



April 2014 News from the International Biochar Initiative

IBI Releases First Annual *State of the Biochar Industry Report*

IBI is pleased to announce the recent release of the first-ever State of the Biochar Industry report which provides a broad overview of the current state of the biochar sector as identified by surveys and other data throughout 2013. The report provides experts and laypeople a snapshot of commercial and non-commercial biochar operations and activities. Our findings confirm some early successes in biochar commercialization are evident and a biochar supply chain has emerged—from equipment manufacturers to biochar purveyors to production and use consultants.

The report's findings are based primarily on information gathered through public surveys and internet based research, but also on accumulated knowledge of the present biochar landscape offered by IBI, the report authors, and contributors to this report. It is IBI's intent to produce this report on an annual basis to continue to track trends and growth in the biochar industry—both on the commercial as well as the project side.

To download and read the report, including a 4-page summary and a database of 175 global biochar companies, please see: http://www.biochar-international.org/State_of_industry_2013.

Progress Made Towards Finalizing *IBI Biochar Standards Version 2.0 for Public Review*

IBI is making progress towards amending the proposed policy revisions to the *IBI Biochar Standards Version 2.0* based on the substantive feedback received during the two webinars hosted by IBI in March and the 30 day public comment period. As a reminder, the four proposed policy revisions deal with biochar weathering, post-processing, sampling, and the use of biomass ash from bioenergy production facilities. Recordings of both webinars as well as presentation slides are available at <http://www.biochar-international.org/characterizationstandard>.

In the coming weeks, IBI will finalize changes to the draft V2.0, seek clarifying information from experts where necessary, and then post the amended proposed revisions and a final draft V2.0 for public review and comment by IBI membership. At that time we will also publish a summary and tally of all comments received during the public comment period and webinars including an IBI response to each comment. IBI welcomes all feedback on the proposed revisions—**available for review here** [hyperlink http://www.biochar-international.org/sites/default/files/Public_Comment_IBI_Biochar_Standards_V2.0%20clean.pdf]-as well as general comments on the *IBI Biochar Standards* and invites you to email us your thoughts to standards@biochar-international.org. We are grateful for the constructive feedback received from our members, stakeholders, and the biochar community in this important effort to support the growing biochar industry.

Consider Certifying your Biochar with IBI

Do you manufacture your own biochar? Do you want to provide quality and safety assurances to your biochar customers? Are you based in the United States or Canada? If so, the *IBI Biochar Certification Program* is for you! Based on the *IBI Biochar Standards*—a guiding document that provides the tools needed to universally and consistently define what biochar is, and to confirm that a product intended for sale or use as biochar possesses the necessary characteristics for safe use—we are confident that the *IBI Biochar Certification Program* is a defining step in creating a biochar industry.

The program, designed to assert the highest level of quality and safety, is accessible to a range of biochar manufacturers. Whether you are an existing manufacturer eager to differentiate your product in the marketplace by achieving IBI Biochar Certification for your biochar, or are simply paying close attention to the program's evolution, begin your path to IBI Biochar Certification today by accessing the *IBI Biochar Certification Program* webpage (link to: <http://www.biochar-international.org/certification>) which contains the necessary information to help you register your biochar, test it, and submit an application to receive IBI Biochar Certification of your product.

Update on the ACR Methodology for Emissions Reductions from Biochar Projects

The [voluntary carbon offset Methodology for Emissions Reductions from Biochar Projects](#) is advancing through the review process with Winrock International's American Carbon Registry (ACR). Following on the public comment period and responses by the methodology development team—comprised of The Climate Trust, The Prasino Group, and IBI—earlier this year, the revised version of the methodology is now undergoing scientific peer review by a panel convened by ACR. The team will respond to at least two rounds of comments from the panel and expects to begin an initial round of responses by late April. Upon completion of the peer review and approval by ACR, the final methodology will be published on ACR's website and will then be available for use by project proponents. For more information on the methodology please visit ACR's website [link to: <http://americancarbonregistry.org/carbon-accounting/methodology-for-biochar-projects>] or contact IBI at info@biochar-international.org.

IBI Business and Organization Member Profiles

A listing of all current IBI [Business](#) and [Organization](#) Members can be found on our website. For more information on membership opportunities and benefits, or to join, please see: <http://www.biochar-international.org/join>. Please note, Business and Organization descriptions are submitted by each individual entity, and are not developed or written by IBI.

Renewing Business Member: **Rainbow Bee Eater (RBE)**

The Rainbow Bee Eater (RBE) System aims to deliver cost competitive 'carbon negative' gas and/or electrical energy in regional areas using renewable agricultural residues such as wheat straw. The RBE System converts biomass into a clean syngas and high quality biochar using a modern continuous pyrolysis process. RBE's research, development, and demonstration plant commenced operations on a 25,000 ha wheat farm in the Western Australian wheat belt in 2013. RBE works with independent researchers on the application and impact of biochar in agricultural, horticultural, and forestry practices. For more information or to discuss biochar research and demonstration activities contact info@rainbowbeeeater.com.au or see the website at: <http://www.rainbowbeeeater.com.au>.



Profile: Typhoon Ketsana survivor makes a lifetime commitment to increase sustainability through biochar and gasifier stoves

Typhoon Ketsana hit the Philippines on the morning of September 26, 2009; an event which was both terrifying and life changing for a University of Santo Tomas Instructor (and IBI Advisory Committee member), Neil Ian P. Lumanlan. Lumanlan thought it was the end of his life as he watched floodwaters rise to the roof of a neighbor's house and experienced his city, Marikina, flood with ten feet of water. Though elevated, his apartment had water up to the waist, his wife and child were trapped in a hospital a few blocks away, and his car was submerged. At 11 pm that night, he waded through extremely cold and neck deep water to bring supplies to his wife and child at the hospital and then returned to his apartment. Lumanlan was sleepless through the night, and tossed and turned wondering what he, as an individual, could do to fight climate change to reduce the likelihood of further severe weather events.

In the aftermath of the typhoon, more than 100 people died in the city of Marikina. The waters left dead animals, mud, and sewage in the streets and houses, and the Department of Health declared a breakout of leptospirosis in the city. The devastation and trauma he experienced during typhoon Ketsana in the Philippines made him ask the question: "What will happen to my children if we Filipinos do nothing about climate change?"

Lumanlan did some research and spent his summer vacations from 2010 to 2012 learning more about gasifier stoves and biochar. He found that making biochar was not only a great learning experience but also fit into his love for more sustainable gardening. Lumanlan started mixing biochar with bokashi compost and vermicast and used this mixture on his flowers and vegetables. An instructor of undergraduate Environmental science, he integrated gasifier stoves and biochar in teaching sustainability to accounting majors to introduce them to new technologies. As a supporter of the University of Santo Tomas' community development efforts, he saw the problems facing rural farmers—diminishing forests, eye and respiratory problems, pesticide polluted waterways, and poverty associated with an inability to compete with imported cash crops and requirements of purchasing fertilizers.

With this understanding, Lumanlan started the GreenStoVes project to help typhoon affected areas become less reliant on external imports. As a student project, Neil taught students basic "tincanium" stove building; stoves were made of used food tin cans and paint cans. Lumanlan first introduced rocket stoves (using the model of Larry Winiarsky) and donated them to farmers who were still relying on open fires for cooking food. There was great enthusiasm, especially among the women, who saw the smokeless stoves that could utilize a variety of feedstocks. It was a great tool in explaining the connections between traditional stoves and deforestation, agriculture and climate change, as well as indoor air pollution and health risks among women and children. He then started introducing basic gasifier stoves that produced biochar and taught organic and natural farming techniques, including the use of microbial inoculants and bokashi composting to divert farmers from burning crop wastes and a reliance on fertilizers. In addition to bokashi composting to prevent air pollution from burning of crop wastes and charcoal making, Lumanlan



wants to promote briquetting of urban yard wastes to provide non-wood fuel to poor communities in the city of Marikina so they have more options for heating and cooking. Lumanlan believes that all these steps can start helping the people in his country, both urban and rural, not only lessen their contribution to climate change, but help them survive when more devastating events occur.

For more information on this work or to contact Lumanlan, please email Neil at neilian_ust@yahoo.com

Biochar Briefs: News Roundup for April

We update the website daily with new articles on biochar. For more information, please see: <http://www.biochar-international.org/newsbriefs>.

Australia

Energy Farmers Australia is a biochar technology company based in Western Australia which was founded four years ago by agriculturalist Euan Beamont and his engineer business partner Tom Vogan to improve energy efficiency and waste management on agricultural land. They have developed and built a prototype pyrolysis kiln which is auger-fed and has passed Australian emissions standards. The company is looking to more widely scale their unit in the area and start providing biochar for agricultural purposes. (link to: <http://phys.org/news/2014-04-western-australian-company-biochar-farms.html>)

New Zealand

New Zealand farmer Peter Yealands has an array of sustainable and innovative designs at his farm. For instance, he has imported 30 endangered mini-sheep from Australia to graze more than 4000 km of "vine road" where he grows wine grapes. The sheep are too small to reach the grapes themselves, so can both help weed and mow the rows between grapes and are large enough to fight off predators. Additionally, Yealands is using the grape marc (the skins and stalks of grapes once juice has been extracted) as a feedstock for producing biochar which is then used back in the soils as an amendment. (link to: <http://www.stuff.co.nz/business/farming/agribusiness/9889501/Farmer-of-the-Year-has-bold-ideas>).

United States

Dr. Ajay Nair, a horticulturist at Iowa State University, is focusing his research on biochar in perennial tree fruit systems. Says Nair (in a telephone interview with *Good Fruit Grower*), "We've found that soil does respond to the addition of biochar. It makes it lighter and fluffier, decreasing its bulk density and making it less susceptible to compaction." Nair has found little published research to-date on biochar use in perennial tree fruit systems and suggests that orchardists and grape growers might want to try it out for themselves on a small scale. (link to: <http://www.goodfruit.com/organic-matter-that-lasts>).

Opportunities in Biochar

- Job postings in biochar (as well as research/educational opportunities) can be accessed at: <http://www.biochar-international.org/network/jobs>.
- Submit an abstract to the Special Symposium on "Biochar: Production, Characterization and Applications" at CLEAR 2014 Conference, in Chuncheon, Korea, **due April 30**. For more information: <http://www.biochar-international.org/node/4827>.
- Submit an abstract to the 3rd Annual Global Conference on Environmental and Water Resources Management, Climate Change, and Energy in the UK, **due April 30**. For more information: <http://www.biochar-international.org/node/4774>.

- Contribute to the *Biology and Fertility of Soils* special issue with your research on biochar. For more information, see the website of the Mediterranean Biochar Symposium: <http://www.meditbiochar.org/index.html>. Submissions **due May 31**.
- Looking for potential grant funding? Check out the Terra Viva Grants Directory which develops and manages information about grants for agriculture, energy, environment, and natural resources in the world's developing countries at: <http://www.terravivagrants.org/Home>.

Attend a Biochar Training Course for Environmental Sustainability and Economic Development, June 26 – 28, 2014 in Santiago de Compostela, Spain

This course intends to provide an in-depth understanding of biochar for a target audience of government officials, policy makers, financiers, and entrepreneurs in the European region. The course will provide an introductory high-level overview of biochar and biochar systems, covering production through to utilization. Specifically, the course will focus on production technologies, biochar characterization, standardization and certification; ability to address specific soil constraints and use in agricultural systems; biochar carbon accounting and climate change; commercialization and economics; and biochar sustainability issues, including potential risks and research gaps. For more information on this event, please see: http://www.biochar-international.org/Biochar_Spain_June_2014.

An Invitation to Submit Biochar Samples for a Raman Spectroscopy Survey of Biochar

John McDonald-Wharry, a doctoral student in Chemistry and Engineering at the University of Waikato in New Zealand, is studying the use of Raman spectroscopy to characterize the “effective heat treatment temperature” of biochars. The results of his work have been published and to help validate and extend this methodology, he would like to apply the technique to a wide range of biochars from diverse backgrounds—and is thus calling on the biochar community.

McDonald-Wharry seeks to have a broad range of biochar producers including companies, hobbyists, academic researchers, and other interested groups send a few biochar samples to him at the University of Waikato. There is no cost to the producer other than shipping. In exchange for sending a sample, participants will receive a copy of the results and an estimate of the “effective heat treatment temperature” based upon the current model. To read more about this effort and find information on how to submit a sample, please see: <http://www.biochar-international.org/node/5020>.

Announcing the Biochar Plus Project

The ACP Science and Technology Programme, with the financial support of the European Union, has co-financed a new biochar project which will be coordinated by the University of Udine (Italy). The project called "**ENERGY, HEALTH, AGRICULTURAL AND ENVIRONMENTAL BENEFITS FROM BIOCHAR USE: BUILDING CAPACITIES IN ACP COUNTRIES—Biochar Plus**" involves eight partners from seven countries and three distinguished international institutions as associated partners: UNIDO (Austria), the African Union (Ethiopia), and Cornell University (USA). *ACP countries include African, Caribbean, and Pacific Group of States.*

The main scope of the work includes:

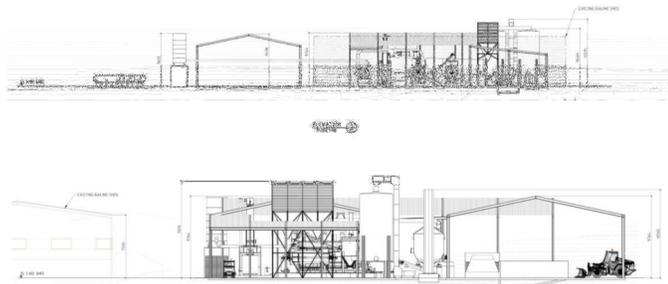
1. To create a network between all the activities/actors (in industrial, research, and agricultural sectors) who worked in the past or are to date involved in biochar research,

- experiments, field trials, etc—in all the activities related to advancing charcoal/biochar technology within the African Continent.
2. To describe the state of the art in biochar technology through databases, photos, presentations, maps, and videos. Interested parties can contact the organizers (info.biocharplus@gmail.com) and submit materials that may contribute to this goal.
 3. The organization of three international meetings for a bottom-up approach that will be held in western, eastern, and southern Africa and organization of a workshop for top-down actions which will include the three associated partners.

For more information on this work and how to get involved, please see: http://www.biochar-international.org/biochar_plus_project.

A Local Government Council in Australia seeks international interest in a biochar facility

The Ballina Shire Council is a small regional Council on the north Coast of sub-tropical New South Wales (NSW) Australia. They are proposing to proceed with the construction of a slow-pyrolysis facility to convert regionally-sourced municipal organic waste into biochar suitable for enhancing local agricultural soils. The Council is currently seeking interest from international technology and facility providers who might wish to be involved in the project.



In 2012, the Council was successful in attracting \$4.25 million in funding from the Commonwealth Government's "Regional Development Australia Fund" to build Australia's first large-scale commercial biochar manufacturing facility. The funding has provided the impetus to turn a five-year trial into a commercial operation involving the processing of up to 29,000 (wet) tonnes per year of the region's organic waste.

This project is designed to optimize economic and environmental outcomes through the conversion of waste streams from Council operations into biochar and electricity. Trials have been conducted in collaboration with the NSW Department of Primary Industries at a demonstration plant using slow-pyrolysis technology. The aim of the trial was to determine the feasibility of using curbside-collected garden organics and food waste, self-haul garden organics, and bio-solids to produce a quality biochar product that could be marketed to local farmers.

The Council is now seeking registrations of interest from suitable international technology providers to become involved in the design and/or construction of this plant, and plans to begin construction of the plant within the next 12 months. Further information is available at www.ballina.nsw.gov.au or via email to ssmith@ballina.nsw.gov.au.

Upcoming Calendar Events

- April 27 – May 2: EGU 2014: "Strategies for effective soil carbon sequestration through synergies in pyrogenic carbon, charcoal and biochar research". Location: Vienna, Austria. For more information: <http://www.biochar-international.org/node/4612>.

- June 2 – 6, 2014: Woodpecker's Farm Biomass Energy Workshop. Location: Thornfield, MO, United States. For more information: <http://www.biochar-international.org/node/5036>.
- June 8 – 13: Biochar Symposium entitled "Biochar Soil Amendment for Environmental and Agronomic Benefits" at the 20th World Congress of Soil Science. Location: Seoul, Korea. For more information: <http://www.biochar-international.org/node/4494>.
- June 10 – 11: The International Conference on Agriculture and Forestry 2014 (ICOAF 2014). Location: Colombo, Sri Lanka. For more information: <http://www.biochar-international.org/node/5008>.
- June 15 – 20: 3rd Annual Global Conference on Environmental and Water Resources Management, Climate Change, and Energy. Location: London, UK. For more information: <http://www.biochar-international.org/node/4773>.
- June 22 – 27: The 10th International Symposium on Earthworm Ecology with a session "Earthworm interactions with biochar as a soil amendment". Location: Athens, Georgia, USA. For more information: <http://www.biochar-international.org/node/4743>.
- June 23 – 26: 22nd European Biomass Conference and Exhibition. Location: Hamburg, Germany. For more information: <http://www.biochar-international.org/node/4485>.
- June 26 – 28: ORBIT 2014 Conference on Biochar. Location: Gödöllő, Hungary. For more information: <http://www.biochar-international.org/node/4716>.

See the [IBI Calendar page](#) for more events. To add an event to the calendar, send the information to info@biochar-international.org.

Regional Group Updates

To read more on the 57 regional and national biochar groups, please see IBI's website (link to: <http://www.biochar-international.org/network/communities>). This month's regional update section contains news from the Biochar Interest Group in New Zealand (BIG-NZ).

Biochar Interest Group in New Zealand

BIG-NZ is an independent, voluntary group interested in the production and application of biochar in NZ. There are many new posts from April 2014 on their website including the opportunity to submit abstracts to local conferences, some news on biochar from around New Zealand and posted stories that pertain to the community. For more information, please see: <http://soilcarbon.org.nz>.

Recently Published Biochar Research

IBI tracks all published research on biochar and includes it in our [online bibliography](#). The following articles were added in the last month. Please visit the website bibliography for more information on any of these articles. Due to copyright infringement laws, we cannot provide full copies of articles unless we have permission from the publisher. If you have published work that is not included, [please email us](#).

Angst, Teri E.; Johan Six; Dave S. Reay; Saran P. Sohi (2014). Impact of pine chip biochar on trace greenhouse gas emissions and soil nutrient dynamics in an annual ryegrass system in California. *Agriculture, Ecosystems & Environment*.

Creamer, Anne Elise; Bin Gao; Ming Zhang (2014). Carbon dioxide capture using biochar produced from sugarcane bagasse and hickory wood. *Chemical Engineering Journal*.

Crombie, Kyle; Ondrej Mašek (2014). Pyrolysis biochar systems, balance between bioenergy and carbon sequestration. GCB Bioenergy.

Devi, Parmila; Anil K. Saroha (2014). Risk analysis of pyrolyzed biochar made from paper mill effluent treatment plant sludge for bioavailability & eco-toxicity of heavy metals. Bioresource Technology.

Dil M.; M. Oelbermann (2014). Evaluating the long-term effects of pre-conditioned biochar on soil organic carbon in two southern Ontario soils using the century model. Sustainable agroecosystems in climate change mitigation. Chapter 13.

Fang, Yunying (2014). Biochar Carbon stability in some contrasting soils from Australia. PhD Thesis University of Sydney, Faculty of Agriculture and Environment.

Hadjittofi, Loukia; Melpomeni Prodromou; Ioannis Pashalidis (2014). Activated Biochar Derived from Cactus Fibres – Preparation, Characterization and Application on Cu(II) Removal from Aqueous Solutions. Bioresource Technology.

Hamid, Sharifah Bee Abdul; Zaira Zaman Chowdhury; Sharifuddin Mohammad Zain (2014). Base Catalytic Approach: A Promising Technique for the Activation of Biochar for Equilibrium Sorption Studies of Copper, Cu(II) Ions in Single Solute System. Materials. 7, 2815-2832.

Hu, Junli; Fuyong Wu; Shengchun Wu; Cheung Lung Lam; Xiangui Lin; Ming Hung Wong (2014). Biochar and *Glomus caledonium* Influence Cd Accumulation of Upland Kangkong (*Ipomoea aquatica* Forsk.) Intercropped with Alfred Stonecrop (*Sedum alfredii* Hance). Scientific Reports 4, Article number: 4671.

Khan, Sardar; Brian J. Reid; Gang Li; Yong-Guan Zhu (2014). Application of biochar to soil reduces cancer risk via rice consumption: A case study in Miaoqian village, Longyan, China. Environment International. Volume 68, Pages 154–161.

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Lu, Huanping; Zhian Li; Shenglei Fu; Ana Méndez; Gabriel Gascó; Jorge Paz-Ferreiro (2014). Can Biochar and Phytoextractors Be Jointly Used for Cadmium Remediation? PLOS ONE; <http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0095218>.

Manyà, Joan Josep; Sergio Laguarda; Miguel A Ortigosa; and José A Manso (2014). Biochar from Slow Pyrolysis of Two-Phase Olive Mill Waste: Effect of Pressure and Peak Temperature on its Potential Stability. Energy Fuels.

Mia, S.; J.W. van Groenigen; T.F.J. van de Voorde; N.J. Oram; T.M. Bezemer; L. Mommer; S. Jeffery (2014). Biochar application rate affects biological nitrogen fixation in red clover conditional on potassium availability. Agriculture, Ecosystems & Environment.

Mukherjee, A., Lal, R., and Zimmerman, A. R. (2014). Impacts of biochar and other amendments on soil-carbon and 10 nitrogen stability: A laboratory column study. Soil Sci. Soc. Am. J.

Naeem, Muhammad Asif; Muhammad Khalid; Muhammad Arshad; Rashid Ahmad (2014). Yield and Nutrient Composition of Biochar Produced from Different Feedstocks at Varying Pyrolytic Temperatures. Pak. J. Agri. Sci., Vol. 5; <http://pakjas.com.pk/papers%5C2245.pdf>.

Oram, Natalie J.; Tess F.J. van de Voorde; Gert-Jan Ouweland; T. Martijn Bezemer; Liesje Mommer; Simon Jeffery; Jan Willem Van Groenigen (2014). Soil amendment with biochar

increases the competitive ability of legumes via increased potassium availability. *Agriculture, Ecosystems & Environment*.

Quin, P.R.; A.L. Cowie; R.J. Flavel; B.P. Keen; L.M. Macdonald; S.G. Morris; B.P. Singh; I.M. Young; L. Van Zwieten (2014). Oil mallee biochar improves soil structural properties—A study with x-ray micro-CT. *Agriculture, Ecosystems & Environment*.

Reddy, D. Harikishore Kumar and Seung-Mok Lee (2014). Magnetic biochar composite: Facile synthesis, characterization and application for heavy metal removal. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*.

Roth; Christa (2014). Micro-gasification: cooking with gas from dry biomass; An introduction to concepts and applications of wood-gas burning technologies for cooking. 2nd revised edition. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Programme; https://energypedia.info/images/4/48/2014-03_Micro_gasification_manual_GIZ_HERA_Roth.pdf.

Schimmelpfennig, Sonja; Christoph Müller; Ludger Grünhage; Christian Koch; Claudia Kammann (2014). Biochar, hydrochar and uncarbonized feedstock application to permanent grassland—Effects on greenhouse gas emissions and plant growth. *Agriculture, Ecosystems & Environment*.

Shan, Jun; Yongfeng Wang; Jianqiang Gu; Wenqiang Zhou; Rong Ji; Xiaoyuan Yan (2014). Effects of biochar and the geophagous earthworm *Metaphire guillelmi* on fate of ¹⁴C-catechol in an agricultural soil. *Chemosphere*. Volume 107, Pages 109–114.

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Tammeorg, Priit; Tuure Parviainen; Visa Nuutinen; Asko Simojoki; Elina Vaara; Juha Helenius (2014). Effects of biochar on earthworms in arable soil: avoidance test and field trial in boreal loamy sand. *Agriculture, Ecosystems & Environment*.

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Ubando, Aristotle T.; Alvin B. Culaba; Kathleen B. Aviso; Denny K. S. Ng; Raymond R. Tan (2014). Fuzzy mixed-integer linear programming model for optimizing a multi-functional bioenergy system with biochar production for negative carbon emissions. *Clean Technologies and Environmental Policy*.

Van Zwieten, L.; B.P. Singh; S.W.L. Kimber; D.V. Murphy; L.M. Macdonald; J. Rust; S. Morris (2014). An incubation study investigating the mechanisms that impact N₂O flux from soil following biochar application. *Agriculture, Ecosystems & Environment*.

Verhoeven, Elizabeth; Johan Six (2014). Biochar does not mitigate field-scale N₂O emissions in a Northern California vineyard: An assessment across two years. *Agriculture, Ecosystems & Environment*.

Viger, Maud; Robert D. Hancock; Franco Miglietta; Gail Taylor (2014). More plant growth but less plant defence? First global gene expression data for plants grown in soil amended with biochar. *GCB Bioenergy*.

Yin, Yun-feng; He Xin-hua; Gao Ren; Ma Hong-liang; Yang Yu-sheng (2014). Effects of Rice Straw and Its Biochar Addition on Soil Labile Carbon and Soil Organic Carbon. *Journal of Integrative Agriculture*.

Zheng, Qing-fu; Wang Yong-he, Sun Yue-guang, Niu He-he, Zhou Jia-ru, Wang Zhi-min, Zhao Ji (2014). Study on Structural Properties of Biochar under Different Materials and Carbonized by FTIR. *Spectroscopy and Spectral Analysis*.