核农学报 2011, 25(6) 1300-1305 DOI: ISSN: 1000-8551 CN: 11-2265/S

同位素示踪·资源环境·动植物生理

利用^{15}N自然丰度法区分有机和常规生产的作物

孟凡乔[1], 诸葛玉平[2], 吴文良[1], 苏志慧[1], 王会[2]

1. 中国农业大学资源与环境学院,北京 100193;
2. 山东农业大学资源与环境学院,山东 泰安 271018

摘要:

应用^{15}N自然丰度法区分有机和常规生产作物,是近年来国内外氮同位素技术应用研究的热点之一。由于化学合成氮肥和有机肥δ^{15}N的不同,作物产品中相应的δ^{15}N也不同,因此利用作物δ^{15}N判断肥料类型就成为可能。影响作物δ^{15}N的因素,除氮肥类型外,还包括作物的类型、生长阶段、部位、大气沉降、水分、pH以及土地利用方式等。在利用作物^{15}N自然丰度判断氮肥类型过程中,必须特别注意这些因素的综合影响。目前的研究表明,叶菜类、生长期短的作物,生长过程中吸收的氮来源于肥料氮的比例要高于土壤氮,因而利用^{15}N判断使用化肥或有机肥的准确率较高。有机肥中有效N含量越高,越能显著增加植物中的^{15}N含量。化肥和有机肥生产的植物发生δ^{15}N值重叠,主要是由于化肥N通过NH_3挥发和反硝化损失进而导致土壤中^{15}N富集,进而在植物中体现出来。对于氮素在土壤和作物系统中的定量分析.有助于利用作物^{15}N判断氮肥类型。

关键词: ^{15}N 有机作物 氮肥 分馏

IDENTIFICATION OF ORGANICALLY AND CONVENTIONALLY PRODUCED CROPS BY NATURAL ^{15}N ABUNDANCE METHOD

MENG Fan-qiao[1], ZHUGE Yu-ping[2], WU Wen-liang[1], SU Zhi-hui[1], WANG Hui[2]

1. College of Resources and Environmental Sciences, China Agricultural University, Beijing 100193;
2. College of Resources and Environmental Sciences, Shandong Agricultural University, Tai'an, Shandong 271018

Abstract:

In recent years, the application of natural ^{15}N abundance, for identification of whether crops have been produced organically or conventionally, has attracted significant interest in China and abroad. Since ^{15}N in synthetic and organic nitrogen fertilizers are different, the crops produced on the fertilizers have different ^{15}N levels, which makes identification possible. In addition to nitrogen fertilizer types, crop types, growth stage, sampled part, air nitrogen deposition, water content, pH and land utilization can also influence the fractionation and distribution of ^{15}N in soil-crop system, which should be considered during identification process. This research indicates that for foliar and short growth stage crops, ^{15}N identification has higher accuracy than for fruit, root and long growth stage crops. As available nitrogen increases in organic fertilizers, there is a greater possibility of higher ^{15}N in the plant. Overlapping values between organic and chemical fertilized plants are mainly attributed to ^{15}N enrichment of N derived from synthetic fertilizer through N loss via NH_3 volatilization and denitrification. Quantitative mass balance analysis of ^{15}N within the soil-crop system can improve the efficiency of ^{15}N identification.

Keywords: ^{15}N organic crop nitrogen fertilizer fractionation

收稿日期 2011-03-23 **修回日期** 2011-05-24 **网络版发布日期**

DOI:

基金项目:

国家自然科学基金(30970533)

通讯作者:

作者简介: 孟凡乔(1969-), 男, 山东临沭人,博士,副教授,研究方向为土壤有机碳、氮和有机农业。E-mail: mengfq@cau.edu.cn

作者Email:

参考文献：

[1] Willer H, Kilcher L. The world of organic agriculture. statistics and emerging trends 2011［R］. International Federation of Organic Agriculture Movements (IFOAM), Bonn, and Research Institute of Organic Agriculture (FiBL), Frick, 2011

[2] IFAD. Organic agriculture and poverty reduction in asia: china and india focus［R］. No. 1664, 2005.

[3] Xu Freddie. China organic products shanghai organic retail market profile［R］. USDA Foreign Agriculture Service, GAIN report: CH8821, 2008

[4] ABC News. I-Team: Organic food contamination. http://www.wjla.com/news/stories/0708/538424.html , 2008, ［Feb 28, 2009］

[5] 中国农业年鉴编辑委员会. 中国农业年鉴［M］. 北京:农业出版社, 2006

[6] 李冬初. 应用NUTMON方法评价华北平原典型集约小农户体系的养分循环和经济状况［D］. 北京:中国农业大学硕士论文, 2006

[7] Kohl D H, Shearer G, Commoner B. Variation in ^{15}N in maize and soil following application of fertilizer nitrogen［J］. Soil Science of Society of American Proc, 1973, 37: 888-892

[8] Yoneyama T, Muraoka T, Murakami T, Boonkerd N. Natural abundance of ^{15}N in tropical plants with emphasis on tree legumes［J］. Plant and Soil, 1993, 153: 295-304

[9] Choi W J, Ro H M, Lee S M. Natural ^{15}N abundances of inorganic nitrogen in soil treated with fertilizer and compost under changing soil moisture regimes［J］. Soil Biolology and Biochemistry. 2003, 35(10): 1289-1298

[10] Nakano A, Uehara Y, Yamauchi A. Effect of organic and inorganic fertigation on yields, $\delta^{15}N$ values, and $\delta^{13}C$ values of tomato (Lycopersicon esculentum Mill. cv. Saturn)［J］. Plant and Soil, 2003, 255(1): 343-349

[11] Bateman A S, Kelly S D, Jickells T D. Nitrogen isotope relationships between crops and fertilizer: implications for using nitrogen isotope analysis as an indicator of agricultural regime［J］. Journal of Agricultural and Food Chemistry, 2005, 53: 5760-5765

[12] Bateman A S, Kelly Simon D, Woolfe M. Nitrogen Isotope Composition of Organically and Conventionally Grown Crops［J］. Journal of Agricultural and Food Chemistry , 2007,55: 2664－2670

[13] Evans R D, Bloom A J, Sukrapanna S S, Ehleringer J. R. Nitrogen isotope composition of tomato (Lycopersicon esculentum Mill. cv. T-5) grown under ammonium or nitrate nutrition［J］. Plant, Cell Environment, 1996,19: 1317-1323

[14] Choi W J, Lee S M, Ro H M, Kim K C, Yoo S. H. Natural ^{15}N abundances of maize and soil amended with urea and composted pig manure［J］. Plant and Soil, 2002, 245: 223-232

[15] 罗绪强,王世杰,刘秀明.稳定氮同位素在环境污染失踪中的应用进展［J］. 矿物岩石地球化学通报, 2007,26(3): 691－695

[16] Vitoria L, Otero N, Soler A, Canals A. Fertilizer characterization: isotopic data (N, S, O, C, and Sr)［J］. Environmental Science and Technology, 2004,38: 3254－3262

[17] Bedard-Haughn A, van Groenigen J W, van Kessel C. Tracing ^{15}N through landscapes: potential uses and precautions［J］. Journal of Hydrology, 2003, 272: 175-190

[18] 王东升. 氮同位素($^{15}N/^{14}N$)在地下水氮污染研究中的应用基础［J］. 地球学报, 1997, 18(2): 220-223

[19] 熊正琴,邢光熹,沈光裕,孙德玲. 太湖地区湖、河和井水中氮污染状况的研究［J］. 农村生态环境 , 2002, 18(2): 29-33

[20] 张翠云,张 胜,李政红,刘少玉. 利用氮同位素技术识别石家庄市地下水硝酸盐污染源［J］. 地球科学进展 , 2004, 19(2): 183-191.

[21] 蔡德陵,李红燕,周卫建,刘卫国,曹蕴宁. 无定河流域碳氮稳定同位素研究［J］. 地球化学, 2004, 33(6): 619-626

[22] Russow R, Boehme F. Determination of the total nitrogen deposition by the ^{15}N isotope dilution method and problems in extrapolating results to field scale［J］. Geoderma, 2005, 127: 62~70.

[23] 肖化云,刘丛强,李思亮. 贵阳地区夏季雨水硫和氮同位素地球化学特征［J］. 地球化学, 2003, 32(3): 248－254

[24] 刘卫国,王 政. 黄土高原现代植物-土壤氮同位素组成及对环境变化的相应［J］. 科学通报, 2008, 53(23): 2917－2924

[25] Zhang Y, Liu X J, Fangmeier A, Goulding K T W, Zhang F S. Nitrogen inputs and isotopes in precipitation in the North China Plain［J］. Atmospheric Environment, 2008, 42: 1436-1448

[26] 朱兆良. 中国土壤的氮肥利用与农业中的氮素管理. 中国土壤肥力［M］. 北京:中国农业出版社, 1998: 160-211

[27] 党廷辉,蔡贵信,郭胜利,郝明德,王百群.用^{15}N标记肥料研究旱地冬小麦氮肥利用率与趋向［J］. 核农学报,2003,17(4):280-285

[28] 巨晓棠,潘家荣,刘学军,张福锁. 北京郊区冬小麦/夏玉米轮作体系中氮肥去向研究［J］. 植物应用与肥料学报,2003, 3: 264-270

[29] 易现峰,张晓爱.稳定性同位素技术在生态学上的应用［J］. 生态学杂志, 2005, 24(3):306-314

[30] 郭波莉, 魏益民,潘家荣,李 勇. 碳、氮同位素在牛肉产地溯源中的应用研究［J］. 中国农业科学. 2007,40(2): 365-372

[31] 曾庆飞,孔繁翔,张恩楼,谭 啸. 利用稳定同位素技术研究外源物质输入对太湖微食物链的贡献［J］. 环境科学,2007,28(8): 1670~1674

[32] Yun S I, Ro H M, Choi W J, Chang S X. Interactive effects of N fertilizer source and timing of fertilization leave specific N isotopic signatures in Chinese cabbage and soil［J］. Soil Biology and Biochemistry, 2006, 38: 1682-1689

[33] 劉滄棪,彭宗仁,吳昇鴻,等. 分析植體氮同位素組成鑑別有機蔬菜之初步評估［J］. 臺灣農業研究, 2009, 53(3):169-175

[34] Lim S S, Choi W J, Kwak J H, Jung J W, Chang S X, Kim H Y, Yoon K S, Choi S M. Nitrogen and carbon isotope responses of Chinese cabbage and chrysanthemum to the application of liquid pig manure［J］. Plant and Soil, 2007, 295: 67-77

[35] Steele K W. Fractionation of nitrogen isotopes by animals: a further complication to the use of variations in the natural abundance of $\delta^{15}N$ for tracer studies［J］. Journal of Agricultural Science, 1977, 90: 7-9

[36] 肖敏. 长期施肥对土壤碳氮储量及氮素矿化动力学的影响［D］. 北京:中国农业大学硕士论文, 2006

[37] Del Amor F M, Navarro J, Aparicio P M. Isotopic Discrimination as a tool for organic farming certification in Sweet Pepper ［J］. Journal of Environmental Quality, 2008, 37:182-185

[38] Shearer G, Kohl D H. Natural ^{15}N abundance as a method of estimating the contribution of biologically fixed nitrogen to N_2-fixing systems: Potential for non-legumes［J］. Plant and Soil, 1988, 110: 317-327

[39] Aranibar J N, Otter L Macko S A, Feral C J W, Epstein H E. Nitrogen cycling in the soil-plant system along a precipitation gradient in the Kalahari sands［J］. Global Change Biology, 2004, 10(3): 359~373

[40] Yasmin K, Kadisch G, Baggs E M. Comparing ^{15}N-labelling techniques for enriching above and below-ground components of the plant-soil system［J］. Soil Biology and Biochemistry, 2006,38: 397－400

[41] 李思亮,刘丛强,肖化云. 地表环境氮循环过程中微生物作用及其同位素分馏研究综述［J］. 地质地球化学,

2002, 30(4): 40-45

[42] Feigin A, Sheare G, Kohl D H. The amount and nitrogen-15 content of nitrate in soil profiles from two central Illinois fields in a corn-soybean rotation［J］. Soil Science of Society of America, 1974. 38: 465－471

[43] 陈传平,梅博文.地层水中无机化合物氮同位素测定方法初步研究［J］. 石油天然气学报. 2005,27(4): 433－434

[44] 苏 波,韩兴国,黄建辉. ^{15}N自然丰度法在生态系统氮素循环研究中的应用［J］. 生态学报,1999,19(3): 408－416

[45] Oelbermann M, Voroney R P, Kass D C L, Schloenvoigt A M. Soil carbon and nitrogen dynamics using stable isotopes in 19-and 10-year-old tropical agroforestry systems［J］. Geoderma, 2006, 130: 356-367

[46] 袁玉伟,张志恒,赵 明,徐明飞,杨桂玲,郑纪慈,王 强. 施肥对土壤及黄瓜中稳定性氮同位素丰度的影响［J］. 核农学报, 2010, 24(1): 108－113

[47] Evans R D, Physiological mechanisms influencing plant nitrogen isotope composition［J］. Trends in Plant Science, 2001, 6(3): 121-126

[48] Camin F, Perini M, Bontempo L, Fabroni S, Faedi W, Magnani S, Baruzzi G, Bonoli M, Tabilio M R, Musmeci S. Potential isotopic and chemical markers for characterising organic fruits［J］. Food Chemistry, 2011, 125: 1072-1082

[49] Sturm M, Kacjan-Mar I N, Lojen S. Can $\delta^{15}N$ in lettuce tissues reveal the use of synthetic nitrogen fertiliser in organic production?［J］. J.Sci.Food Agric, 2011, 91: 262-267

[50] Robinson D. $\delta^{15}N$ as an integrator of the nitrogen cycle［J］. Trends in Ecology Evolution, 2001, 16: 153-162

本刊中的类似文章

1．寇长林,徐建生,王恒宇.砂质潮土冬小麦对氮肥的利用与氮素平衡[J]. 核农学报, 2003,17(06): 476-480

2．尚兴甲,王梅芳,张兰稳,孔繁华,王淑杰,陈建中.冬小麦不同时期追施尿素的效果[J]. 核农学报, 2003,17(06): 485-487

3．党廷辉,蔡贵信,郭胜利,郝明德,王百群.用~(15)N标记肥料研究旱地冬小麦氮肥利用率与去向[J]. 核农学报, 2003,17(04): 280-285

4．巨晓棠,潘家荣,刘学军,陈新平,张福锁,毛达如.高肥力土壤冬小麦生长季肥料氮的去向研究 Ⅰ.冬小麦生长季肥料氮的去向[J]. 核农学报, 2002,16(06): 397-402

5．李世娟,周殿玺,兰林旺.不同水分和氮肥水平对冬小麦吸收肥料氮的影响[J]. 核农学报, 2002,16(05): 315-319

6．李长洪,李华兴,张新明,刘远金.用~(15)N同位素稀释法研究沸石对氮肥利用率的影响[J]. 核农学报, 2002,16(04): 237-241

7．王才斌,成波,孙秀山,郑亚萍,陈殿绪.应用~(15)N研究小麦花生两熟制氮肥分配方式对小麦、花生产量及N肥利用率的影响[J]. 核农学报, 2002,16(02): 98-102

8．齐孟文,王念萍,彭根元,石定燧,杨茁萌,安沙舟.鲁梅克斯K-1杂交酸模的施氮模型选择及氮肥推荐[J]. 核农学报, 2001,15(06): 351-354

9．齐孟文,王念萍,彭根元,石定燧,杨茁萌,安沙舟.氮肥水平对鲁梅克斯K-1杂交酸模氮素利用和氮素平衡的影响[J]. 核农学报, 2001,15(05): 298-301

10．王百群,张卫,余存祖.用~(15)N示踪法研究不同土壤水分条件下小麦对氮的吸收利用[J]. 核农学报, 1999,13(06): 362-367

11．周克瑜,施书莲,杜丽娟,曹亚澄,孙国庆,邢光熹.豆科固氮植物植株茎叶、根和根瘤的δ~(15)N值变异[J]. 核农学报, 1998,12(02): 0-0

12．许宁.不同施氮水平对茶树~(14)C-同化产物积累与分配的影响[J]. 核农学报, 1997,11(03): 0-0

13．余美炎，申秀珍，王奎波，王同燕，陈学留，王志芬.高产小麦施肥效应的研究[J]. 核农学报, 1994,8(01): 0-0

14． 樊红柱, 曾祥忠, 吕世华.水稻不同移栽密度的氮肥效应及氮素去向[J]. 核农学报, 2009,23(4): 681-685

15．刘启鑫,聂光明.不同播期下低芥酸油菜利用氮肥的研究[J]. 核农学报, 1992,6(01): 23-28