the different depth of treatment with control soil. Adsorption phosphorous concentration was greater in top soil and generally decreased with soil depth.

Thus, Shirani *et al*. (2002), Blanco-Conquie *et al*. (2007), Thelen *et al*. (2010) and Aghamirzadeh *et al* (2015), reported that increasing soil depth lead to soil compaction, low OM and weak structure of the soil (Liu *et al*., 2010). Therefore, low in OM content consequently have weak structural stabilities and decreased P concentration (Erich *et al*., 2002). Long-term, the use of biological operating system (pit-seeding method) cause more energy to be kept low phosphorus bonds and the increasing availability of this feature (Kuligowski, 2010). The decomposition of organic matter (Zohar *et al*., 2010) and organic acids (Liu *et al*., 2010) increases the amount of phosphorus in solution phase (Reddy *et al*., 2000) and increased adsorption phosphorous.

Studies of the direct effects of different part of plant on carbon stock in plant are limited. *Agropyron desertorum* produced litter with greater concentration of phenolics, condensed tannins, fiber and lignin (Wardle *et al*., 2002; Bananomi *et al*., 2013; Aghmirzadeh *et al*., 2015). This may be explained by the fact that the lignin-degrading microorganisms, under the nutrient conditions that exist in most litter, grow more slowly than those degrading the polymer carbohydrates, and that lignin as a chemical compound in foliar litter normally is degraded more slowly than many other components. A basic condition appears to be that the fiber structure enables the holocellulose to be degraded to higher extent than lignin (Austin & Vivanco., 2006; Bakker *et al*., 2011). Eventually decomposition will reach a condition in which the litter contain primarily material that is rich in lignin, and any remaining cellulose and hemicelluloses are enclosed and protected by lignin and newly formed humic compounds. That is, the litter with its greater C:N ratio and higher lignin content decomposed more slowly than the other part of plant therefore, stock of carbon is the highest in litter of plant.

In addition, phosphorous play an important role in plant growth and is one of the components of key molecules. The results show that using pit seeding method cause that concentration of phosphorous was promoted in soil (Kuligowski, 2010), therefore, this strategy can sink for adsorption phosphorous of soils and it helps to improve phosphorous in different part of plant (Reddy *et al*., 2000). Leaf area per plant is considered as indicator of element fixation such as C and P. If leaf area is more, photosynthesis becomes greater and fixation in this part is more than others. The biological management (pit-seeding method) and mechanical practice (construction broad-base terrace) improved soil physical environment for better uptake of nutrients from the soil (Jonasson *et al*., 2004; Thelen *et al*., 2010), therefore, leaf area in the plant became greater and stock of P in litter is highest.

Conclusion

Using of biological sources (*Agropyron desertorum*) improves soil structure, soil fertility, production and ensures long term sustainability of agricultural and natural ecosystems. The effects of using biological operating system (pit-seeding) and mechanical practice (construction broad-base terrace) significantly improved soil organic carbon (SOC), carbon sequestration (CS), total nitrogen (TN) and adsorption phosphorous (AP). In short-term, this method changed the near surface soil structure and SOC concentration therefore the SOC concentration, CS, TN and AP higher in 0 to 10cm than 10 to 40cm depth. Construction broad-base terrace by the pit-seeding method (bio-mechanical method) has effected on stock of carbon, nitrogen and phosphorous in different part of plant. Additionally, for increasing in CS, TN and AP due to application construction broad-base terrace by the pit-seeding might indicate a potential of this management practice into promoting carbon sequestration and reducing the rate of increase in atmospheric CO_2 and increasing productivity of soil, particularly in many areas with degraded and erosion soils.

References

Aghmirzadeh S, Solimani A, Parvizi Y, Soleymani N, Naghibi M. 2015. The effect of biological operating system on capture of organic carbon in soil and plant. Arabian Journal of Geoscience **12,** 10887-10892.

Ameri AA, Sanadgol AA. 2010. Comparison of Seed Bed Preparation Methods on Seedling Emergence Rate in Six Range Species in Khash Rangelands of Iran, Journal of Rangeland Science. Vol. **1,** No. 1.

ASAE (American Society of Agricultural Engineers). 2003. Design, Layout, Construction, and Maintenance of Terrace Systems. ASAE Standards S268.4 Feb 2003. St. Joseph MI.

Austin AT, Vivanco L. 2006. Plant litter decomposition in a semi-arid ecosystem controlled by photo degradation, Nature. Vol. **442.**

Bakker MN, Carreno-Rocababo G, Poorter L. 2011. Leaf economics traits predict litter decomposition of tropical plants and differ among land use types. Functional Ecology **25,** 473-483.

Bhattacharyya R, Prakas V, Kunda S, Srivastva AK, Gupta HS. 2009. Soil aggregation and organic matter in a sandy clay loam soil of the India himalayas under different tillage and crop regims. Agriculture, Ecosystems and Environment **132,** 126-134.

Blake GR, Hartge KH. 1986. Bulk density. p. 363-375. In A. Klute (Ed.) Methods of soil analysis, Part 1. 2nd ed. Agron. Mongr. 9. ASA and SSSA, Madison WI.

Blanco-Conqui H, Lal R. 2007. Soil structure and organic carbon relationships following 10 years of wheat straw management in no-till. Soil and Tillage Research **95,** 240-254.

Bonanomi G, Incerti G, Giannino F, Mingo A, Lanzotti V, Mazzoleni S. 2013. Litter quality assessed by solid state 13C NMR spectroscopy predicts decay rate better than C/N and Lignin/N ratios. Soil Biology & Biochemistry **56,** 40-48.

Bronick CJ, Lal R. 2005. Manuring and rotation effects on soil organic carbon concentration for different aggregate size fraction on two soils in northest ernohio, USA. Soil and Tillage Research **81,** 239-252.

Denef K, Six J, Paustian K, Merckx R. 2001. Importance of macro aggregate dynamics in controlling soil carbon stabilization: short-term effects of physical disturbance induced by dry-wet cycles. Soil Biology and Biochemistry **33,** 2145-2153.

Dierberg FE, Debusk TA, Larson NR, Kharbanda MD, Chan N, Gabriel MC. 2011. Effect of sulfate amendments on mineralization and phosphorous release from south Florida (USA) wetland soils under anaerobic condition. Soil Biology and Biochemistry. **43,** 31-45.

Dou X, Dang Q, Li M, Wang W, Zhang Q, Chang X. 2013. Reforestation of *Pinus massoniana* alters soil organic carbon and nitrogen dynamics in eroded soil in south China. Ecological Engineering **52,** 154-160.

Gee GW, Bauder JW. 1986. Particle-size analysis. p. 383-411. In A. Klute (Ed.) Methods of soil analysis. Part 1. 2nd Ed. Agron. Monogr. 9. ASA and SSSA, Madison WI.

Jackson ML. 1973. Soil Chemical analysis. Printice Hall of India, New Dehli.

Jonasson S, Castro J, Michelsen A. 2004. Litter, warming and plants affect respiration and allocation of soil microbial and plant C, N and P in arctic mesocosms. Soil Biology & Biochemistry **36,** 1129-1139.

Knops JMH, Wedin DA, Naeem S. 2010. The Role of Litter Quality Feedbacks in Terrestrial Nitrogen and Phosphorus Cycling, The Open Ecology Journal **3,** 14-25.

Krogstad T, Sogan TA, Asdal A, Saeb A. 2005. Influence of chemically and biologically stabilized sewage sludge on plant-available phosphorous in soil. Ecological & engineering **25,** 51-60.

Kuligowski K, Poulsen TG, Rubaek GH, Sorensen P. 2010. Plant-availability to barley of phosphorous in ash from thermally treated animal manure in comparison to other manure based materials and commercial fertilizer, European Journal of agronomy **33,** 293-303.

Liu E, Yan C, Mei X, He W, Bing SH, Ding L, Liu S, Fan T. 2010. Long-term effect of chemical fertilizer effects on soil organic matter fraction and microbes under a wheat-maize cropping system in Northen China. Geoderma **149,** 318-324.

Mac Dicken KG. 1997. A guide to monitoring carbon storage in forestry and agro forestry projects. Winrock international institute for agricultural development, forest carbon monitoring program pp. 91.

Mkhabela MS, Warman PR. 2005. The influence of municipal solid waste compost on yeild, soil phosphorous availability and uptake by two vegetable crops grown in a Pugwash sandy salin soil in Nova Scotia. Agriculture ecosystem and environment **106,** 57-67.

Ohno T, Griffin TS, Libman M, Porter GA. 2005. Chemical characterization of soil phosphorous and organic matter in different cropping systems in Maine, U.S.A. Agriculture ecosystems & environment **1065,** 625-634.

Olson KR, Al-Kaisi MM. 2015. The importance of soil sampling depth for accurate account of soil organic carbon sequestration, storage, retention and loss. Catena **125,** 33-37.

Page AL, Miller RH, Jeeney DR. 1992a. Methods of Soil Analysis, Part 1. Physical properties. SSSA Pub., Madison 1750 p.

Page AL, Miller RH, Jeeney DR. 1992b. Methods of Soil Analysis, Part 2. Chemical and mineralogical properties. SSSA Pub., Madison 1159 p.

Philips LP, Eken MR, West MS. 2015. Soil Organic Carbon Beneath Croplands and Re-established Grasslands in the North Dakota Prairie Pothole Region. Environmental Management **55,** 1191-1199.

Powlson DS, Riche AB, Coleman K, Glending MJ, Withmore AP. 2008. Carbon sequestration in European soils through straw incorporation: limitation and alternatives. Waste Management **28,** 741-746.

Qiu L, Wei X, Ma T, Wei Y, Horton R, Zhang X, Chang J. 2015. Effects of land-use change on soil organic carbon and nitrogen in density fractions and soil δ13C and δ15N in semiarid grasslands. Plant Soil **390**, 419-430.

Reddy DD, Rao AS, Rupa TR. 2000. Effect of continuous use of cattle manure and fertilizer phosphorous on crop yields and soil organic phosphorous in vertisoil. Bioresource Technology **75,** 113-118.

Shirani H, Hajabbasi MA, Afyani M, Hemmat A. 2002. Effects of farmyard manure and tillage systems on soil physical properties and corn yield in centeraliran. Soil and Tillage Research **68,** 101-108.

Thelen KD, Fornning BE, Krauchenko A, Min DH, Robertson GP. 2010. Integrating livestock manure with a corn-soybean bioenergy cropping system improves short-term carbon sequestration rates and net global warming potential. Biomass and Bioenergy **34,** 960-966.

Walker DJ, Bernal MP. 2008. The effects of olive mill waste compost and poultry manure on the availability and plant uptake of nutrients in a highly saline soil. Bioresource Technology **99,** 396-403.

Wardle DA, Bonner KI., Barker GM. 2002. Linkages between plant litter decomposition, litter quality, and vegetation responses to herbivores. Functional Ecology **16,** 585-595.

Youjin L, Zifang W, Ming G, Chaoful W. 2011. Effects of conservation tillage on organic carbon, nitrogen and enzyme activities in a hydragric anthrosol of Chongqing, Energy Procedia **5,** 30-36.

Young C, Liu S, Schumacher JA, Schumacher TE, Kaspar TC, Mccarty GW, Napton D, Jaynes DS. 2014. Evaluation of a model framework to estimate soil and soil organic carbon redistribution by water and tillage using137Cs in two U.S. Midwest agricultural fields. Geoderma **232-234,** 437-487.

Zohar I, Shiviv A, Young M, Kendall C, Silva S, Payan A. 2010. Phosphorous dynamics in soils irrigated with reclaimed waste water or fresh water- a study using oxygen isotopic composition of phosphorous. Geoderma **159,** 109-121.