The Pharma Innovation Journal 2022; SP-11(10): 1443-1447

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(10): 1443-1447

www.thepharmajournal.com
Received: 23-07-2022
Accepted: 29-08-2022

May Zar Myint
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

Raihana Habib Kanth
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

Amal Saxena
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

FA Bahar
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

Kusheed A Dar
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

SS Mehdi
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

AA Saad
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

Tauseef Ahmad Bhat
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

Tahir Ahmad Sheikh
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

Mohd Salim Mir
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

Owais Ali Wani
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

Corresponding Author:
Division of Agronomy, FOA, Wadura, Sher-E-Kashmir University of Agricultural Sciences and Technology, Kashmir, Jammu and Kashmir, India

Role of cultural management practices in carbon sequestration in agricultural soil

May Zar Myint, Raihana Habib Kanth, Amal Saxena, FA Bahar, Kusheed A Dar, SS Mehdi, AA Saad, Tauseef Ahmad Bhat, Tahir Ahmad Sheikh, Mohd Salim Mir and Owais Ali Wani

Abstract
The efficiency of agricultural management-induced practises, which leads to adjusted biomass carbon (C) inputs to the soil and ultimately adjusted soil organic carbon content (SOC) in soil, has an impact on increasing biomass production and soil carbon content. Thus, under appropriate management approaches, the dynamics of soil organic carbon (SOC) represent a healthy balance between carbon input and output. Carbon sequestration is the process by which plants remove CO_2 from the atmosphere and store it in soil-based long-lived carbon pools. Therefore, carbon sequestration generally takes place when the input exceeds the output. SOC in soil can also grow by improving biomass production through management strategies such crop management, conservation farming, soil and nutrient management. Additionally, the breakdown of soil organic matter substantially differs with and without enough addition and/or the presence of organic matter (OM) in soil which relatively dominates the microbial community and activities. The greater OM decomposition by the microbial activities and the greater stabilize C production.

Keywords: Carbon sequestration, crop residues, managements practices, organism

Introduction
Soil is created when rocks are broken down by wind, water, and environmental variables. These basic natural resources are the main resource that is limited in use for the agricultural food production system as a result of the growing world population and the effects of climate change. Additionally, soil is a source of atmospheric CO_2 and can help to slow down global warming by absorbing atmospheric CO_2 and converting it into the soil carbon pool. According to Lal (2007) [18], a 1 Pg increase in the soil carbon pool is comparable to a 0.47 ppm decrease in the atmospheric CO_2 concentration. The net removal of atmospheric CO2 by plants and its storage in soil as soil organic matter is known as carbon sequestration from an agricultural perspective (SOM). The qualities of the soil, the profile and terrain, the location of the landscape, the temperature, and the amount of rainfall all had an impact on the size and characteristics of the soil organic carbon pools. Soil organic carbon (SOC) is the result of increased carbon inputs from biomass production and decreased carbon outputs from conservation tillage's reduced soil disturbance, decreased soil erosion, enhanced infiltration, and increased soil biodiversity (Hossain *et al.* 2020) [35]. It depends mostly on cultural and nutrient-induced management strategies that influence biomass production and stubbles returned well into the soil and ultimately result in enhanced soil carbon in soil. Increasing biomass production and return into soils can improve SOC. Increased soil organic matter and microbial activity as a result of improved nutrient availability and organic matter breakdown may result from the addition of cultural practices and nutrient management. As a result, carbon sequestration is essential for agricultural land to achieve increased crop yield as well as a decrease in greenhouse gas emissions from agricultural soil (Lal, 2008) [19].

Carbon sequestration
Storage of CO_2 in long-lived carbon pools in soil, the ocean, ground water, rivers, and deep geological strata is known as carbon sequestration. By enhancing the amount of soil organic matter that was affected by the addition of agricultural practices managements, soil carbon sequestration in agricultural land has a key role on improving soil quality and increasing crop yield.

Soil carbon sequestration can be defined as the process of increasing soil organic carbon (SOC) and soil inorganic carbon (SIC) pools through prescribed nutrient management methods, cultural practices, and land use. The two primary categories of sources that leak carbon into the atmosphere during carbon sequestration are natural and manmade sources. The majority of the carbon found in natural resources was created through the microbial degradation of crop and animal waste, which was then released as CO_2 into the atmosphere (Hossain *et al.* 2020) [35]. The main man-made source of anthropogenic carbon, fossil fuel combustion, is responsible for the majority of it. It is estimated that between 6 and 8 Pg C yr^{-1} came from all anthropogenic emissions, with CO_2 emissions from energy, process industry, land use conversion, and soil cultivation contributing 8.6 Pg C yr^{-1} (Fung, 2000) [8]. The two main types of carbon sequestration are biotic and abiotic carbon sequestration. When higher plants and microbes use atmospheric CO_2 for their growth, development, and decomposition and subsequently release it into the atmosphere through respiration, this is referred to as the biotic process. Engineering methods for separating, capturing, transporting, and injecting CO_2 are used in abiotic processes, which are dependent on physical and chemical interaction (Lal, 2008) [19].

Soil Carbon Sequestration as influenced by Cultural Managements

In Figure (Lal, 2003) [17], the two main processes affecting soil organic carbon sequestration are biomass production and organic matter decomposition. In general, cultural and soil management practices such as tillage systems management, nutrient management, soil management, and environment management are key factors in soil organic carbon sequestration (Hossain *et al.* 2020) [35].

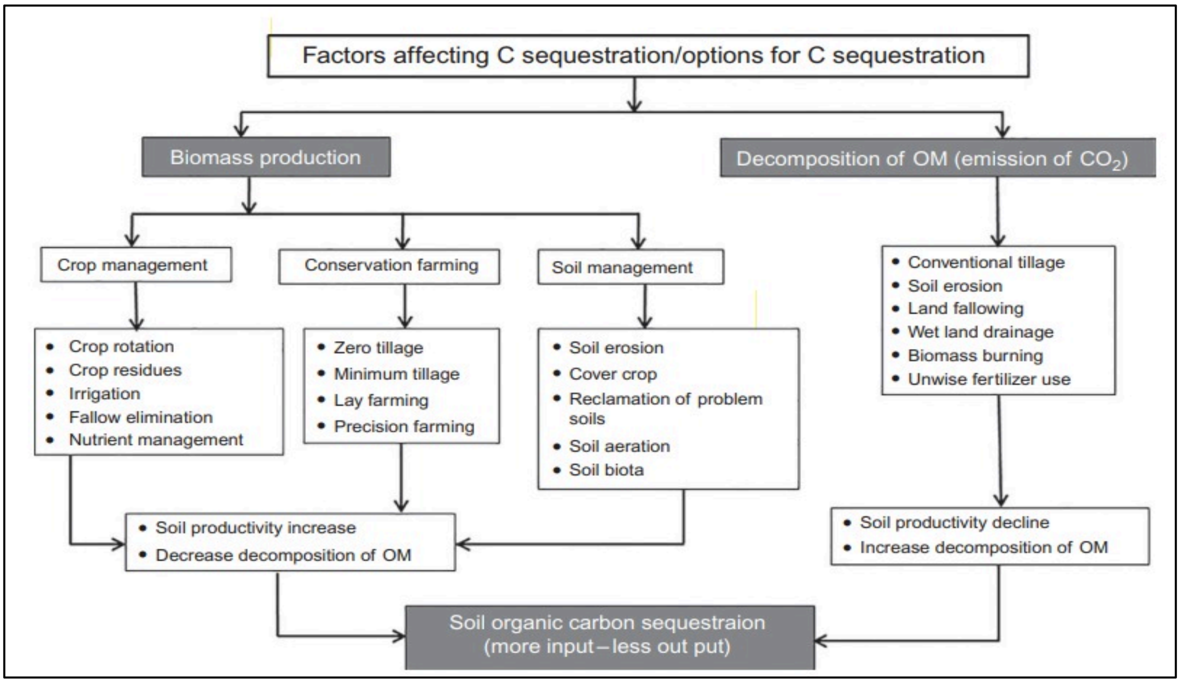

Fig 1: Agricultural practices affecting carbon sequestration in agricultural land (Lal, 2003) [17]

A. Tillage systems management

Tillage techniques are crucial factor in agricultural crop production systems because they control soil fertility, soil aggregate development, and stability (Saljinikov *et al.* 2013) [26]. As a result, it can have a big impact on carbon sequestration, either positively or negatively. According to AI-Kaisi *et al.* (2014) [1], conventional tillage among tillage systems promotes the decomposition of soil organic matter by causing stabilized soil aggregate, which is important for good soil structure and crop development, to break down and by exposing encapsulated carbon to microbial activity processes. Due to less soil disturbance, increased soil macro- and micro-aggregate stability, increased infiltration and water holding capacity, and soil conservation, conservation tillage methods like no-till and minimum-till have favorable effects on SOC content on agricultural land (Hossain *et al.* 2020) [35]. Each tillage systems maintains at least 30 percent of soil surface mulched by crop residues after planting which has a greater impact on no-tillage farming's ability to reduce soil erosion, retain moisture, and sequester SOC (Lal, 1997) [15] and the magnitude of residue which returned into soil increase soil organic matter (SOM) (Campbell *et al.* 2001) [5]. Because no-tillage with crop stubbles and amendments breakdown in the soil more slowly, SOC progressively builds up in the soil (AI-Kaisi *et al.* 2014) [1], improving the amount of water and nutrients that are readily available to crops for their growth. So after 18 years, no-tillage enhanced soil organic matter (OM) in the top 15 cm by 18% more than conventional tillage (Beare *et al.* 1994) [3]. The main source of carbon in crop land is crop residue, which contains on average 45% C on a dry weight basis and acts as a source of C and nutrients for microbes in soil. However, in no-tillage systems where the biomass C inputs are less than output (by decomposition, leaching, and removal of residues), the SOC sequestration rate may have a negative impact (Lal, 2007) [18]. Moreover, no-tillage adoption does not promote SOC sequestration without sufficient fertilization (Campbell *et al.* 2001) [5]. Nitrogen and phosphorus are the nutrients with the highest demand for plant growth because they have a significant impact on biomass productivity (Jacinthe *et al.* 2002) [12].

B. Nutrient managements

Nutrient management is a key component in regulating biomass production and crop residue breakdown, both of which are crucial for soil carbon sequestration (Lal, 2003) [17[. Applying of nutrients to the soil, which is impacted by the existence and addition of organic matter in the soil, soil parameters, and crop managements, is necessary to achieve the primary goal of producing high yield, biomass, and more residue inputs (Lal, 2007) [18]. Because biomass intake dominates the decomposition of organic matter caused by fertilization, the concentration of soil organic carbon is significantly higher in less fertile soil than in highly fertile soil (Schipper *et al.* 2007) [27]. It was found that farmland nitrogen management strategies can increase soil carbon pools by 50-150 kg ha^{-1} $year^{-1}$ (Lal *et al.* 1998) [16]. Similar to this, it had been established that variations in carbon and nitrogen content before and after soil improvement utilizing the application of coal bio-briquette ash organic manure (Sakai Y *et al*. 2020) [25]. Nowadays. Nutrient management induced by application of fertilizers may enhance biomass production and results in crop residue return into soil and thereby increase soil organic matters, organic C and N and it is, therefore, very necessary for increasing SOC sequestration in soil (Campbell *et al.* 2001) [5]. According to reporting of Rashad Hegazy, (2016) [10], crop residue production is about (620) Mt or (91) % in 2008 in Asia and (5) %, (3) %, (1) % in America, Africa and Europe, respectively**.** Because soil organic matter is directly related to crop residue inputs will results in an increase in soil C and N. Average rates of residue-C conversion into soil organic carbon were 14% and 32%, respectively, with and without fertilizer application (Lal, 2007) [18]. Thus, the addition of crop residue to the soil is a nutrient recycling to improve soil quality in physical and chemical conditions, soil environment as well as protects soil from erosion activities. The removal of crop residues leads to low soil fertility and decreased crop production and (80) % of total N, P, K taken up by the crops (Sahu J *et al*. (2019) [13].

Nitrogen

The most significant nutrient element in terms of governing numerous metabolic processes and responding to crop vegetative development is nitrogen (Batabyal *et al.* 2015) [2]. N fertilizer placement, crop residue retention, and soil nutrient status all play a role in how much carbon (C) is added to the soil through increased plant biomass and breakdown. N input in low fertility can store more soil organic carbon (SOC) and greater response to plant biomass and SOC because of greater biomass C input than output is possible by providing N to N-limited soils. Soil organic carbon accumulation rate more increases with increasing N level in N-limited soil than N-rich soil. Fertilizer placement in the soil is crucial to C and is controlled by tillage techniques and residue retention. Placement of N below the surface of no-tillage increases N availability, which can be mineralized by a large number of microorganisms and plant uptake and thereby promotes plant development (Hossain *et al.* 2020) [35]. Lack of accessible C produced from residues for microbial activity causes a decrease in SOC in the no-residue soil (Chowdhury. A and Farrell. M, 2015) [6].

Phosphorus

For life functions like photosynthesis, energy conversion, and other metabolic processes in plants, phosphorus is another crucial element. P fertilizer increases the photosynthetic activity of leaves and other green portions of plants, increasing above-ground biomass and SOC in the soil as a result. Even if P is added to the soil, only 10-20% of the added P can be absorbed by plant roots because it quickly fixes or precipitates into forms that are not readily available, which reduces biomass production and SOC concentration in the soil. By adding OM, which contains significant amounts of organic acids (such as phytates, phospholipids, and nucleic acids), it is possible to decrease the fixation of P while increasing the quantity of inorganic P in the soil. Additionally, root morphology, such as root cluster, root hair growth, root length, and root exudates that can mobilize P, as well as their root architecture because of low molecular weight compounds as root exudates by plant roots that can be dissolve phosphates of Ca, Al, and Fe to increase plant available P in soil, greatly influence how well plants adapt to low P availability (Wang *et al.* 2006a, 2006b [31, 32], Shen *et al.* 2011) [29].

Potassium

Potassium (K) is another necessary nutrient for plants, especially for their developing tissues and reproductive organs. It also helps with carbohydrate synthesis and transport, which leads to increased biomass production after proper potassium fertilization. Only a small part of the total potassium in soil may be absorbed by plants as exchangeable and solution potassium inorganic captions, with the majority of the potassium occurring in primary and secondary minerals like K-feldspar and mica (Batabyal *et al*. 2015 [2], Szczerba *et al*. 2008) [30].

Secondary Nutrients

The secondary nutrients, S, Ca, and Mg, which are essential for a balanced diet for plants, are indirectly introduced to the soil through fertilizers and soil amendments. They may also be contributed through increased biomass output, which has a favorable effect on the buildup of soil organic carbon. For the structures and functions of enzymes, proteins in leaf tissues and seeds, the formation of metabolism compounds (amino acids, methionine, proteins, etc.), and the increase in biomass production, sulphur (S) is a key macronutrient. It also has a positive impact on the accumulation of soil organic carbon. Due to better circumstances for microbial activity and organic matter decomposition, calcium and magnesium (Ca and Mg) can directly participate in the complexation of organic matter in soil and enhance the soil's organic carbon content. Examples are O'Brien *et al.* (2015) [21] and Li *et al.* (2019) [20] who demonstrated the significance of the most abundant cations on the exchange surfaces of soil colloids in boosting SOC stores in grasslands.

C. Soil Management

In agricultural land, soil management is important component for enhancing soil structure, physical and chemical composition, and C content. Inappropriate land use practices and poor soil management practices can also degrade soil. This degradation lowers biomass productivity and reduces the amount of plant residues that are returned to the soil (Lal, 2003) [17]. It also has a significant impact on improving soil C content and soil quality for growth of plants and microorganisms (Lal, 2007) [18]. Soil acidification and soil salinization are the two main issues with soil degradation for crop development. According to Wong *et al.* (2009) [33], saline soil is categorized based on electrical conductivity, exchangeable sodium percentage, and pH. Saline soil impacts plant growth, nutrients, water availability, and plant toxicity through changing physical and chemical qualities (Reddy and

Reddy, 2016) [22]. Increased osmotic pressure may lead to the dehydration of microbial cells and the death of sensitive microorganisms as a result of decreased soil microbial activity and declining SOM decomposition (Setia *et al.* 2010), which in turn has an impact on soil carbon sequestration. Application of soluble calcium salts (calcite and carbonates), soluble gypsum, calcium chloride, and phosphogypsum, acids, or acid formers (sulphuric acid, iron sulphate, lime sulphur etc.) (Reddy and Reddy, 2016) [22] and manure is the most widely used technique among those for saline soils. They increase soil's physical, chemical, and biological qualities, such as soil aggregation and stabilization, SOC content (More, 1994) [14] and soil structure by replacing excess Na with Ca in the clay exchange sites (Rengasamy and Marchuk, 2011 [23]; Zaka *et al*. 2003) [34].

Acid soil has an impact on nutrient availability, microbial activity, plant root development, and growth, which led to a decrease in soil microbial biomass (Cihacek *et al*. 2021) [7]. Through its amelioration, immobilization, and mobilization processes, lime application into soil has the potential to modify the chemical properties of the soil both directly and indirectly. It can also promote soil structure development and hydraulic conductivity (Bolan *et al*. 2003 [4], Haynes and Naidu, 1998) [9]. Thus, due to the pH rising caused by the decarboxylation of organic anions (Tang and Yu, 1999) or the release of basic captions during OM decomposition, plants may easily take up available plant nutrients, producing more biomass and increasing carbon sequestration. Because crop residues are primarily N-induced-organic C and have a liming effect, their addition to soil can also raise pH in soil. It may also aid in raising the OM stock in the soil. Application of lime and crop wastes fosters the growth of soil microorganisms, resulting in increased OM breakdown via microbial activity and soil stabilization of C pools (Hossain *et al.* 2020) [35].

D. Environmental managements

Environmental elements like soil temperature, aeration, and biodiversity have an impact on the increased biomass production and organic matter decomposition caused by an increased nutrient availability for microbial activities. However, in humid, sub-humid, and desert zones, a 3 °C increase in temperature can reduce SOC pools in the soil by 28%, 20%, and 15%, respectively. The composition and activity of soil macro- and microorganisms are included in biodiversity, which is a significant element in soil C dynamics. Organic polymers produced by soil biota help to form and stabilize aggregates, which raises the SOC concentration. The oxygen in the macrospores of the drained soil is used by plant roots for their growth, and in exchange, they breathe out CO2 through respiration. When the percentage of oxygen in the root zone drops below 10%, plant growth begins to deteriorate.

Conclusion

The improvement of the soil environment and SOM content, which is a significant element for the decomposition of OM by microbial activities and, ultimately, the creation of SOC pools, is influenced by cultural and nutrient-induced management methods. Soil organic matter is important for the development and stability of SOC because it affects the chemical, biological, and physical characteristics of soil and plays a crucial role in the nutrient cycling for soil and plants, which raises crop yields, produces more biomass, and can also feedback into the soil system as a result of rising C inputs. No-till farming techniques, which have stable soil aggregates and soil biodiversity, help to boost the amount of water and nutrients that plants can access for growth and development, as well as the amount of carbon in soils. It has frequently been demonstrated that adding fertilizers, agricultural residues, and amendments increases soil C, which is mostly related to higher plant biomass output. However, it has also been demonstrated that adding fertilizer accelerates the breakdown of SOM, causing the loss of decomposable C pools from the soil. Soil organic carbon sequestration depends greatly on fertilization rates and timing. Therefore, management strategies have a significant impact on crop yield over the long term and increase the amount of carbon that returns to the soil.

References

1. Al-Kaisi MM, Douella A, Kwaw-Mensah D. Soil micro aggregate and macro aggregate decay over time and soil carbon changes as influenced by different tillage systems. Journal of Soil and Water Conservation. 2014;69(6):574-580.
2. Batabyal K, Dutta SK, Sarkar D, Majumdar K. Primary and secondary plant nutrients. Principle of Soil Science; c2015. p. 191-221.
3. Beare HM, Cabrera PE, Coleman DC. Aggregate-protected and unprotected organic pools in conventional and no-tillage soils. Soil sciences society of America Journal. 1994;58:787-795.
4. Bolan NS, Hedley MJ. Role of carbon and nitrogen cycles in soil acidification. In: Rengel, Z. (Ed., Handbook of soil acidity. Marcel Deker, New York; c 2003. p. 47-48.
5. Campbell CA, Sellers F, Lafond GF, Zentner RP. ‘Adopting zero tillage management: Impact on soil C and N under long-term crop rotations in a thin black Chernogen’, Canadian. Journal of Soil Science. 2001;81:129-148.
6. Chowdhury S, Farrell M, Kim GH, Bolan NS. Assessing the interaction between soil organic carbon and added plant residues with contrasting C: N ration. In: Oral presentation. 5th International Symposium on soil organic matter, Gottingen, Germany; c2015 September. p. 20-24.
7. Cihacek L, Landblom DGL, Buetow RR, Alghamdi R. What is Soil Acidity? NDSU Extension, North Daota State University, Fargo, North Dakota; c2021.
8. Fung I. ‘Variable carbon sinks’, Science. 2000;290:1313-1314.
9. Haynes RJ, Naidu R. Influence of lime, fertilizer and manure applications on soil organic matter content and soil physical conditions: A review. Nutrient Cycling in Agro ecosystem. 1998;51:123-137.
10. Hegazy R, Snadro J. Report: Rice Straw Collection. International Rice Research Institute Crop and Environmental Sciences Division, Postharvest unit, Kafrelsheik University; c2016. https://www.researchgate.net/publication/309177865.
11. Hossian MZ, Sarkar B, Bolan N. Role of cultural and nutrient management practices in carbon sequestration in agricultural soil. Advance in Agronomy. ISSN: 0065-2113; c2020.
12. Jacinthe PA, Lal R, Kimble JM. Carbon budget and seasonal carbon dioxide emission from a Central Ohio Luvisol as influenced by wheat residue management. Soil

and Tillage Research. 2002;67:147-157.
13. Sahu J, Prasad M, Sahu R, Kumar D, Mandal SK, Sohane RK. Crop residue management under changing climate scenario. Current Journal of Applied Science and Technology. Article No. CJAST.52046. 2019;37(6):1-6.
14. More SD. Effect of farm wastes and organic manures on soil properties, nutrient availability and yield of rice-wheat grown on Sodic Vertisol. Journal of the Indian Society of Soil Science. 1994;42(2):253-256.
15. Lal R. Residue management, conservation tillage and soil restoration for mitigating greenhouse effect by CO_2 enrichment. Soil and Tillage Research. 1997;43:81-107.
16. Lal R, Kimble JM, Follett RF, Cole CV. The potential of U.S cropland to sequester carbon and mitigate the greenhouse effect. Lewis Publishers, Chelsea, MI; c1998.
17. Lal R. Global potential of soil carbon sequestration to mitigate the greenhouse effect. Critical Reviews Plant Science. 2003;22(2):151-184.
18. Lal R. Carbon management in agricultural soils. Carbon management and sequestration center, The Ohio State University, Columbus, USA. Mitigation and adaption strategies for global change. 2007;12:303-322.
19. Lal R. Carbon sequestration. The Ohio State University. Philosophical Transactions of the Royal Society B. 2008;363:815-830.
20. Li T, Zhang H, Wang X, Cheng S, Fang H, Liu G, *et al.* Soil erosion affects variations of soil organic carbon and soil respiration along a slope in Northeast China. Ecological Process. 2019;8:28. DOI: https://doi.org/10.1186/s13717-019-0184-6.
21. O'Brien SL, Jastrow JD, Grimley DA, Gonzalez-Meler MA. Edaphic controls on soil organic carbon stocks in restored grasslands. Geoderma. 2015;251-252:117-123.
22. Reddy TY, Reddy GH. Principles of Agronomy (Fifth revised edition); 2016.
23. Rengaasamy P, Marchuk A. Cation ration of soil structural stability (CROSS). Soil Research. 2011;49:280-285.
24. Tang C, Yu Q. Impact of chemical composition of legume residues and initial soil pH on pH change of a soil after residue incorporation. Plant and Soil. 1999;215:29-38.
25. Sakai Y, Nakamura M, Wang C. Soil carbon sequestration due to salt-affected soil amelioration with coal bio-briquette ash: A case study in Northeast China. Department of environmental chemistry and chemical engineering, school of advanced engineering, Kogakuin University, Tokyo. Mineral. 2020;10:1019; DOI: 10.3390 /min1011019.
26. Saljinikov E, Cakmak D, Rahimgdieva S. Soil organic matter stability as affected by land management in steppe ecosystem. Intech Journal, Chapter 10; c2013. p. 269-310. DOI: http:/dx.doi.org/10.5772/53557.
27. Schipper LA, Baisden WT, Parfitt RL, Ross C, Claydon JJ, Arnold G. Large losses of soil C and N from soil profiles under pasture in New Zealand during the past 20 years. Global Change Biology. 2007;13(6):1138-1144.
28. Setia R, Marschner S, Baldock J, Chittleborough D, Smith J. Introducing a decomposition rate modifier in the Rothamsted carbon model to predict soil organic carbon stocks in saline soils. Environmental Science Technology. 2011;45(15):6396-6403.
29. Shen J, Yuan L, Zhang J, Li H, Bai Z, Chen X, *et al.* Phosphorus dynamics: from soil to plant. Plant Physiology. 2011;156(3):997-1005.
30. Szczerba MW, Britto DT, Ali SA, Balkos KD, Kronzucker HJ. $NH4^{+}$- stimulated and inhibited components of K^{+} transport in rice (*Oryza sativa* L.). J. Exp. Bot. 2008;59(12):3415-3423.
31. Wang AS, Angle JS, Chaney RL, Delorme TA. Soil pH effects on uptake of Cd and Zn by Thlaspi caerulescens. Plant and Soil. 2006;281(1)325-337.
32. Wang Z, Shen J, Zhang F. Cluster-root formation, carboxylate exudation and proton release of Lupinus pilosus Murr. As affected by medium pH and P deficiency. Plant and Soil. 2006;287:247-256.
33. Wong VNL, Dalal R, Greene RSB, Murphy BW. Soil carbon dynamics in saline and sodic soils; A review. Fenner School of Environment and Society. The Australian National University, Australia. Soil Use and Management. 2009;26(1):2-11.
34. Zaka MAF, Mujeeb F, Sarwar G, Hassan NM, Hassan G. Agro melioration of saline sodic soils. On Line Journal of Biological Sciences. 2003;3(3):329-334.
35. Hossain MM, Sultana A, Purohit N. Mental health outcomes of quarantine and isolation for infection prevention: A systematic umbrella review of the global evidence. Epidemiology and health; c2020. p. 42.