核农学报 2012, (3) 543-551,593 DOI: ISSN: 1000-8551 CN: 11-2265/S

同位素示踪·资源环境·动植物生理

坡耕地侵蚀区和堆积区初春土壤呼吸的变化

耿肖臣[1], 李勇[2], 于寒青[1], 刘国强[1]

1. 中国农业科学院农业环境与可持续发展研究所, 北京 100081;
2. 河南师范大学生命科学学院, 河南 新乡 453007

摘要:

以黄土高原侵蚀坡耕地(坡地1和坡地2)为对象,选择土壤温度和水分变化较为剧烈的初春3月,采用^{137}Cs和$^{210}Pb_{ex}$示踪技术,在确定的侵蚀和堆积区布设有根和无根2种处理,利用Li-8100土壤碳通量自动测量系统原位监测土壤呼吸,同时监测土壤温度和水分变化。与侵蚀区比较,观测期间堆积区有根和无根处理土壤CO_2排放通量均有明显增加,只是这种增加有时没有达到统计上的显著水平。土壤堆积使坡地1有根和无根处理区土壤CO_2排放通量分别增加了24.43%(由8.02% 至 44.41%)和23.95%(由6.37% 至 43.26%);土壤堆积使坡地2有根和无根处理区土壤CO_2排放通量分别增加了44.64%(由17.33% 至 74.63%)和25.28%(由10.23% 至 39.76%)。3月份坡耕地侵蚀区和堆积区土壤呼吸随观测时间的变化与土壤温度和水分密切相关,但是,在整个观测期间侵蚀区和堆积区的土壤水分和温度没有差异,研究揭示了坡耕地土壤呼吸空间变化的土壤侵蚀驱动机理。

关键词: 原位土壤呼吸 土壤侵蚀 水温条件 坡耕地 黄土高原

THE VARIATIONS OF SOIL RESPIRATION AT THE ERODED AND DEPOSITED SITES OF THE CULTIVATED SLOPES DURING EARLY SPRING TIME

GENG Xiao-chen[1], LI Yong[2], YU Han-qing[1], LIU Guo-qiang[1]

1. Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, Beijing 100081;
2. College of Biological Sciences, Henan Normal University, Xinxiang, Henan 453007

Abstract:

Studies on soil erosion-induced exchange of CO_2 between soil and atmosphere are mainly based on the modeling method and incubation experiments, but few direct measurements of the exchange are conducted in the field conditions. The objectives this present study were to investigate the spatial and temporal variations of the in-situ soil CO_2 flux from the eroded and deposited sites in the sloping land in the early spring time, and assess the role of soil erosion and deposition, soil temperature and moisture controlling these variations. Two cultivated slopes of Slope 1 and Slope 2 were selected in Pucheng County of Shaanxi Province, Loess Plateau of China. Fallout ^{137}Cs and $^{210}Pb_{ex}$ techniques were used to identify the sites where soil erosion or deposition occurred in each slope. Two treatments including with root and without root were triplicated at eroded and deposited sites, respectively. In-situ measurements of soil CO_2 flux by using Li-8100 Automated Soil CO_2 Flux System soil temperature and moisture were monitor in each treatment plots, during March when the soil temperature and moisture vary significantly. Compared with the eroded sites, the amount of soil CO_2 flux from all the plots in deposited sites increased consistently, although they did not reach statistically significant level during the measurement period. For slope 1, soil deposition resulted in an increase by 24.43% and 23.95% of soil CO_2 flux in the plots with roots and the plots without roots, respectively, ranging from 8.02% to 44.41% and 6.37% to 43.26%, and for slope 2, soil CO_2 flux was elevated by 44.64% and 25.28%, respectively, ranging from 17.33% to 74.63% and 10.23% to 39.76%. Our results suggested that soil erosion and deposition processes may control the spatial variations in soil CO_2 flux in cultivated slopes in Chinese Loess Plateau.

Keywords: in-situ soil respiration soil erosion and deposition soil temperature and moisture cultivated slopes the Loess Plateau

收稿日期 2011-11-07 修回日期 2012-02-13 网络版发布日期

DOI:

基金项目:

国家自然科学基金 (41171231,40671097, 31000944)

通讯作者: 李 勇(1958-),男,陕西蒲城人,博士,研究员,博士生导师,主要从事土壤侵蚀与碳循环研究。 Tel: 82106016;E-mail: yongli32@hotmail.com
作者简介:
作者Email: yongli32@hotmail.com

参考文献:

[1] Jobbery E G, Jackson R B. The vertical distribution of soil organic carbon and its relation to climate and vegetation [J]. Ecological Applications, 2000, 10: 423-436
[2] Houghton R A. Why are estimates of the terrestrial carbon balance so different? [J]. Global Change Biology, 2003, 9: 500-509
[3] Ritchie J C, McCarty G W. (137) Cesium and soil carbon in a small agricultural watershed [J]. Soil & Tillage Research, 2003, 69: 45-51
[4] Li Y, Zhang Q W, Reicosky D C, et al. Changes in soil organic carbon induced by tillage and water erosion on a steep cultivated hillslope in the Chinese Loess Plateau from 1898-1954 and 1954-1998[J]. Journal of Geophysical Research, 2007, 112, G01021, doi: 10.1029/2005JG000107
[5] Stallard R F. Terrestrial sedimentation and the carbon cycle: Coupling weathering and erosion to carbon burial [J]. Global Biogeochemical Cycles, 1998, 12: 231-257
[6] Gregorich E G, Greer K J, Anderson D W, et al. Carbon distribution and losses: erosion and deposition effects [J]. Soil & Tillage Research, 1998, 47: 291-302
[7] Harden J W, Sharpe J M, Parton W J, et al. Dynamic replacement and loss of soil carbon on eroding cropland[J]. Global Biogeochemical Cycles, 1999, 13: 885-901
[8] Lal R. Soil erosion and the global carbon budget [J]. Environment International, 2003, 29: 437-450
[9] Liu S G, Bliss N, Sundquist E, et al. Modeling carbon dynamics in vegetation and soil under the impact of soil erosion and deposition[J]. Global Biogeochemical Cycles, 2003, 17(2): 1074
[10] Smith S V, Sleezer R O, Renwick W H, et al. Fates of eroded soil organic carbon: Mississippi basin case study [J]. Ecological Applications, 2005, 15: 1929-1940
[11] Yoo K, Amundson R, Heimsath A M, et al. Erosion of upland hillslope soil organic carbon: coupling field measurements with a sediment transport model [J]. Global Biogeochemical Cycles, 2005, 19, GB3003, doi: 10.1029/2004GB002271
[12] Van Oost K, Quine T A, Govers G, et al. The impact of agricultural soil erosion on the global carbon cycle [J]. Science, 2007, 318: 626-629
[13] Smith S V, Renwick W H, Buddemeier R W, et al. Budgets of soil erosion and deposition for sediments and sedimentary organic carbon across the conterminous United States[J]. Global Biogeochemical Cycles, 2001, 15: 697-707
[14] Rosenbloom N A, Harden J W, Neff J C, et al. Geomorphic control of landscape carbon accumulation [J]. Journal of Geophysical Research, 2006, 111, G01004, doi: 10.1029/2005JG000077
[15] Jenerette G D, Lal R. Modeled carbon sequestration variation in a linked erosion-deposition system [J]. Ecological Modelling, 2007, 200: 207-216
[16] Izaurralde R C, Williams J R, Post W M, et al. Long-term modeling of soil C erosion and sequestration at the small watershed scale [J]. Climatic Change, 2007, 80: 73-90
[17] Gaiser T, Stahr K, Billen N, et al. Modeling carbon sequestration under zero tillage at the regional scale. I. The effect of soil erosion [J]. Ecological Modelling, 2008, 218: 110-120
[18] Billings S A, Buddemeier R W, Richter D, et al. A simple method for estimating the influence of eroding soil profiles on atmospheric CO_2 [J]. Global Biogeochemical Cycles, 2010, 24, GB2001, doi: 10.1029/2009GB003560
[19] Jacinthe P-A, Lal R, Kimble J M. Carbon dioxide evolution in runoff from simulated rainfall on long-term no-till and plowed soils in southwestern Ohio [J]. Soil & Tillage Research, 2002, 66: 23-33
[20] Jacinthe P-A, Lal R, Owens L B, et al. Transport of labile carbon in runoff as affected by land use and rainfall characteristics [J]. Soil & Tillage Research, 2004, 77: 111-123
[21] Polyakov V O, Lal R. Soil erosion and carbon dynamics under simulated rainfall [J]. Soil Science, 2004, 169: 590-599
[22] Polyakov V O, Lal R. Soil organic matter and CO_2 emission as affected by water erosion on field runoff plots [J]. Geoderma, 2008, 143: 216-222
[23] Mora J L, Guerra J A, Armas C M, et al. Mineralization rate of eroded organic C in andosols of the Canary Islands[J]. Science of the Total Environment, 2007, 378: 143-146
[24] Van Hemelryck H, Fiener P, Van Oost K, et al. The effect of soil redistribution on soil organic carbon: an experimental study [J]. Biogeosciences, 2010, 7: 3971-3986
[25] Bajracharya R M, Lal R, Kimble J M. Erosion effects on carbon dioxide concentration and carbon flux from an ohio alfisol[J]. Soil Science Society of America Journal, 2000, 64: 694-700
[26] 李嵘, 李勇, 李俊杰, 孙丽芳, 张晴雯. 黄土丘陵侵蚀坡地土壤呼吸初步研究[J]. 中国农业气象, 2008, 29(2): 123-126
[27] Van Hemelryck H, Govers G, Van Oost K. Evaluating the impact of soil redistribution on the in situ mineralization of soil organic carbon[J]. Earth Surface Processes and Landforms, 2011, 36: 427-438

[28] Li Y, Zhang Q W, Reicosky D C. Using ^{137}Cs and $^{210}Pb_{ex}$ for quantifying soil organic carbon redistribution affected by intensive tillage on steep slopes [J]. Soil & Tillage Research, 2006, 86: 176-184
[29] Wallbrink P J, Murray A S. Use of fallout radionuclides as indicators of erosion processes [J]. Hydrological Processes, 1993, 7: 297-304
[30] Zapata F. The use of environmental radionuclide as tracers in soil erosion and sedimentation investigation: Recent advances and future developments [J]. Soil & Tillage Research, 2003, 69: 3-13
[31] Walling D E, Collins A L, Sichingabula H M. Using unsupported lead-210 measurements to investigate soil erosion and sediment delivery in a small Zambian catchment [J]. Geomorphology, 2003, 52: 193-213
[32] 赵广东, 王 兵, 杨 晶, 张志坚. LI-8100开路式土壤碳通量测量系统及其应用[J]. 气象研究, 2005, 33: 363-366
[33] 耿绍波, 饶良懿, 鲁绍伟, 杨晓菲, 高 东. 国内应用LI-8100开路式土壤碳通量测量系统测量土壤呼吸研究进展[J]. 内蒙古农业大学学报, 2010, 31: 309-316
[34] 李 勇, 耿肖臣, 于寒青, 万国江.标准物质对HPGeγ谱仪测定环境放射性核素^{210}Pb和^{137}Cs的影响[J].核农学报,2010,24(6): 1249-1254
[35] Mielnick P C, Dugas W A. Soil CO_2 flux in a tallgrass prairie [J]. Soil Biology and Biochemistry, 2000, 32: 221-228
[36] Wu J B, Guan D X, Wang M, et al. Year-round soil and ecosystem respiration in a temperate broad-leaved Korean Pine forest [J]. Forest Ecology and Management, 2006, 223: 35-44
[37] Zheng Z M, Yu G R, Fu Y L, et al. Temperature sensitivity of soil respiration is affected by prevailing climatic conditions and soil organic carbon content: A trans-China based case study [J]. Soil Biology and Biochemistry, 2009, 41: 1531-1540
[38] Davidson E A, Belk E, Boone R D. Soil water content and temperature as independent of confounded factors controlling soil respiration in a temperate mixed hardwood forest [J]. Global Change Biology, 1998, 4: 217-227
[39] Han G X, Zhou G S, Xu Z Z, et al. Biotic and abiotic factors controlling the spatial and temporal variation of soil respiration in an agricultural ecosystem [J]. Soil Biology and Biochemistry, 2007, 39: 418-425
[40] Linn D M, Doran J W. Effect of water-filled pore space on carbon dioxide and nitrous oxide production in tilled and non-tilled soils[J]. Soil Science Society of America Journal, 1984, 48 (6): 1267-1272
[41] Doran J W, Mielke L N, Power J F. Microbial Activity as Regulated by Soil Water-Filled Pore Space [C]. In: Transactions of the 14th International Congress of Soil Science, 1990, 3: 94-99
[42] Skopp J, Jawson M D, Doran J W. Steady-state aerobicmicrobial activity as a function of soil water content [J]. Soil Science Society of America Journal, 1990, 54 (6): 1619-1625
[43] Xu M, Qi Y. Spatial and seasonal variation of Q10 determined by soil respiration measurementsat a SierraNevada forest [J]. Global Biogeochemistry Cycles, 2001a, 15: 687-696
[44] Xu M, Qi Y. Soil-surface CO2 efflux and its spatial and temporal variations in a young ponderosa pine plantation in northern California [J]. Global Change Biology, 2001b, 7: 667-677
[45] Curiel Yuste J, Janssens I A, Carrara A, Meiresonne L, Ceulemans R. Interactive effects of temperature and precipitation on soil respiration in a temperate maritime pine forest[J]. Tree Physiology, 2003, 23 (18): 1263-1270
[46] Luo Y Q, Zhou X H. Soil Respiration and the Environment [M]. Amsterdam Elsevier, 2006: 92
[47] 杨新民, 王文焰, 沈 冰. 陕西黄土区土壤的农业水文特性研究[J]. 西北水资源与水工程, 1997, 8: 18-24
[48] Davidson E A, Verchot L V, Cattanio J H, et al. Effects of soil water content on soil respiration in forests and cattle pasture of eastern Amazonia[J]. Biochemistry, 2000, 48: 53-69
[49] Almagro M, Lopez J, Querejeta J I, et al. Temperature dependence of soil CO_2 efflux is strongly modulated by seasonal patterns of moisture availability in a Mediterranean ecosysterm [J]. Soil Biology and Biochemistry, 2009, 41: 594-605
[50] Li Y, Lindstrom M J. Evaluating soil quality-soil redistribution relationship on terraces and steep hillslope[J]. Soil Science Society of America Journal, 2001, 65: 1500-1508
[51] Reicosky D C, Lindstrom M J, Schumacher T E, et al. Tillage-induced CO_2 loss across an eroded landscape [J]. Soil & Tillage Research, 2005, 81: 183-194

本刊中的类似文章

1．李立青,刘普灵,杨明义.放射性核素~7Be在土壤侵蚀研究中的应用现状及前景[J]. 核农学报, 2003,17(05): 392-395

2．石辉,李占斌,赵晓光.铀钍衰变系核素在土壤侵蚀应用研究的进展[J]. 核农学报, 2003,17(05): 396-399

3．宋炜,刘普灵,杨明义.核素示踪技术在土壤侵蚀研究中的应用进展[J]. 核农学报, 2003,17(03): 236-238

4．琚彤军,田均良,刘普灵,李雅琦,张梅花.REE示踪条带施放法研究坡面土壤侵蚀垂直分布规律[J]. 核农学报, 1999,13(06): 347-352

5．杨明义,田均良,刘普灵.~(137)Cs测定法研究不同坡面土壤侵蚀空间的分布特征[J]. 核农学报, 1999,13(06): 368-372

6．李勇,Ｆｒｉｅｌｉｎｇｈａｕｓ Ｍ．,Ｂｏｒｋ Ｈ．Ｒ．.利用~(137)Cs技术研究土壤可蚀性的时空变异(英文)[J]. 核农学报, 1999,13(03): 0-0

7．李雅琦,田均良,刘普灵,琚彤军.利用稀土元素示踪法研究黄土高原土壤侵蚀空间分布规律[J]. 核农学报, 1997,11(03): 0-0
8． 薛凯, 杨明义, 张风宝, 孙喜军.利用淤地坝泥沙沉积旋迴反演小流域侵蚀历史[J]. 核农学报, 2011,25(1): 115-120
9．于寒青, 李勇, Nguyen M L, Funk R, 刘国强, 李俊杰.基于FRN技术的我国不同地区典型土壤保持措施的有效性评价[J]. 核农学报, 2012,(2): 340-347
10． 王禹, 杨明义, 刘普灵.典型黑土直型坡耕地土壤侵蚀强度的小波分析[J]. 核农学报, 2010,24(1): 98-103
11．张风宝1,2 杨明义2 .基于7Be示踪和细沟沟网分形维数研究坡面土壤侵蚀[J]. 核农学报, 2010,24(5): 1032-1037
12．刘志强;杨明义;刘普灵;田均良;.~(137)Cs示踪技术背景值研究进展与建议[J]. 核农学报, 2008,22(06): 913-917+922
13．钱娟;杨浩;杨九东;张明礼;王小雷;徐从安;.盆栽-自然土生长试验研究小麦对土壤中~(137)Cs的吸收[J]. 核农学报, 2008,22(05): 686-692
14．张风宝;杨明义;李占斌;刘普灵;田均良;.坡面植物生长期内对~7Be的截留吸收及影响因素分析[J]. 核农学报, 2008,22(02): 213-217
15．尚佰晓;王瑄;王莉;.利用REE示踪技术研究土壤侵蚀的进展[J]. 核农学报, 2008,22(01): 111-115
