

## REFERENCES

- Abd Elhamid, E.M., Sadak, M.S., Ezzo, M.I., & Abdalla, A.M. 2021. Impact of glycine betaine on drought tolerance of *Moringa oleifera* plant grown under sandy soil. *Asian J. Plant Sci*, 20: 578–589.
- Abdel-Fattah, T.M., Mahmoud, M.E., Ahmed, S.Bi., Huff, M.D., Lee, J.W., & Kumar, S. 2015. Biochar from woody biomass for removing metal contaminants and carbon sequestration. *Journal of Industrial and Engineering Chemistry*, 22:103-109. DOI 10.1016/j.jiec.2014.06.030.
- Achard P, Gong FS, Alioua M, Hedden P, & Genschik P. 2008. The cold-inducible CBF1 factor-dependent signaling pathway modulates the accumulation of the growth-repressing DELLA proteins via its effect on gibberellin metabolism. *Plant Cell*. 2008; 20(8):2117–2129. doi: 10.1105/tpc.108.058941 PMID: 18757556.
- Achard, P., Cheng, H., De Grauwe, L., Decat, J., Schoutteten, H., Moritz, T., et al. 2006. Integration of plant responses to environmentally activated phytohormonal signals. *Science*. 2006; 311(5757):91–94. PMID: 16400150
- Agegnehu, G., Bass, A. M., Nelson, P. N., & Bird, M. I. 2016. Benefits of biochar, compost and biochar-compost for soil quality, maize yield and greenhouse gas emissions in a tropical agricultural soil. *Science of the Total Environment*, 543, 295–306. <https://doi.org/10.1016/j.scitotenv.2015.11.054>
- Aiswal, A.K., Elad, Y., Gräber, E.R., & Frenkel, O. 2014. *Rhizoctonia solani* suppression and plant growth promotion in cucumber as affected by biochar pyrolysis temperature, feedstock and concentration. *Soil Biol Biochem* 69:110-118
- Allan, W. L., Clark, S. M., Hoover, G. J., & Shelp, B. J. 2009. Role of plant glyoxylate reductases during stress: A hypothesis. In *Biochemical Journal* (Vol. 423, Issue 1, pp. 15–22). <https://doi.org/10.1042/BJ20090826>.
- Amelung, W. 2001. Methods using amino sugars as markers for microbial residues in soils. In: Lal R, Kimble JM, Follett RF, Stewart BA (eds) *In Assessment methods for soil carbon*. Lewis Publishers, Boca Raton, pp 233–270.

- Amiour, N., Imbaud, S., Clement, G., Agier, N., Zivy, M., Valot, B., et al. 2012. The use of metabolomics integrated with transcriptomic and proteomic studies for identifying key steps involved in the control of nitrogen metabolism in crops such as maize. *J Exp Bot.* 63: 5017±5033. <https://doi.org/10.1093/jxb/ers186> PMID: 22936829
- Anandyawati, Sumarsih, E., Nugroho, B., & Widyastuti, R. 2017. Study of Root Exudate Organic Acids and Microbial Population in the Rhizosphere of Oil Palm Seedling. *Journal of Tropical Soils*, 22(1), 29–36. <https://doi.org/10.5400/jts.2017.v22i1.29-36>
- Angst, T. E., Six, J., Reay, D. S., & Sohi, S. P. 2014. Impact of pine chip biochar on trace greenhouse gas emissions and soil nutrient dynamics in an annual ryegrass system in California. *Agriculture, Ecosystems and Environment*, 191, 17–26. <https://doi.org/10.1016/j.agee.2014.03.009>
- Ankati S, & Podile AR. 2019. Metabolites in the root exudates of groundnut change during interaction with plant growth promoting rhizobacteria in a strain-specific manner. *Journal of Plant Physiology* 243:153057. DOI: <https://doi.org/10.1016/j.jplph.2019.153057>, PMID: 31675630.
- Appuhn, A. & Joergensen, R.G., 2006. Microbial colonisation of roots as a function of plant species. *Soil Biology & Biochemistry* 38, 1041–1051.
- Aqil, M. 2012. Deskripsi varietas unggul jagung. Balai Penelitian Tanaman Serealia, Badan Penelitian dan Pengembangan Pertanian: Bogor.
- Aqil, M., & Arvan, R.Y. 2016. Deskripsi varietas unggul jagung. Balai Penelitian Tanaman Serealia, Badan Penelitian dan Pengembangan Pertanian: Bogor.
- Aranjuelo I., Tcherkez G., Molero G., Gilard F., Avise J. & Nogués S. 2013. Concerted changes in N and C primary metabolism in alfalfa (*Medicago sativa*) under water restriction. *Journal of Experimental Botany* 64, 885-897.
- Arruda, P., Kemper, E. L., Papes, F., & Leite, A. 2000. Regulation of lysine catabolism in higher plants. *Trends Plant Sci.* 5:324-330.
- Arthur, L.L., karen, L.C., sherry, L.G., & James, A.B. 1983. Glyoxylate and Glutamate Effects on Photosynthetic Carbon Metabolism in Isolated Chloroplasts and Mesophyll Cells of Spinach. *Plant Physiol.* 72, 420-425.

- Ashraf, M. & Foolad, M.R. 2007. Roles of glycine betaine and proline in improving plant abiotic stress resistance. *Environ. Exp. Bot.* 59, 206–216.
- Askeland, M., Clarke, B., & Paz-Ferreiro, J. 2019. Comparative characterization of biochars produced at three selected pyrolysis temperatures from common woody and herbaceous waste streams. *PeerJ*, 7. <https://doi.org/10.7717/peerj.6784>
- Astafieva, A.A., Enyenihi, A.A., Rogozhin, E.A., Kozlov, S.A., Grishin, E.V., Odintsova T.I., et al. 2015. Novel proline-hydroxyproline glycopeptides from the dandelion (*Taraxacum officinale* Wigg.) flowers: de novo sequencing and biological activity. *Plant Sci.* 238:323–9. <https://doi.org/10.1016/j.plantsci.2015.07.002>.
- Atakora, W.K., Kwakye, P.K., Weymann, D., & Brüggemann, N. 2019. Stimulus of nitrogen fertilizers and soil characteristics on maize yield and nitrous oxide emission from Ferric Luvisol in the Guinea Savanna agro-ecological zone of Ghana. *Sci. Afr.* 6: e00141. <https://doi.org/10.1016/j.sciaf.2019.e00141>.
- Azargohar, R., Jacobson, K.L., Powell, E.E., & Dalai, A.K. 2013. Evaluation of properties of fast pyrolysis products obtained from Canadian waste biomass. *Journal of Analytical and Applied Pyrolysis* 104:330\_340 DOI 10.1016/j.jaap.2013.06.016.
- AzizM-TJ & LarherF. 1999. Salt stress-induced proline accumulation and changes in tyramine and polyamine levels are linked to ionic adjustment in tomato leaf discs. *Plant Sci.* 145:83-91; [http://dx.doi.org/10.1016/S0168-9452\(99\)00071-0](http://dx.doi.org/10.1016/S0168-9452(99)00071-0).
- Badan Pusat Statistik (BPS-Statistic Indonesia). 2014. Jakarta
- Badan Pusat Statistik (BPS-Statistic Indonesia). 2018 Jakarta
- Badan Pusat Statistik (BPS-Statistic Indonesia). 2020. Analisis produktivitas jagung dan kedelai di Indonesia 2020 (Hasil survei ubinan) [Analysis of maize and soybean productivity in Indonesia (the result of crop cutting survey)]. Badan Pusat Statistik (Sttaistic Indonesia): Jakarta.

- Badan Pusat Statistik (BPS-Statistic Indonesia). 2021. Buletin statistik perdagangan luar negeri (Foreign trade statistical bulletin). Badan Pusat Statistik (Statistis Indonesia): Jakarta.
- Badri, D.V., & Vivanco, J.M. 2009. Regulation and function of root exudates. *Plant, Cell and Environment* (2009) 32, 666–681.
- Bai, M., Zeng, W., Chen, F., Ji, X., Zhuang, Z., Jin, B., Wang, J., Jia, L., Peng, Y. 2022. Transcriptome expression profiles reveal response mechanisms to drought and drought-stress mitigation mechanisms by exogenous glycine betaine in maize. *Biotechnol. Lett.* 44, 367–386.
- Bai, Z., BodéS, H.D., Zhang, X.D., Boeckx, P. 2013. Kinetics of amino sugar formation from organic residues of different quality. *Soil Biol Biochem* 57:814–821.
- Bais, H.P., Weir, T.L., Perry, L.G. et al. 2006. The role of root exudates in rhizosphere interactions with plants and other organisms. *Annu Rev Plant Biol* . 57:233–66.
- Ball, P.N., Mackenzie, M.D., Deluca, T.H. et al (2010) Wildfire and charcoal enhance nitrification and ammonium-oxidizing bacterial abundance in dry montane forest soils. *J Environ Qual* 39:1243–1253
- Bantacut, T. & Pradifta, J. 2018. Nitrogen cycling in Indonesian agriculture around 1968 to 2008 and its environmental impacts. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan (Journal of Natural Resources and Environmental Management)*. 8(3): 308–318. <https://doi.org/10.29244/jpsl.8.3.308-318>.
- Barbour, W. M., Hattermann, D. R., & Stacey, G. 1991. Chemotaxis of *Bradyrhizobium japonicum* to soybean exudates. *Appl. Environ. Microbiol.* 57, 2635–2639.
- Baronti S, Alberti G, DelleVedove G et al. 2010. The biochar option to improve plant yields: first results from some field and pot experiments in Italy. *Italian Journal of Agronomy*, 5,3–11.
- Bashan, Y., & Holguin, G. 1997. Azospirillum-plant relationships: environmental and physiological advances, *Can. J. Microbiol.* 43:103–121.
- Benavente, I., Gascó, G., Plaza, C., Paz-Ferreiro, J., & Méndez, A. 2018. Choice of py-rolysis parameters for urban wastes affects soil enzymes and plant

germination in a Mediterranean soil. *Science of the Total Environment* 634:1308\_1314 DOI 10.1016/j.scitotenv.2018.04.120.

Bender, R.A. 2012 Regulation of the histidine utilization (hut) system in bacteria. *Microbiol Mol Biol Rev* 76:565–584

Berg, G.M. & Jorgensen, N.O.G. 2006. Purine and pyrimidine metabolism by estuarine bacteria. *Aquat Microb Ecol*, Vol. 42: 215–226.

Bernards, M. A. 2010. Plant natural products: A primer, *Can. J. Zool.*, vol. 88, pp. 601– 614. doi: 10.1139/Z10-035.

Bertin, C., Yang, X., & Weston, L.A. 2003. The role of root exudates and allelochemicals in the rhizosphere. *Plan and soil* 256: 67-83.

Bhuvaneswari, K. & Sulochana, C. B., 1956. Assay of root exudates. *Curr. Sci.* 24, 376-377.

Biederman, L. A., & Stanley Harpole, W. 2013. Biochar and its effects on plant productivity and nutrient cycling: A meta-analysis. *GCB Bioenergy*, 5(2), 202–214. <https://doi.org/10.1111/gcbb.12037>

Bin-feng SUN, ZHAO Hong, LÜ Yi-zhong, LU Fei, WANG Xiao-ke. 2016. The effects of nitrogen fertilizer application on methane and nitrous oxide emission/uptake in Chinese cropland. *Journal of Integrative Agriculture*, 15 (2): 440-450

Bollmann, A., and Conrad, R. 1998. Influence of O<sub>2</sub> availability on No and N<sub>2</sub>O release by nitrification and denitrification in soils. *Global Change Biology* (1998) 4: 387-396.

Bourdin B, Adenier H, Perrin Y (2007) Carnitine is associated with fatty acid metabolism in plants. *Plant Physiol Biochem* 45:926–931. <https://doi.org/10.1016/j.plaphy.2007.09.009>

Bowatte, S., Newton, P. C. D., Hoogendoorn, C. J., Hume, D. E., Stewart, A. V., Brock, S. C., & Theobald, P. W. (2016): Wide variation in nitrification activity in soil associated with different forage plant cultivars and genotypes. *Grass and Forage Science*, 71(1): 160–171. <https://doi.org/10.1111/gfs.12175>.

Bremner JM, McCarty GW. 1993. Inhibition of nitrification in soil by allelochemicals derived from plants and plant residues. *Soil Biochem* 8:181–218

- Britto, D. T., & Kronzucker, H. J. 2004. Bioengineering nitrogen acquisition in rice: Can novel initiatives in rice genomics and physiology contribute to global food security? *BioEssays*, 26(6), 683–692. <https://doi.org/10.1002/bies.20040>
- BUGG, T. D. H., AND C. T. WALSH. 1992. Intracellular steps of bacterial cell wall peptidoglycan biosynthesis—Enzymology, antibiotics, and antibiotic resistance. *Natural Product Reports* 9 : 199 – 215 .
- Butterbach-Bahl, K., and Dannenmann, M. 2011. Denitrification and associated soil N<sub>2</sub>O emissions due to agricultural activities in a changing climate. *Current Opinion in Environmental Sustainability*, 3:389–395.
- Byrnes, R.C., Nùñez, J., Arenas, L., Rao, I., Trujillo, C., Alvarez, C., Arango, J., Rasche, F., Chirinda, N., 2017. Biological nitrification inhibition by *Brachiaria* grasses mitigates soil nitrous oxide emissions from bovine urine patches. *Soil Biology & Biochemistry* 107 (2017) 156-163.
- C.H. Cheng, J. Lehmann, J.E. Thies, S.D. Burton, & M.H. Engelhard. 2006. Oxidation of black carbon by biotic and abiotic processes, *Org. Geochem.* 37 : 1477–1488.
- Campbell, W. J. & Ogren, W. L. 1990. Glyoxylate inhibition of ribulose bisphosphate carboxylase/oxygenase activation in intact, lysed, and reconstituted chloroplasts. *Photosynth. Res.* 23, 257–268
- Cañas, R.A., Amour, N., Quilleré, I., & Hirel, B. 2011. An integrated statistical analysis of the genetic variability of nitrogen metabolism in the ear of three maize inbred lines (*Zea mays* L.). *J. Exp. Bot.* 62: 2309–2318. <https://doi.org/10.1093/jxb/erq373>.
- Caputo, C & Barneix, A. J. 1997. Export of amino acids to the phloem in relation to N supply in wheat. *Physiol. Plant.* 101, 853–860. doi: 10.1111/ j.1399-3054.1997.tb01073.x
- Carvalhais, L. C., Dennis, P. G., Fedoseyenko, D., Hajirezaei, M. R., Borriss, R., & von Wirén, N. (2011). Root exudation of sugars, amino acids, and organic acids by maize as affected by nitrogen, phosphorus, potassium, and iron deficiency. *Journal of Plant Nutrition and Soil Science*, 174(1), 3–11. <https://doi.org/10.1002/jpln.201000085>

- Cayuela, M. L., van Zwieten, L., Singh, B. P., Jeffery, S., Roig, A., & Sánchez-Monedero, M. A. 2014. Biochar's role in mitigating soil nitrous oxide emissions: A review and meta-analysis. *Agriculture, Ecosystems and Environment*, 191, 5–16. <https://doi.org/10.1016/j.agee.2013.10.009>
- Cayuela, M.L., Zwieten, L.V., Singh, B.P., Jeffery, S., Roig, A., Sánchez-Monedero, &M. 2013. Biochar's role in mitigating soil nitrous oxide emissions: A review andmeta-analysis. *Agriculture, Ecosystems & Environment* 191: 5–16.
- Chen, F.J., Fang, Z.G., Gao, Q., Ye, Y.L., Jia, L.L., Yuan, L.X., Mi, G.H., & Zhang, F.S. 2013. Evaluation of the yield and nitrogen use efficiency of the dominant maize hybrids grown in North and Northeast China. *Sci. China Life Sci.* (2013) 56: 552–560. <https://doi.org/10.1007/s11427-013-4462-8>.
- Chen, X., Cui, Z., Fan, M., Vitousek, R., Zhao, M., Ma, W., Wang, Z., Zhang, W., Yan, X., Yang, J., Deng, X., Gao, Q., Zhang, Q., Guo, S., Ren, J., Li, S., Ye, Y., Wang, Z., Huang, J., Tang, Q., Sun, Y., Peng, X., Zhang, J., He, M., Zhu, Y., Xue, J., Wang, G., Wu, L., An, N., Wu, L, Ma, L, Zhang, W., & Zhang, F., 2014. Producing more grain with lower environmental costs. *Nature* 514, 486-491.
- Chu, Q., Sha, Z., Maruyama, H., Yang, L., Pan, G., Xue, L., & Watanabe, T. 2019. Metabolic reprogramming in nodules, roots, and leaves of symbiotic soybean in response to iron deficiency. *Plant Cell and Environment*, 42(11), 3027–3043. <https://doi.org/10.1111/pce.13608>
- Clarke, V.C., Loughlin, P.C., Day, D.A., Smith, P.M.C. 2014. Transport processes of the legume symbiosome membrane. *Front Plant Sci* 5: 699.
- Cooper, H.D. & Clarkson, D.T. 1989. Cycling of amino nitrogen and other nutrients between shoots and roots in cereals: a possible mechanism integrating shoot and root in the regulation of nutrient uptake. *Journal of Experimental Botany* 40, 753–762.
- Coskun, D., Britto, D. T., Shi, W., & Kronzucker, H. J. 2017. Nitrogen transformations in modern agriculture and the role of biological nitrification inhibition. *Nature Plants*, 3(June), 1–10. <https://doi.org/10.1038/nplants.2017.74>
- Csonka, L.N. & Hanson, A.D. 1991. Prokaryotic osmoregulation: Genetics and physiology. *Annu. Rev. Microbiol.* 45:569–606.

- Dai, X.Y., Ping, C.L., Hines, M.E., Zhang, X.D., Zech, W. 2002. Amino sugars in arctic soils. *Communications in Soil Science and Plant Analysis* 33, 789–805.
- Dakora, F. D. & Phillips, D. A. 2002. Root exudates as mediators of mineral acquisition in low-nutrient environments. *Plant Soil* 245, 35–47. doi: 10.1023/a:1020809400075.
- Das, O. & Sarmah, A.K. 2015. The love\_hate relationship of pyrolysis biochar and water: a perspective. *Science of the Total Environment* 512:682\_685.
- Davies, B., Coulter, J. A., & Pagliari, P. H. 2020. Timing and rate of nitrogen fertilization influence maize yield and nitrogen use efficiency. *PLoS ONE*. 15(5). <https://doi.org/10.1371/journal.pone.0233674>.
- Davis, L. C. & W. H. Orme-Johnson. 1976. Nitrogenase IX: effect of the MgATP generator on the catalytic and EPR properties of the enzyme in vitro. *Biochim. Biophys. Acta* 452:42-58.
- Dayanand, C.D., Krishnamurthy, N., Ashakiran, S., & Shashidhar, K.N. 2011. Carnitine: a novel health factor—an overview. *Int J Pharm Biomed Res* 2:79–89 Frank JA, Moroni.
- De Gryze, S., Cullen, M., & Durschinger, L. 2010: Evaluation of the opportunities for generating carbon offsets from soil sequestration of biochar. Issues paper commissioned by the Climate Action Reserve. Terra Global Capital, San Francisco, CA, USA.
- De Vries, W., Van der Salm, C., Reinds, G.J., & Erisman, J.W. 2007. Element fluxes through European forest ecosystems and their relationships with stand and site characteristics. *Environ. Pollut.* 148: 501–513. <https://doi.org/10.1016/j.envpol.2006.12.001>.
- De Vries, W., van der Salm, C., Reinds, G.J., & Erisman, J.W. 2007. Element fluxes through European forest ecosystems and their relationships with stand and site characteristics. *Environ. Pollut.* 148(2), 501–513. doi:10.1016/j.envpol.2006.12.001
- Delgado, J.A., Shaffer, M., Hu, C., Lavado, R., Cueto-Wong, J., Joosse, P., Sotomayor, D., Colon, W., Follett, R., DelGrosso, S., Li, X., & Rimski-Korsakov, H. 2008. An index approach to assess nitrogen losses to the

environment. Ecol. Eng. 32: 108–120.  
<https://doi.org/10.1016/j.ecoleng.2007.10.006>.

- DeMoll, E. & Auffenberg, T. 1993. Purine metabolism in *Methanococcus vannielii*. *J Bacteriol* 175:5754–5761
- Deng, Q., Hui, D. F., Wang, J. M., Iwuozo, S., Yu, C. L., Jima, T., Smart, D., Reddy, C., & Dennis, S. 2015. Corn yield and soil nitrous oxide emission under different fertilizer and soil management: a three-year field experiment in Middle Tennessee, *PLoS ONE* 10(4): 14.
- Deng, Q., Hui, D., Wang, J., Yu, C., Li, C., Reddy, K.C., & Dennis, S. 2016. Assessing the impact of tillage and fertilization management on nitrous oxide emission in a cornfield using the DNDC model. *Journal of Geophysical Research: Biogeosciences.*, 121, 337-349.
- Derrien, D., Marol, C., Balesdent, J. 2004. The dynamics of neutral sugars in the rhizosphere of wheat. An approach by <sup>13</sup>C pulse-labelling and GC/C/IRMS. *Plant Soil* 267:243– 253. <https://doi.org/10.1007/s11104-005-5348-8>.
- Dhaniaputri, R., Suwono, H., Amin, M., & Lukiaty, B. 2022. Introduction to Plant Metabolism, Secondary Metabolites Biosynthetic Pathway, and In-Silico Molecular Docking for Determination of Plant Medicinal Compounds: An Overview.
- Dias, G.B., Gomes, V.M., Pereira, U.Z, Ribeiro, S.F.F., Carvalho, A.O, Rodrigues., R, et al. 2013. Isolation, characterization and antifungal activity of proteinase inhibitors from *Capsicum chinense* Jacq. seeds. *Protein J.* 32:15–26.
- Ding, W., Cai, Y., Cai, Z., Yagi, K., & Zheng, X. 2007. Nitrous oxide emissions from an intensively cultivated maize–wheat rotation soil in the North China Plain. *Science of the Total Environment*, 373: 501–511.
- Ding, X.L., Zhang, X.D., He, H.B., & Xie, H.T. 2010. Dynamics of soil amino sugar pools during decomposition processes of corn residues as affected by inorganic N addition. *J Soils Sediments* 10:758–766.
- Ding, Z., Tang, M., Chen, X., Yin, L., Gui, H., & Zhu, B. 2019. Measuring rhizosphere effects of two tree species in a temperate forest: A comprehensive method

comparison. Rhizosphere, 10(May).  
<https://doi.org/10.1016/j.rhisph.2019.100153>

- Doan, T. H., Doan, T. A., Kangas, M. J., Ernest, A. E., Tran, D., Wilson, C. L., et al. 2017. A low-cost imaging method for the temporal and spatial colorimetric detection of free amines on maize root surfaces. *Front. Plant Sci.* 8:1513. doi: 10.3389/fpls.2017.01513.
- Dobbelaere, S., Croonenborghs, A., Thys, A., Ptacek, D., Okon, Y., Vanderleyden, J., 2002. Effect of inoculation with wild type *Azospirillum brasilense* and *A. irakense* strains on development and nitrogen uptake of spring wheat and grain maize. *Biol. Fert. Soils* 36, 284-297.
- Domene, X., Enders, A., Hanley, K., & Lehmann, J. 2015. Ecotoxicological characterization of biochars: role of feedstock and pyrolysis temperature. *Science of the Total Environment* 512\_513:552\_561.
- Downie, A., Crosky, A., & Munroe, P. 2009. Physical properties of biochar. In: Lehmann, J., Joseph, S. (Eds.), *Biochar for Environmental Management: Science and Technology*. Routledge, pp. 13–32
- Duku, M. H., Gu, S., & Hagan, E. B. 2011. Biochar production potential in Ghana—A review. *Renewable and Sustainable Energy Reviews*, 15(8), 3539–3551. doi:10.1016/j.rser.2011.05.010
- Dunn, M.F. 1998. Tricarboxylic acid cycle and anaplerotic enzymes in rhizobia. *J Exp Bot* 22: 105 – 123.
- Edwards, J. D., Pittelkow, C. M., Kent, A. D., & Yang, W. H. 2018. Dynamic biochar effects on soil nitrous oxide emissions and underlying microbial processes during the maize growing season. *Soil Biology and Biochemistry*, 122: 81–90. <https://doi.org/10.1016/j.soilbio.2018.04.008>
- Eissenstat, D. M., Wells, C. E., Yanai, R. D., & Whitbeck, J. L. 2000. Building roots in a changing environment: Implications for root longevity. *New Phytol.* 147, 33–42. doi:10.1046/j.1469-8137.2000.00686.x
- Enders, A., & Lehmann, J. 2012. Comparison of Wet-Digestion and Dry-Ashing Methods for Total Elemental Analysis of Biochar. *Communications in Soil*

Science and Plant Analysis, 43(7), 1042–1052.  
<https://doi.org/10.1080/00103624.2012.656167>

- Eviati, Sulaiman. 2009. Petunjuk Teknis Edisi 2. Analisis Kimia Tanah, Tanaman, Air dan Pupuk. Bogor: Balai Penelitian Tanah.
- Fait, A., Fromm, H., Dirk, W., Galili, G. & Fernie, A. 2008. Highway or byway: the metabolic role of the GABA shunt in plants. *Trends Plant Sci.* 13, 14–19.
- FAO. 2003. World agriculture: Towards 2015/2030. An FAO perspective. FAO, Rome.
- FAO. 2019. World fertilizer trends and outlook to 2022. Rome.  
<https://www.fao.org/3/ca6746en/ca6746en.pdf>. (Accessed on:)
- FAOSTAT. 2016. Greenhouse gas emission from agriculture, forestry and other land use (AFOLU). FAO, Rome.
- Faragova, N., Farago, J., Drabekova, J. 2005. Evaluation of abundance of aerobic bacteria in the rhizosphere of transgenic and non-transgenic alfalfa lines. *Folia Microbiol* 50: 509–514.
- Fernie, A.R. & Martinoia, E. 2009. Malate. Jack of all trades or master of a few? *Phytochemistry* 70: 828–832.
- Fernie, A.R., Carrari, F., & Sweetlove, L.J. 2004. Respiratory metabolism: Glycolysis, the TCA cycle and mitochondrial electron transport. *Curr Opin Plant Biol* 7: 254–261.
- Fidel, R. B., Laird, D. A., & Parkin, T. B. 2019. Effect of biochar on soil greenhouse gas emissions at the laboratory and field scales. *Soil Systems*, 3(1), 1–18.  
<https://doi.org/10.3390/soilsystems3010008>.
- Figueroa-Soto, C.G. & Valenzuela-Soto, E.M. 2018. Glycine betaine rather than acting only as an osmolyte also plays a role as regulator in cellular metabolism. *Biochimie* 2018, 147, 89–97.
- Filleur, S., Dorbe, M.F., Cerezo, M., Orsel, M., Granier, F., Gojon, A. & Daniel-Vedele, F. 2001. An Arabidopsis T-DNA mutant affected in NRT2 genes is impaired in nitrate uptake. *FEBS Lett.* 489: 220–224.

- Finan, T.M., Wood, J.M., & Jordan, D.C. 1983. Symbiotic properties of C4-dicarboxylic acid transport mutants of *Rhizobium leguminosarum*. *J Bacteriol* 154:1403–1413.
- Finkina, E.I., Melnikova, D.N., Bogdanov, I.V., & Ovchinnikova, T.V. 2019. Peptides of the innate immune system of plants. Part II. Biosynthesis, biological functions, and possible practical applications. *Russ J Bioorganic Chem.* 2019;45:55–65.
- Flores-Tinoco, C. E., Tschan, F., Fuhrer, T., Margot, C., Sauer, U., Christen, M., & Christen, B. 2020. Co-catabolism of arginine and succinate drives symbiotic nitrogen fixation. *Molecular Systems Biology*, 16(6). <https://doi.org/10.15252/msb.20199419>
- Forde, B. G. 2014. Nitrogen signalling pathways shaping root system architecture: an update. *Current opinion in plant biology* 21, 30–36.
- Forde, B. G., & Lea, P. J. 2007. Glutamate in plants: metabolism, regulation, and signalling. *J. Exp. Bot.* 58, 2339–2358. doi: 10.1093/jxb/erm121.
- Forde, B.G. & Clarkson, D.T. 1999. Nitrate and ammonium nutrition of plants: physiological and molecular perspectives. *Advances in Botanical Research* 30, 1–90.
- Forde, B.G. 2000. Nitrate transporters in plants: structure, function and regulation. *Biochim. Biophys. Acta* 1465: 219–235.
- Franco-Luesma, S., Lafuente, V., Alonso-Ayuso, M., Bielsa, A., Kouchami-Sardoo, I., Arrúe, J. L., & Álvaro-Fuentes, J. 2022. Maize diversification and nitrogen fertilization effects on soil nitrous oxide emissions in irrigated Mediterranean conditions. *Frontiers in Environmental Science.* 10. <https://doi.org/10.3389/fenvs.2022.914851>
- Fu, X.D. & Harberd, N.P. 2003. Auxin promotes *Arabidopsis* root growth by modulating gibberellin response. *Nature.* 2003; 421(6924):740–743. PMID: 12610625.
- Fulton, W., Gray, M., Prah, F., and Kleber, M. 2013. A simple technique to eliminate ethylene emissions from biochar amendment in agriculture. *Agron. Sustain. Dev.* 33, 469–474. doi: 10.1007/s13593-012-0118-5

- Gal, A., & Vyn, T. 2011. Soil Nitrous Oxide Emissions in Corn following Three Decades of Tillage and Rotation Treatments. *Soil Sci. Soc. Am. J.* 75:152–163.
- Galston, A.W., Kaur-Sawhney, R., Altabella, T., & Tiburcio, A.F. 1997. Plant polyamines in reproductive activity and response to abiotic stress. *Bot Acta* 1997;110:197-207
- Gao, A.G., Hakimi, S.M., Mittanck, C.A., Wu, Y., Woerner, B.M., Stark, D.M., Shah, D.M., Liang, J., & Rommens, C.M. 2000. Fungal pathogen protection in potato by expression of a plant defensin peptide. *Nat Biotechnol* 18:1307–1310.
- Garnett, T., Plett, D., Conn, V., Conn, S., Rabie, H., Rafalski, J.A., Dhugga, K., Tester, M.A., & Kaiser, B.N. 2015. Variation for N uptake system in maize: Genotypic response to N supply. *Front. Plant Sci*, 6: 936. <https://doi.org/10.3389/fpls.2015.00936>.
- Gautam, S., Tiwari, U., Sapkota, B., Sharma, B., Parajuli, S., Pandit, N.R., Gaihre, Y.K., & Dhakal, K. 2022. Field evaluation of slow-release nitrogen fertilizers and real-time nitrogen management tools to improve grain yield and nitrogen use efficiency of spring maize in Nepal. *Heliyon*, 8: e09566. <https://doi.org/10.1016/j.heliyon.2022.e09566>.
- Gent, L., & Forde, B. G. 2017. How do plants sense their nitrogen status? *J. Exp. Bot.* 68, 2531–2539. doi: 10.1093/jxb/erx013
- Ghani, W. A. W. A. K., Mohd, A., da Silva, G., Bachmann, R. T., Taufiq-Yap, Y. H., Rashid, U., & Al-Muhtaseb, A. H. 2013. Biochar production from waste rubber-wood-sawdust and its potential use in C sequestration: Chemical and physical characterization. *Industrial Crops and Products*, 44, 18–24. <https://doi.org/10.1016/j.indcrop.2012.10.017>
- Gheith, E. M. S., El-Badry, O. Z., Lamlom, S. F., Ali, H. M., Siddiqui, M. H., Ghareeb, R. Y., El-Sheikh, M. H., Jebri, J., Abdelsalam, N. R., & Kandil, E. E. 2022. Maize (*Zea mays* L.) Productivity and Nitrogen Use Efficiency in Response to Nitrogen Application Levels and Time. *Frontiers in Plant Science*. 13. <https://doi.org/10.3389/fpls.2022.941343>.

- Grassini, P., & Cassman, K.G. 2012. High-yield maize with large net energy yield and small global warming intensity. *Proc. Natl. Acad. Sci. U. S. A.* 109: 1074–1079. <https://doi.org/10.1073/pnas.1116364109>.
- Grattan, S. R., & Grieve, C. M. 1985. Betaine status in wheat in relation to nitrogen stress and to transient salinity stress. *Plant and Soil* 85, 3-9.
- Gul, S., Whalen, J. K., Thomas, B. W., Sachdeva, V., & Deng, H. 2015. Physico-chemical properties and microbial responses in biochar-amended soils: Mechanisms and future directions. *Agriculture, Ecosystems and Environment*, 206, 46–59. <https://doi.org/10.1016/j.agee.2015.03.015>
- Guo, J. & Chen, B., 2014. Insights on the molecular mechanism for the recalcitrance of biochar: interactive effects of carbon and silicon components. *Environ. Sci. Technol.* 48, 9103–9101.
- Guo, J.H., Liu, X.J., Zhang, Y., Shen, J.L., Han, W.X., Zhang, W.F., Christie, P., Goulding, K.W.T., Vitousek, P.M., & Zhang, F.S., 2010. Significant acidification in major Chinese croplands. *Science* 327, 1008-1010.
- Guo, Y., & Rockstraw, D. 2007. Activated carbons prepared from rice hull by one-step phosphoric acid activation. *Microporous Mesoporous Mater.* 100:12–19. doi:10.1016/j.micromeso.2006.10.006
- Haase, S., Neumann, G., Kania, A., Kuzyakov, Y., Römheld, V., & Kandeler, E. 2007. Elevation of atmospheric CO<sub>2</sub> and N-nutritional status modify nodulation, nodule-carbon supply, and root exudation of *Phaseolus vulgaris* L. *Soil Biol. Biochem.* 39, 2208–2221.
- Haefele, S.M., Konboon, Y., Wongboon, W., Amarante, S., Maarifat, A.A., Pfeiffer, E.M., & Knoblauch, C. 2011. Effects and fate of biochar from rice residue in ricebased system. *Field Crop. Res.* 123 (3): 430-440.
- Hale, S.E., Lehmann, J., Rutherford, D., Zimmerman, A., Bachmann, R.T., Shitumbanuma, V., O'Toole, A., Sundqvist, K.L., Arp, H.P.H., & Cornelissen, G., 2012. Quantifying the total and bioavailable PAHs and dioxins in biochars. *Environ. Sci. Technol.* 46 (5), 2830-2838.

- Han, X.; Hu, C.; Chen, Y.; Qiao, Y.; Liu, D.; Fan, J.; Li, S.; Zhang, Z. Crop yield stability and sustainability in a rice-wheat cropping system based on 34-year field experiment. *Eur. J. Agron.* 2020, 113, 125965.
- Harley, J. L., 1952. Association between microorganisms and higher plants (mycorrhiza). *Ann. Rev. Microbiol.* 6, 367-386.
- Hass, A., Gonzalez, J.M., Lima, I.M., et al. 2012. Chicken manure biochar as liming and nutrient source for acid Appalachian soil. *Journal of Environmental Quality*, 41,1096–1106.
- Hassan, H.F., & Coombs, G.H. 1988. Purine and pyrimidine metabolism in parasitic protozoa. *FEMS Microbiol Rev* 4:47–83.
- Häusler, R. E., Ludewig, F., & Krueger, S. 2014. Amino acids – a life between metabolism and signaling *Plant Sci.* 229, 225–237. doi: 10.1016/j.plantsci.2014.09.011.
- He, H., Wu, M., Guo, L., Fan, C., Zhang, Z., Su, R., Peng, Q., Pang, J., & Lambers, H. 2020. Release of tartrate as a major carboxylate by alfalfa (*Medicago sativa* L.) under phosphorus deficiency and the effect of soil nitrogen supply. *Plant and Soil*, 449(1–2), 169–178. <https://doi.org/10.1007/s11104-020-04481-9>
- He, H.B., Li, X.B., Zhang, W., & Zhang, X.D. 2011. Differentiating the dynamics of native and newly immobilized amino sugars in soil frequently amended with inorganic nitrogen and glucose. *Eur J Soil Sci*, 62: 144–151.
- Heitkötter, J., & Marschner, B. 2015. Interactive effects of biochar ageing in soils related to feedstock, pyrolysis temperature, and historic charcoal production. *Geoderma* 245\_246:56\_64.
- Hermanto, D.S, & E. Hikmat. 2009. Deskripsi varietas unggul palawija 1918-2009. Puslitbang Tanaman Pangan Bogor.330 hlm.
- Hilber, I., Blum, F., Leifeld, J., Schmidt, H.-P., & Bucheli, T.D., 2012. Quantitative determination of PAHs in biochar: a prerequisite to ensure its quality and safe application. *J. Agric. Food Chem.* 60 (12), 3042-3050.
- Hirel, B., Bertin, P., Quilleré, I., Bourdoncle, W., Attagnant, C., Dellay, C., Gouy, A., Cadiou, S., Retailiau, C., Falque, M., & Gallais, 2001. A. Towards a better

understanding of the genetic and physiological basis for nitrogen use efficiency in maize. *Plant Physiol*, 125: 1258–1270. <https://doi.org/10.1104/pp.125.3.1258>.

Hmid A, Mondelli D, Fiore S, Fanizzi FP, Chami ZAI, Dumontet S. 2014. Production and characterization of biochar from three-phase olive mill waste through slow pyrolysis. *Biomass and Bioenergy* 71:330\_339 DOI 10.1016/j.biombioe.2014.09.024.

Huang, N.C., Liu, K.H., Lo, H.J., & Tsay, Y.F. 1999. Cloning and functional characterization of an Arabidopsis nitrate transporter gene that encodes a constitutive component of low-affinity uptake. *Plant Cell*, 11 (8):1381–1392. PMID: 10449574.

Huervano, X., Menendez, S., Bolanos-Benavides, M-M., Gonzales-Murua, C., & Estavillo, J-M. 2019. 3,4-Dimethylpyrazole Phosphate (DMPP) Reduces N<sub>2</sub>O Emissions from a Tilled Grassland in the Bogotá Savanna. *Agronomy*, 9, 102.

Hungria, M., Campo, R.I., Souza, E.M., & Pedrosa, F.O., 2010. Inoculation with selected strains of *Azospirillum brasilense* and *A. lipoferum* improves yields of maize and wheat in Brazil. *Plant Soil* 331, 413-425.

Hwang, B., Hwang, J.S., Lee, J., & Lee, D.G. 2010. Antifungal properties and mode of action of psacothasin, a novel knottin-type peptide derived from *Psacothea hilaris*. *Biochem Biophys Res Commun* 400:352–357

Imsande, J., & Touraine, B. 1994. N demand and the regulation of nitrate uptake. *Plant Physiology* 105, 3–7.

International Biochar Initiative (IBI). 2015. Standardized Product Definition and Product Testing Guidelines for Biochar That Is Used in Soil. International Biochar Initiative, November, 23. [http://www.biochar-international.org/sites/default/files/Guidelines\\_for\\_Biochar\\_That\\_Is\\_Used\\_in\\_Soil\\_Final.pdf](http://www.biochar-international.org/sites/default/files/Guidelines_for_Biochar_That_Is_Used_in_Soil_Final.pdf)

IPCC. 2014. *Mitigation of Climate Change*. Cambridge University Press, Cambridge.

IPCC. 2019. *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food*

security, and greenhouse gas fluxes in terrestrial ecosystems [P. R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. (In press).

Ishikawa, T., Subbarao, G.V., Ito, O., & Okada, K. 2003 Sup-  
pression of nitrification  
and nitrous oxide emission by the tropical grass *Brachiaria humidicola*.  
*Plant Soil* 255:413–419

Islami, T., & Utomo, H.U. 1995. Hubungan tanah, air dan tanaman. IKIP Press.  
Semarang.

Itoh, Y., Nishijyo, T., & Nakada, Y. 2007. Histidine catabolism and catabolite  
regulation. In: Ramos H-L, Fillous A (eds) *Pseudomonas*. Springer, Berlin  
Heidelberg New York, pp 371–395.

Jaeger, C. H., Lindow, S. E., Miller, W., Clark, E., & Firestone, M. K. 1999. Mapping  
of sugar and amino acid availability in soil around roots with bacterial  
sensors of sucrose and tryptophan. *Appl. Environ. Microbiol.* 65, 2685–  
2690.

Jalali, M. 2013. Using chemical analysis and modeling to enhance the understanding  
of soil solution of some calcareous soil. *Environ Earth Sci*, 68:2041–2049.

Jarvis, S.C., & Barraclough D. 1991. Variation in mineral nitrogen content under  
grazed grassland swards. *Plant Soil* 138:177–188

Jeffery, S., Verheijen, F. G. A., van der Velde, M., & Bastos, A. C. 2011. A quantitative  
review of the effects of biochar application to soils on crop productivity using  
meta-analysis. *Agriculture, Ecosystems and Environment*, 144(1), 175–  
187. <https://doi.org/10.1016/j.agee.2011.08.015>

Jindo, K., Mizumoto, H., Sawada, Y., Sanchez-Monedero, M. A., & Sonoki, T. 2014.  
Physical and chemical characterization of biochars derived from different  
agricultural residues. *Biogeosciences*, 11(23), 6613–6621.  
<https://doi.org/10.5194/bg-11-6613-2014>

Jones, D. L., & Kielland, K. 2012. Amino acid, peptide and protein mineralization  
dynamics in a taiga forest soil. *Soil Biology & Biochemistry*, 5 : 60 – 69 .

- Jones, D. L., & Darrah, P. R. 1995. Influx and efflux of organic acids across the soil-root interface of *Zea mays* L. and its implications in rhizosphere C flow. In *Plant and Soil* (Vol. 173).
- Joseph, S., Graber, E. R., Chia, C., Munroe, P., Donne, S., Thomas, T., Nielsen, S., Marjo, C., Rutledge, H., Pan, G. X., Li, L., Taylor, P., Rawal, A., & Hook, J.: 2013. Shifting paradigms: development of high-efficiency biochar fertilizers based on nano-structures and soluble components, *Carbon Manage.*, 4, 323–343.
- Kambo, H.S., & Dutta, A. 2015. A comparative review of biochar and hydrochar in terms of production, physico-chemical properties and applications. *Journal of Renewable Sustainable Energy* 45:359\_378 DOI 10.1016/j.rser.2015.01.050.
- Kameyama, K., Miyamoto, T., Shiono, T. & Shinogi, Y. 2012. Influence of Sugarcane Bagasse-derived Biochar Application on Nitrate Leaching in Calcaric Dark Red Soil. *Journal of Environmental Quality*, 41 (4):1131-1137.
- Kammann, C., Ippolito, J., Hagemann, N., Borchard, N., Cayuela, M. L., Estavillo, J. M., Fuertes-Mendizabal, T., Jeffery, S., Kern, J., Novak, J., Rasse, D., Saarnio, S., Schmidt, H. P., Spokas, K., & Wrage-Mönnig, N. 2017. Biochar as a tool to reduce the agricultural greenhouse-gas burden—knowns, unknowns and future research needs. In *Journal of Environmental Engineering and Landscape Management* (Vol. 25, Issue 2, pp. 114–139). Taylor and Francis. <https://doi.org/10.3846/16486897.2017.1319375>
- Kammann, C., Ratering, S., Eckhard, C., Müller, C. 2012. Biochar and hydrochar effects on greenhouse gas (carbon dioxide, nitrous oxide, and methane) fluxes from soils. *J Environ Qual* 41:1052–1066
- Kaplan, F., Kopka, J., Haskell, D. W., Zhao, W., Schiller, K. C., Gatzke, N., Sung, D. Y., & Guy, C. L. 2004. Exploring the temperature-stress metabolome of *Arabidopsis*. *Plant Physiology*, 136(4), 4159–4168. <https://doi.org/10.1104/pp.104.052142>
- Karagöz, S., Bhaskar, T., Muto, A., Sakata, Y., 2005. Comparative studies of oil compositions produced from sawdust, rice husk, lignin and cellulose by hydrothermal treatment. *Fuel* 84 (7-8), 875-884.

- Karwat, H., Moreta, D., Arango, J., Núñez, J., Rao, I., Rincón, Á., Rasche, F., & Cadisch, G. 2017. Residual effect of BNI by *Brachiaria humidicola* pasture on nitrogen recovery and grain yield of subsequent maize. *Plant and Soil*, 420 (1–2), 389–406. <https://doi.org/10.1007/s11104-017-3381-z>
- Ke, Q., Ye, J., Wang, B., Ren, J., Yin, L., Deng, X., & Wang, S. 2018. Melatonin mitigates salt stress in wheat seedlings by modulating polyamine metabolism. *Front. Plant Sci.* 9, 914.
- Keeney, D. R., & Nelson, D. W. 1983. Nitrogen-inorganic forms. In “Methods of soil analysis: Part 2 chemical and microbiological properties, 2<sup>nd</sup> ed.” A. L. Page ed. ASA: Madison, WI, SSSA: 643–698. <https://doi.org/10.2134/agronmonogr9.2.2ed.c33>.
- Keiluweit, M., Nico, P., Johnson, M., & Kleber, M. 2010. Dynamic molecular structure of plant biomass-derived black carbon (biochar). *Environ. Sci. Technol.* 44:1247–1253. doi:10.1021/es9031419
- Kellermeier, F., Armengaud, P., Seditas, T. J., Danku, J., Salt, D. E., & Amtmann, A. (2014). Analysis of the root system architecture of *Arabidopsis* provides a quantitative readout of crosstalk between nutritional signals. *Plant Cell* 26, 1480–1496. doi: 10.1105/tpc.113.122101
- Kempers, A.J., & Zweers, A. 1986. Ammonium determination in soil extracts by the salicylate method. *Commun. Soil Sci. Plant Anal.* 17: 715–723. <https://doi.org/10.1080/00103628609367745>.
- Khadem, A., & Raiesi, F. 2017. Responses of microbial performance and community to corn biochar in calcareous sandy and clayey soils. *Applied Soil Ecology*, 114, 16–27. <https://doi.org/10.1016/j.apsoil.2017.02.018>
- Khan, N.A., Mir, R., Khan, M., Javid, S., & Samiullah. 2002. Effects of gibberellic acid spray on nitrogen yield efficiency of mustard grown with different nitrogen levels. *Plant Growth Regulation*, 38 (3):243–247.
- Kiba, T., Kudo, T., Kojima, M., Sakakibara, H.. 2011. Hormonal control of nitrogen acquisition: roles of auxin, abscisic acid, and cytokinin. *Journal of Experimental Botany*. 62(4):1399–1409. doi: 10.1093/jxb/erq410 PMID: 21196475.

- King, C.A., & Purcell, L.C. 2005. Inhibition of N<sub>2</sub> fixation in soybean is associated with elevated ureides and amino acids. *Plant Physiology* 137, 1389–1396.
- Kloss, S., Zehetner, F., Dellantonio, A., Hamid, R., Ottner, F., Liedtke, V., Schwanninger, M., Gerzabek, M. H., & Soja, G. 2012. Characterization of Slow Pyrolysis Biochars: Effects of Feedstocks and Pyrolysis Temperature on Biochar Properties. <https://doi.org/10.2134/jeq2011.0070>
- Kolodkin-gal, I., Romero, D., Cao, S.G., Clardy, J., Kolter, R., & R. Losick. 2010. D-Amino acids trigger biofilm disassembly. *Science*, 328: 627 – 629 .
- Kołodziejowska, D.; Wnętrzak, R.; Leahy, J.J.; Hayes, M.H.B.; Kwapiński, W.; Hubicki, Z. Kinetic and adsorptive characterization of biochar in metal ions removal. *Chem. Eng. J.* 2012, 197, 295–305.
- Kolton, M., Harel, Y.M., Pasternak, Z., Graber, E.R., Elad, Y., Cytryn, E. 2011. Impact of biochar application to soil on the root-associated bacterial community structure of fully developed greenhouse pepper plants. *Appl. Environ. Microbiol*, 77: 4924–4930. [CrossRef]
- Krapp, A., Berthomé, R., Orsel, M., Mercey-Boutet, S., Yu, A., Castaings, L., Elftieh, S., Major, H., Renou, J. P., & Daniel-Vedele, F. 2011. Arabidopsis roots and shoots show distinct temporal adaptation patterns toward nitrogen starvation. *Plant Physiology*, 157(3), 1255–1282. <https://doi.org/10.1104/pp.111.179838>
- Krouk, G., Ruffel, S., Gutiérrez, R.A., Gojon, A., Crawford, N.M., Coruzzi, G.M., et al. 2011. A framework integrating plant growth with hormones and nutrients. *Trends in Plant Science.*; 16(4):178–182. doi: 10.1016/j.tplants.2011.02.004 PMID: 21393048
- Kul'ko, A.B., Kisi, I. O.V., Sadykova, V.S., Mikhailov, V.F., Vasilieva, I.M, Shulenina, L.V., et al. 2016. Investigation of thionins from black cumin (*Nigella sativa* L.) seeds showing cytotoxic, regulatory and antifungal activity. *Antibiot i Khimioterapiya*. 61: 8–16.
- Kuzyakov, Y., Bogomolova, I., Glaser, B. 2014. Biochar stability in soil: decomposition during eight years and transformation as assessed by compound-specific <sup>14</sup>C analysis. *Soil Biology and Biochemistry* 70:229\_236 DOI 10.1016/j.soilbio.2013.12.021

- Kyoto Encyclopedia of Genes and Genomes. 2017. KEGG Pathway Database. <<http://www.kegg.jp/kegg/pathway.html#metabolism>>. Accessed on 14 September 2017.
- Lambers, H., Thijs, L.P., & Chapin, F.S. 2008. Plant physiological ecology. Springer, New York, USA.
- Lan, Z.M., Chen, C.R., Rashti, M.R., Yang, H., & Zhang, D.K., 2017. Stoichiometric ratio of dissolved organic carbon to nitrate regulates nitrous oxide emission from the biochar-amended soils. *Sci. Total Environ.* 576, 559–571.
- Lanthanum (La)-involved pyrolysis for adsorption of ammonium (NH<sub>4</sub><sup>+</sup>), nitrate (NO<sub>3</sub><sup>-</sup>), and phosphate (PO<sub>4</sub><sup>3-</sup>). *Chemosphere*, 119, 646–653.
- Lata, J.C., Degrange, V., Raynaud, X., Maron, P.A., Lensi, R., & Abbadie, L. 2004. Grass populations control nitrification in savanna soils. *Funct Ecol* 13:762–763
- Lata, J.C., Durand, J., Lensi, R., & Abbadie, L. 1999. Stable coexistence of contrasted nitrification statuses in a wet tropical savanna system. *Funct Ecol* 13:762–763
- Lea, P.J., Robinson, S.A., & Stewart, G.A. 1990. The enzymology and metabolism of glutamine, glutamate and asparagine. In: Mifflin BJ, Lea PJ, eds. *The Biochemistry of Plants, Vol 16: intermediary metabolism*. Academic Press: San Diego, 121–157.
- Lee, R.B., & Drew, M.G. 1989. Rapid, reversible inhibition of nitrate influx in barley by ammonium. *Journal of Experimental Botany*, 40, 741–52.
- Lehman, J. & Joseph, S. 2009. *Biochar for environmental management science and technology*. Earthscan, London.
- Lehmann, J. 2007. A handful of carbon. *Nature* 447:143\_144 DOI 10.1038/447143a.
- Lehmann, J., & Rondon, M. 2006. Bio-Char Soil Management on Highly Weathered Soils in the Humid Tropics (pp. 517–529). <https://doi.org/10.1201/9781420017113.ch36>
- Lehmann, J., da Silva, J. P., Steiner, C., Nehls, T., Zech, W., & Glaser, B. 2003. Nutrient availability and leaching in an archaeological Anthrosol and a Ferralsol of the Central Amazon basin: Fertilizer, manure and charcoal

amendments. *Plant and Soil*, 249 (2), 343–357.  
<https://doi.org/10.1023/A:1022833116184>

Lehmann, J., Rillig, M.C., Thies, J., Masiello, C.A., Hockaday, W.C., & Crowley, D. 2011. Soil Biology & Biochemistry Biochar effects on soil biota e A review. *Soil Biology and Biochemistry*, 43 (9), 1812–1836.  
<https://doi.org/10.1016/j.soilbio.2011.04.022>

Lei, O., & Zhang, R. 2013. Effects of biochars derived from different feedstocks and pyrolysis temperatures on soil physical and hydraulic properties. *Journal of Soils and Sediments*, 13(9), 1561–1572. <https://doi.org/10.1007/s11368-013-0738-7>

Lelandais-Briere, C., Jovanovic, M., Torres, GAM., Perrin, Y., Lemoine, R., CorreMenguy, F., & Hartmann, C. 2007. Disruption of AtOCT1, an organic cation transporter gene, affects root development and carnitine-related responses in *Arabidopsis*. *Plant J* 51:154–164.

Lentz, R.D., Ippolito, & J.A., 2012. Biochar and manure affect calcareous soil and cornsilage nutrient concentrations and uptake. *J. Environ. Qual.* 41, 1033–1043

Liang, C., & Farjun, C. 2005. Root growth, nitrogen uptake and yield formation of hybrid maize with different N efficiency. Fu-so, Z., and Guo-hua. *Plant Nutrition and Fertilizer Science*. s 11: 615–619.

Lidbury, I., Kimberley, G., Scanlan, D. J., Murrell, J.C. & Chen. Y. 2015. Comparative genomics and mutagenesis analyses of choline metabolism in the marine *Roseobacter* clade. *Environ. Microbiol.* 17: 5048–5062.

Liepman, A. H. and Olsen, L. J. 2001. Peroxisomal alanine:glyoxylate aminotransferase (AGT1) is a photorespiratory enzyme with multiple substrates in *Arabidopsis thaliana*. *Plant J.* 25, 487–498.

Lilly, V. G. & Leonian, L. H., 1939. Vitamin B in soil. *Science* 89, 292.

Liu, F., Rotaru, A.-E., Shrestha, P. M., Malvankar, N. S., Nevin, K. P., & Lovley, D. R. 2012. Promoting direct interspecies electron transfer with activated carbon, *Energy & Environmental Science* 5(10): 8982–8989.  
<https://doi.org/10.1039/c2ee22459c>

- Liu, L., Shen, G., Sun, M., Cao, X., Shang, G., & Chen, P. 2014. Effect of biochar on nitrous oxide emission and its potential mechanisms, *Journal of the Air & Waste Management Association* 64: 894–902.
- Liu, Y.T., Li, Y.E., Wan, Y.F., Chen, D.L., Gao, Q.Z., Li, Y., & Qin, X.B. 2011. Nitrous oxide emissions from irrigated and fertilized spring maize in semi-arid northern China. *Agric. Ecosyst. Environ.* 141: 287–295. <https://doi.org/10.1016/j.agee.2011.03.002>.
- Liu, Z. & Zhang, F. S.: 2009. Removal of lead from water using biochars prepared from hydrothermal liquefaction of biomass, *J. Hazard. Mater.*, 167, 933–939.
- Lodhi, M.A.K. 1982. Additional evidence of inhibition of nitrifiers and possible cycling of inhibitors produced by selected plants in a climax community. *Bull Torrey Bot Club* 109:199–204
- Lu, Y., Zhang, X., Jiang, J., Kronzucker, H. J., Shen, W., & Shi, W. 2019. Effects of the biological nitrification inhibitor 1,9-decanediol on nitrification and ammonia oxidizers in three agricultural soils. *Soil Biology and Biochemistry*, 129, 48–59. <https://doi.org/10.1016/j.soilbio.2018.11.008>
- Mackay, D. M. & Roberts, P. V. 1982. The influence of pyrolysis conditions on yield and microporosity of lignocellulosic chars, *Carbon*, 20, 95–105.
- Maekawa, M., Kawai, K., Takahashi, Y., Nakamura, H., Watanabe, T., Sawa, R., Hachisuka, K., & Kasai, H. 2006. Identification of 4-oxo-2-hexenal and other direct mutagens formed in model lipid peroxidation reactions as dGuo adducts. *Chem. Res. Toxicol.* 19, 130–138.
- Malique, F., Ke, P., Boettcher, J., et al. 2019. Plant and soil effects on denitrification potential in agricultural soils. *Plant Soil* 439:459–474. <https://doi.org/10.1007/s11104-019-04038-5>.
- Mandal, S., Thangarajan, R., Bolan, N. S., Sarkar, B., Khan, N., Ok, Y. S., & Naidu, R. 2016. Biochar-induced concomitant decrease in ammonia volatilization and increase in nitrogen use efficiency by wheat. *Chemosphere*, 142, 120–127. <https://doi.org/10.1016/j.chemosphere.2015.04.086>
- Marschner, H. 1997. *Mineral nutrition of higher plants* second edition. Academic Press Harcourt Brace & Company. Tokyo, Japan

- Marsden, K. A., Jones, D. L., & Chadwick, D. R. 2016. The urine patch diffusional area: An important N<sub>2</sub>O source? *Soil Biology & Biochemistry* 92: 161-170.
- Martin, A., Lee, J., Kichey, T., Gerentes, D., Zivy, M., Tatout, C., et al. 2006. Two cytosolic glutamine synthetase isoforms of maize are specifically involved in the control of grain production. *Plant Cell* 18, 3252–3274. doi: 10.1105/tpc.106.042689
- Mašková, T., & Herben, T. 2018. Root: shoot ratio in developing seedlings: How seedlings change their allocation in response to seed mass and ambient nutrient supply. *Ecology and Evolution*, 8(14): 7143–7150. <https://doi.org/10.1002/ece3.4238>
- Maurer, D., Kiese, R., Kreuzwieser, J., & Rennenberg, H. 2018. Processes that determine the interplay of root exudation, methane emission and yield in rice agriculture. *Plant Biol* 20:951–955. <https://doi.org/10.1111/plb.12880>.
- Maurer, D., Malique, F., Alfarraj, S., Albasher, G., Horn, M. A., Butterbach-Bahl, K., Dannenmann, M., & Rennenberg, H. 2021. Interactive regulation of root exudation and rhizosphere denitrification by plant metabolite content and soil properties. *Plant and Soil*, 467(1–2), 107–127. <https://doi.org/10.1007/s11104-021-05069-7>
- McCormack, M.L., Dickie, I.A., Eissenstat, D.M., Fahey, T.J., Fernandez, C.W., Guo, D.; Helmisaari, H., Hobbie, E.A., Iversen, C.M., Jackson, R.B., et al. 2015. Redefining fine roots improves understanding of below-ground contributions to terrestrial biosphere processes. *New Phytol.* 2015, 207, 505–518.
- McRae, D.G., Miller, R.W., Berndt, W.B., & Joy, K. 1989. Transport of C<sub>4</sub>-dicarboxylates and amino acids by *Rhizobium meliloti* bacteroids. *Mol Plant Microbe Interact* 2:273–278. <https://doi.org/10.1094/MPMI-2-273>.
- McSwiney, C.P., & Robertson, G.P. 2005. Nonlinear response of N<sub>2</sub>O flux to incremental fertilizer addition in a continuous maize (*Zea mays* L.) cropping system. *Glob. Chang. Biol*, 11: 1712–1719. <https://doi.org/10.1111/j.1365-2486.2005.01040.x>.

- Mdlambuzi, T., Muchaonyerwa, P., Tsubo, M., & Moshia, M.E. 2021. Nitrogen fertiliser value of biogas slurry and cattle manure for maize (*Zea mays* L.) production. *Heliyon* 7: e07077. <https://doi.org/10.1016/j.heliyon.2021.e07077>.
- Meiklejohn, J. 1968. Number of nitrifying bacteria in some Rhodesian soils under natural grass and improved pastures. *J Appl Ecol* 5:291–300
- Meister, R., Rajani, M.S., Ruzicka, D., & Schachtman, D.P. 2014. Challenges of modifying root traits in crops for agriculture. *Trends Plant Sci.* 2014, 19, 779–788. [PubMed]
- Mejaya, M.J., A. Takdir, N. Iriany, & M. Yasin. HG. 2010. Development of improved maize varieties in Indonesia.p109-112. In: P.H. Zaidi, M. Azrai, and K. Pixley (eds.): *Maize for Asia*. Proc. of the 10th
- Mensah, A. K., & Frimpong, K. A. 2018. Biochar and/or Compost Applications Improve Soil Properties, Growth, and Yield of Maize Grown in Acidic Rainforest and Coastal Savannah Soils in Ghana. *International Journal of Agronomy*, 2018. <https://doi.org/10.1155/2018/6837404>
- Mercado-Blanco, J., & Bakker, P. 2007. Interactions between plants and beneficial *Pseudomonas* spp.: exploiting bacterial traits for crop protection. *Antonie van Leeuwenhoek*, 92(4): 367–389. doi:10.1007/s10482-007-9167-1.
- Meyer, S., De Angeli, A., Fernie, A.R., & Martinoia, E. 2010. Intra- and extra-cellular excretion of carboxylates. *Trends Plant Sci.* 15: 40–47
- Mi, G.H., Chen, F.J., Wu, Q.P., Lai, N.W., Yuan, L., & Zhang, F.S. 2010. Ideotype root architecture for efficient nitrogen acquisition by maize in intensive cropping systems. *Sci. China Life Sci.* 53: 1369–1373. doi: 10.1007/s11427-010-4097-y.
- Miranda, C.H.B., Cadisch, G., Urquiaga, S., Miranda, C.H.B., Boddey, R.M., Giller, K.E. 1994. Mineral nitrogen in an oxisol from the Brazilian Cerrados in the presence of *Brachiaria* spp. *Eur J Agron* 3:333–337
- Mitsch, M. J., diCenzo, G. C., Cowie, A., & Finan, T. M. 2018. Succinate transport is not essential for symbiotic nitrogen fixation by *Sinorhizobium meliloti* or

*Rhizobium leguminosarum*. Applied and Environmental Microbiology, 84(1). <https://doi.org/10.1128/AEM.01561-17>

- Moe, L. A. 2013. Amino acids in the rhizosphere: From plants to microbes. American Journal of Botany, 100(9), 1692–1705. <https://doi.org/10.3732/ajb.1300033>
- Montes, F., Meinen, R., Dell, C., Rotz, A., Hristov, A.N., Oh, J., Waghom, G., Gerber, P.J., Henderson, B., Makkar, H.P.S., & Dijkstra, J. 2016. SPECIAL TOPICS—Mitigation of methane and nitrous oxide emissions from animal operations: II. A review of manure management mitigation options. J. Anim. Sci. 2013.91:5070–5094.
- Monton, M.R.N & Soga, T. 2007. Metabolome analysis by capillary electrophoresis-mass spectrometry. Journal of Chromatography A, 1168: 237-246.
- Mukhlis 2011 Tanah Andisol Genesis, Klasifikasi, Karakteristik, Penyebaran dan Analisis [Andisol Soil: Genesis, Classification, Characteristics, Distribution and Analysis] (Medan: USU Press) Fiantis, D.; Hakim, N.; van Ranst, E. Properties and utilization of Andisols in Indonesia. J. Integr. Field Sci. 2005, 2, 29–37.
- Mukome, F. N. D., Zhang, X., Silva, L. C. R., Six, J., & Parikh, S. J. 2013. Use of chemical and physical characteristics to investigate trends in biochar feedstocks, J. Agric. Food Chem., 61, 2196–2204.
- Muller, B., & Touraine, B. 1992. Inhibition of NO<sub>3</sub><sup>-</sup> uptake by various phloem translocated amino acids in soybean seedlings. Journal of Experimental Botany 43, 617–623.
- Mwafulirwa, L., Paterson, E., Cairns, J. E., Daniell, T. J., Thierfelder, C., & Baggs, E. M. 2021. Genotypic variation in maize (*Zea mays*) influences rates of soil organic matter mineralization and gross nitrification. New Phytologist, 231(5): 2015–2028. <https://doi.org/10.1111/nph.17537>
- Myrold, D. D., & Tiedje, J. M. (1985). Establishment of denitrification capacity in soil: Effects of carbon, nitrate and moisture. Soil Biology and Biochemistry, 17(6), 819–822. [https://doi.org/10.1016/0038-0717\(85\)90140-3](https://doi.org/10.1016/0038-0717(85)90140-3)

- Nakamura, Y. & Tolbert, N. E. 1983. Serine:glyoxylate, alanine:glyoxylate and glutamate:glyoxylate aminotransferases reactions in peroxisomes from spinach leaves. *J. Biol. Chem.* 258, 7631–7638.
- Nan, W., Yue, S., Li, S., Huang, H., & Shen, Y. 2016. Characteristics of N<sub>2</sub>O production and transport within soil profiles subjected to different nitrogen application rates in China. *Science of the Total Environment*, 542: 864–875. <https://doi.org/10.1016/j.scitotenv.2015.10.147>
- Nartey, O. D., & Zhao, B. 2014. Biochar preparation, characterization, and adsorptive capacity and its effect on bioavailability of contaminants: An overview. In *Advances in Materials Science and Engineering* (Vol. 2014). Hindawi Publishing Corporation. <https://doi.org/10.1155/2014/715398>
- Nasr Esfahani M. N., Kusano M., Nguyen K. H., Watanabe Y., Ha C. V., Saito K., Sulieman S., Herrera-Estrella L. & Tran L. P. 2016. Adaptation of the symbiotic 32 Mesorhizobium-chickpea relationship to phosphate deficiency relies on reprogramming of whole-plant metabolism. *Proceedings of the National Academy of Sciences of the United States of America* 113, 4610-4619.
- Nasr Esfahani M., Sulieman S., Schulze J., Yamaguchi-Shinozaki K., Shinozaki K. & Tran L.S. 2014. Mechanisms of physiological adjustment of N<sub>2</sub> fixation in *Cicer arietinum* L. (chickpea) during early stages of water deficit: single or multi-factor controls. *The Plant Journal* 79, 964-980.
- Nazoa, P., John Vidmar, J., Tranbarger, T. J., Mouline, K., Damiani, I., Tillard, P., Zhuo, D., Glass, A. D. M., & Touraine, B. 2003. Regulation of the nitrate transporter gene AtNRT2.1 in *Arabidopsis thaliana*: responses to nitrate, amino acids and developmental stage. In *Plant Molecular Biology* (Vol. 52).
- Newton, A.C., Fitt, B.D.L., Atkins, S.D., Walters, D.R., & Daniell, T.J. 2010. Pathogenesis, parasitism and mutualism in the trophic space of microbe–plant interactions. *Trends Microbiol.*18(8): 365–373. doi:10.1016/j.tim.2010.06.002. PMID:20598545.
- Nguyen, C. 2003. Rhizodeposition of organic C by plants: mechanisms and controls. *Agronomie* 23:375–396. <https://doi.org/10.1051/agro:2003011>.

- Niu, J., Chen, F., Mi, G., Li, C., & Zhang, F. 2007. Transpiration, and nitrogen uptake and flow in two maize (*Zea mays* L.) inbred lines as affected by nitrogen supply. *Ann. Bot.* 99: 153–160. <https://doi.org/10.1093/aob/mcl237>.
- Novak, J.M., Busscher, W.J., Laird, D.A., Ahmedna, M., & Watts, D.W. 2009. Niandou, M. Impact of biochar amendment on fertility of a southeastern Coastal Plain soil, *Soil Sci.* 174: 105–112.
- Novak, J.M., Lima, I., Xing, B., Gaskin, J.W., Steiner, C., Das, K.C., Ahmedna, M, Rehrah, D, Watts, D.W., Busscher, W.J., & Schomberg, H. 2009. Characterization of designer biochar produced at different temperatures and their effects on a loamy sand. *Ann Environ Sci* 3:195–206
- O’Sullivan, C. A., Fillery, I. R. P., Roper, M. M., & Richards, R. A. 2016. Identification of several wheat landraces with biological nitrification inhibition capacity. *Plant and Soil*, 404(1–2): 61–74. <https://doi.org/10.1007/s11104-016-2822-4>
- Oguntunde, P. G., Abiodun, B. J., Ajayi, A. E., & Van De Giesen, N. 2008. Effects of charcoal production on soil physical properties in Ghana. *J. Plant Nutr. Soil Sci.* 171, 591–596. doi: 10.1002/jpln.200625185
- Ohe, M., Sasaki, H., Niitsu, M., Bagni, N., Tassoni, A.i, Matsuzaki, S. Cadaverine turnover in soybean seedlings using <sup>15</sup>N-labelled lysine and cadaverine. *Plant*
- Oikawa, A., Fujita, N., Horie, R., Saito, K., & Tawaraya, K. 2011. Solid-phases extraction for metabolomics analysis of high-salinity samples by capillary electrophoresis-mass spectrometry. *J. Sep. Sci.* 34, 1063-1068
- Oladele, S., Adeyemo, A., & Awodun, M. 2019. Influence of rice husk biochar and inorganic fertilizer on soil nutrients availability and rain-fed rice yield in two contrasting soils. *Geoderma* 336, 1–11. doi:10.1016/j.geoderma.2018.08.025
- Oppenheimer-Shaanan, Y., Jakoby, G., Starr, M. L., Karliner, R., Eilon, G., Itkin, M., Malitsky, S., & Klein, T. 2022. A dynamic rhizosphere interplay between tree roots and soil bacteria under drought stress. *ELife*, 11. <https://doi.org/10.7554/ELIFE.79679>

- Orsel, M., Krapp, A. & Daniel-Vedele, F. 2002. Analysis of the NRT2 nitrate transporter family in Arabidopsis. Structure and gene expression. *Plant Physiol.* 129: 886–896.
- Otaka, J., Subbarao, G. V., Ono, H., & Yoshihashi, T. 2021. Biological nitrification inhibition in maize—isolation and identification of hydrophobic inhibitors from root exudates. *Biology and Fertility of Soils*, 0123456789. <https://doi.org/10.1007/s00374-021-01577-x>
- Pang, J., Ryan, M.H., Lamberst, H., & Siddique, K.H.M. 2018. Phosphorus acquisition and utilisation in crop legumes under global change. *Curr Opin Plant Biol* 45:248–254.
- Parr, J. F. 2006. Effect of fire on phytolith coloration, *Geochimica et Cosmochimica Acta*, 21, 171–185.
- Paynel, F., Murray, P. J., & Bernard Cliquet, J. 2001. Root exudates: a pathway for short-term N transfer from clover and ryegrass. *Plant Soil* 229, 235–243. doi: 10.1023/a:1004877214831.
- Peiffer, J. A., Spor, A., Koren, O., Jin, Z., Tringe, S. G., Dangl, J. L., Buckler, E. S., & Ley, R. E. 2013. Diversity and heritability of the maize rhizosphere microbiome under field conditions. *Proceedings of the National Academy of Sciences of the United States of America*, 110(16), 6548–6553. <https://doi.org/10.1073/pnas.1302837110>
- Phillips, D. A., Fox, T. C., King, M. D., Bhuvaneshwari, T. V., & Teuber, L. R. 2004. Microbial products trigger amino acid exudation from plant roots. *Plant Physiol.* 136, 2887–2894. doi: 10.1104/pp.104.044222
- Pohlmeyer, K., Soll, J., Grimm, R., Hill, K., Wagner, R. 1998. A high-conductance solute channel in the chloroplastic outer envelope from Pea. *Plant Cell*, 10:1207-16; PMID:9668138.
- Pott, D. M., Osorio, S., & Vallarino, J.G. 2019. From central to specialized metabolism: An overview of some secondary compounds derived from the primary metabolism for their role in conferring nutritional and organoleptic characteristics to fruit, *Front. Plant Sci.*, vol. 10. doi: 10.3389/fpls.2019.00835.

- Pratiwi, E.P.A.; Hillary, A.K.; Fukuda, T.; Shinogi, Y. The effects of rice husk char on ammonium, nitrate and phosphate retention and leaching in loamy soil. *Geoderma* 2016, 277, 61–68.
- Prell, J., & Poole, P. 2006. Metabolic changes of rhizobia in legume nodules. *Trends Microbiol* 14: 161 – 168.
- Preza-Fontes, G., Christianson, L. E., Greer, K., Bhattarai, R., & Pittelkow, C. M. I. 2022. N-season split nitrogen application and cover cropping effects on nitrous oxide emissions in rainfed maize. *Agriculture, Ecosystems and Environment*, pp 326. <https://doi.org/10.1016/j.agee.2021.107813>
- Prommer, J., Wanek, W., Hofhansl, F., Trojan, D., Offre, P., Urich, T., Schleper, C., Sassmann, S., Kitzler, B., Soja, G., & Hood-Nowotny, R.C., 2014. Biochar decelerates soil organic nitrogen cycling but stimulates soil nitrification in a temperate arable field trial. *PLoS One* 9
- Puga, A. P., Grutzmacher, P., Cerri, C. E. P., Ribeirinho, V. S., & Andrade, C. A. de. 2020. Biochar-based nitrogen fertilizers: Greenhouse gas emissions, use efficiency, and maize yield in tropical soils. *Science of the Total Environment*, 704, 135375. <https://doi.org/10.1016/j.scitotenv.2019.135375>
- Qian, K., Kumar, A., Zhang, H., Bellmer, D., & Huhnke, R.. 2015. Recent advances in utilization of biochar. *Journal of Renewable Sustainable Energy* 42:1055\_1064 DOI 10.1016/j.rser.2014.10.074.
- Qiu, S.J., He, P., Zhao, S.C., Li, W.J., Xie, J.G., Hou, Y.P., Grant, C.A., Zhou, W., & Jin, J.Y. 2015. Impact of nitrogen rate on maize yield and nitrogen use efficiencies in northeast China. *Agron. J*, 107: 305–313. <https://doi.org/10.2134/agronj13.0567>.
- Quastel, J. H. 1965. Soil Metabolism. *Annual Review of Plant Physiology*, 16: 217-240.
- Quesada, A., Krapp, A., Trueman, L.J., Daniel-Vedele, F., Fernandez, E., Forde, B.G. & Caboche, M. 1997. PCR-identification of a *Nicotiana plumbaginifolia* cDNA homologous to the high affinity nitrate transporters of the crnA family. *Plant Mol. Biol.* 34: 265–274.

- R Core Team. 2022. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.
- Raaijmakers, J., Paulitz, T., Steinberg, C., Alabouvette, C., & Moëgne-Loccoz, Y. 2009. The rhizosphere: a playground and battlefield for soilborne pathogens and beneficial microorganisms. *Plant Soil*, 321(1–2): 341–361. doi:10.1007/s11104-008-9568-6.
- Rajkovich, S., Enders, A., Hanley, K., Hanley, C., Zimmerman, A.R., & Lehmann, J. 2012. Corn growth and nitrogen nutrition after additions of biochars with varying properties to a temperate soil. *Biol. Fertil. Soils*. 48: 271–284. doi:10.1007/s00374-011-0624-7.
- Ramirez, K.S., Craine, J.M., & Fierer, N., 2012. Consistent effects of nitrogen amendments on soil microbial communities and processes across biomes. *Global Change Biol.* 18, 1918-1927.
- Ravishankara, A.R., Daniel, J.S., & Portmann, R.W. 2009. Nitrous oxide (N<sub>2</sub>O): The dominant ozone-depleting substance emitted in the 21<sup>st</sup> century. *Science*, 326: 123–125. <https://doi.org/10.1126/science.1176985>.
- Redin, M., Recous, S., Aita, C., Chaves, B., Pfeifer, I. C., Bastos, L. M., Pilecco, G. E., & Giacomini, S. J. 2018. Root and shoot contribution to carbon and nitrogen inputs in the topsoil layer in no-tillage crop systems under subtropical conditions. *Revista Brasileira de Ciencia Do Solo*, 42. <https://doi.org/10.1590/18069657RBCS20170355>.
- Riggs, P.J., Chelious, M.K., Inguez, A.L., Kaeppler, S.M., & Triplett, E.W., 2001. Enhanced maize productivity by inoculation with diazotrophic bacteria. *Aust. J. Plant Physiol.* 28, 8-14.
- Rippa, S., Zhao, Y., Merlier, F., Charrier, A., & Perrin, Y. 2012. The carnitine biosynthetic pathway in *Arabidopsis thaliana* shares similar features with the pathway of mammals and fungi. *Plant Physiol Biochem* 60:109–114. <https://doi.org/10.1016/j.plaphy.08.001>.
- Roberts, P., Bol, R., & Jones, D. L. 2007. Free amino sugar reactions in soil in relation to soil carbon and nitrogen cycling. *Soil Biology and Biochemistry*, 39(12), 3081–3092. <https://doi.org/10.1016/j.soilbio.2007.07.001>

- Rogozhin, E.A., Slezina, M.P., Slavokhotova, A.A., Istomina, E.A., Korostyleva, T.V., Astafieva, A.A., Enyenihi, A.A., Rogozhin, E.A., Kozlov, S.A., Grishin, E.V., Odintsova, T.I., et al. 2015. Novel proline-hydroxyproline glycopeptides from the dandelion (*Taraxacum officinale* Wigg.) flowers: de novo sequencing and biological activity. *Plant Sci*, 238:323–9. <https://doi.org/10.1016/j.plantsci.2015.07.002>.
- Ronson, C.W., Lyttleton, P., Robertson, J.G. 1981. C(4)-dicarboxylate transport mutants of *Rhizobium trifolii* form ineffective nodules on *Trifolium repens*. *Proc Natl Acad Sci U S A* 78:4284–4288. <https://doi.org/10.1073/pnas.78.7.4284>.
- Roulet, M. A. & Schopfer, W. H. 1950. Les vitamines du sol et leur signification. *Int. Congr. Soil Sci. Amsterdam* 1, 202-203.
- Roulet, M. A. 1948. Recherches sur les vitamines du sol. *Experientia* 4, 149-150.
- Roumet, C., Birouste, M., Picon-Cochard, C., Ghestem, M., Osman, N., Vrignon-Brenas, S., Cao, K.F., & Stokes, A. 2016. Root structure–function relationships in 74 species: Evidence of a root economics spectrum related to carbon economy. *New Phytol*, 210, 815–826.
- Roy, A.K., Wagner-Riddle, C., Deen, B., Lauzon, J., & Bruulsema, T. 2014. Nitrogen application rate, timing and history effects on nitrous oxide emissions from corn (*Zea mays* L.). *Can. J. Soil Sci.* 94: 563–573. <https://doi.org/10.4141/CJSS2013-118>.
- Ruffel, S., Krouk, G., Ristova, D., Shasha, D., Birnbaum, K.D., & Coruzzi, G.M. 2011. Nitrogen economics of root foraging: Transitive closure of the nitrate–cytokinin relay and distinct systemic signaling for N supply vs. demand. *Proceedings of the National Academy of Sciences of the United States of America*, 108 (45):18524–18529. doi: 10.1073/pnas.1108684108 PMID: 22025711.
- Sae-Tun, O., Bodner, G., Rosinger, C., Zechmeister-Boltenstern, S., Mentler, A., & Keiblinger, K. 2022. Fungal biomass and microbial necromass facilitate soil carbon sequestration and aggregate stability under different soil tillage intensities. *Applied Soil Ecology*, 179. <https://doi.org/10.1016/j.apsoil.2022.104599>

- Sánchez-García, M., Roig, A., Sánchez-Monedero, M. A., & Cayuela, M. L. 2014. Biochar increases soil N<sub>2</sub>O emissions produced by nitrification-mediated pathways. *Frontiers in Environmental Science*, 2(JUL). <https://doi.org/10.3389/fenvs.2014.00025>
- Sas, L., Rengel, Z., & Tang, C. 2001. Excess cation uptake, and extrusion of protons and organic acid anions by *Lupinus albus* under phosphorus deficiency. *Plant Sci.* 160, 1191–1198.
- Sasse, J., Martinoia, E., & Northen, T. 2018. Feed your friends: do plant exudates shape the root microbiome? *Trends Plant Sci.* 23, 25–41. doi: 10.1016/j.tplants.2017.09.003.
- Sauheitl, L., B. Glaser, M. Dippold, K. Leiber, & A. Weigelt. 2010. Amino acid fingerprint of a grassland soil
- Schils, R.L.M., Eriksen, J., Ledgard, S.F., Vellinga, Th.V., Kuikman, P.J., Luo, J., Peterson, S.O., & Velthof, G.L. 2013. Strategies to mitigate nitrous oxide emissions from herbivore production systems. *Animal*, 7:s1, pp 29–40.
- Schimmelpfennig, S., & Glaser, B. 2012. One step forward toward characterization: some important material properties to distinguish biochars. *J Environ Qual*, 2012;41:1001–13.
- Schmidt, H., Nunan, N., Höck, A., Eickhorst, T., Kaiser, C., Woebken, D., et al. 2018. Recognizing patterns: spatial analysis of observed microbial colonization on root surfaces. *Front. Environ. Sci.* 6:61. doi: 10.3389/fenvs.2018.00061.
- Schultz, A.C., Nygaard, P., Saxild, H.H. 2001 Functional analysis of genes that constitute the purine catabolic pathway in
- Schwanninger, M., Rodrigues, J.C., Pereira, H., & Hinterstoisser, B. 2004. Effects of short-time vibratory milling on the shape of FT-IR spectra of wood and cellulose. *Vib. Spectrosc.* 36:23–40. doi:10.1016/j.vibspec.2004.02.003.
- Shaaban, A., Se, S. M., Dimin, M. F., Juoi, J. M., Mohd Husin, M. H., & Mitan, N. M. M. 2014. Influence of heating temperature and holding time on biochars derived from rubber wood sawdust via slow pyrolysis. *Journal of Analytical and Applied Pyrolysis*, 107, 31–39. <https://doi.org/10.1016/j.jaap.2014.01.021>

- Sharma, A., & Johri, B.N., 2003. Growth promoting influence of siderophore producing Pseu-domonas strains GRP3A and PRS9 in maize (*Zea mays* L) under iron limiting conditions. *Microbiol. Res.* 158, 243-248.
- Sharma, R., Wooten, J., Baliga, V., Lin, X., Chan, W., & Hajaligol, M. 2004. Characterization of chars from pyrolysis of lignin. *Fuel* 83:1469–1482. doi:10.1016/j.fuel.2003.11.015
- Shelp, B. J., Allan, W. L. & Faure, D. 2009. Role of  $\gamma$ -aminobutyrate and  $\gamma$ -hydroxybutyrate in plant communication. In *Plant–Environment Interactions* (Baluska, F., ed.), pp. 73–84, Springer-Verlag, Berlin
- Shelp, B. J., Bown, A. W. & McLean, M. D. 1999. Metabolism and functions of  $\gamma$ -aminobutyric acid. *Trends Plant Sci.* 4, 446–452.
- Shen, J., Tang, H., Liu, J., Wang, C., Li, Y., Ge, T., Jones, D.L., & Wu, J., 2014. Contrasting effects of straw and straw-derived biochar amendments on greenhouse gas emissions within double rice cropping systems. *Agric. Ecosyst. Environ.* 188, 264–274.
- Shi, S., Richardson, A. E., O'Callaghan, M., DeAngelis, K. M., Jones, E. E., Stewart, A., et al. 2011. Effects of selected root exudate components on soil bacterial communities. *FEMS Microbiol. Ecol.* 77, 600–610. doi: 10.1111/j.1574-6941.2011.01150.x
- Silva-Olaya, A.M., Cerri, C.E.P., La Scala Jr, N., Dias, C.T.S., & Cerri, C.C., 2013. Carbon dioxide emissions under different soil tillage systems in mechanically harvested sugarcane. *Environ. Res. Lett.* 8, 1-8. <https://doi.org/10.1088/1748-9326/8/1/015014>
- Silveira, J.A.G., Melo, A.R.B., Martins, M.O., Ferreira-Silva, S.L., Aragão, R.M., Silva, E.N., et al. 2012. Salinity affects indirectly nitrate acquisition associated with glutamine accumulation in cowpea roots. *Biologia Plantarum*, 56(3):575–580.
- Simha, P.; Yadav, A.; Pinjari, D.; Pandit, A.B. On the behaviour, mechanistic modelling and interaction of biochar and crop fertilizers in aqueous solutions. *Resour. Technol.* 2016, 2, 133–142.

- Sivolodskii, E. P. 2009. Application of the profiles of amino acid utilization as the sole carbon and nitrogen sources for pseudomonad taxonomy. *Microbiology* 78 : 711 – 716 .
- Smirnov, A.N., et al. 2015. A novel antifungal peptide from leaves of the weed *Stellaria media* L. *Biochimie*;116:125–32. <https://doi.org/10.1016/j.biochi.2015.07.014>.
- Snyder, C. S., Bruulsema, T. W., Jensen, T. L., & Fixen, P. E. 2009. Review of greenhouse gas emissions from crop production systems and fertilizer management effects. In *Agriculture, Ecosystems and Environment* (Vol. 133, Issues 3–4, pp. 247–266). <https://doi.org/10.1016/j.agee.2009.04.021>
- Song, D., Tang, J., Xi, X., Zhang, S., Liang, G., Zhou, W., & Wang, X. 2018. Responses of soil nutrients and microbial activities to additions of maize straw biochar and chemical fertilization in a calcareous soil. *European Journal of Soil Biology*, 84, 1–10. <https://doi.org/10.1016/j.ejsobi.2017.11.003>
- Song, W., & Guo, M. 2012. Quality variations of poultry litter biochar generated at different pyrolysis temperatures. *Journal of Analytical and Applied Pyrolysis*, 94, 138–145. <https://doi.org/10.1016/j.jaap.2011.11.018>
- Song, X., Razavi, B. S., Ludwig, B., Zamanian, K., Zang, H., Kuzyakov, Y., et al. 2020. Combined biochar and nitrogen application stimulates enzyme activity and root plasticity. *Sci. Total Environ.* 735, 139393. [doi:10.1016/j.scitotenv.2020.139393](https://doi.org/10.1016/j.scitotenv.2020.139393)
- Song, Y., Li, Y., Cai, Y., Fu, S., Luo, Y., Wang, H., Liang, C., Lin, Z., Hu, S., Li, Y., & Chang, S. X. 2019. Biochar decreases soil N<sub>2</sub>O emissions in Moso bamboo plantations through decreasing labile N concentrations, N-cycling enzyme activities and nitrification/denitrification rates. *Geoderma*, 348, 135–145. <https://doi.org/10.1016/j.geoderma.2019.04.025>
- Sorai, M., Yoshida, N., Ishikawa, M. 2007. Biogeochemical simulation of nitrous oxide cycle based on the major nitrogen processes. *J. Geophys. Res.-Biogeophys.* 112.

- Sradnick, A., Oltmanns, M., Raupp, J., & Joergensen, R.G. 2014. Microbial residue indices down the soil profile after long-term addition of farmyard manure and mineral fertilizer to a sandy soil. *Geoderma* 226–227:79–84.
- Stefke, B., Windeisen, E., Schwanninger, M., & Hinterstoisser, B. 2008. Determination of the weight percentage gain and of the acetyl group content of acetylated wood by means of different infrared spectroscopic methods. *Anal. Chem.* 80:1272–1279. doi:10.1021/ac7020823.
- Stein, L., And, P., & Burris, R. H. 1983. Adenine Nucleotide Levels in and Nitrogen Fixation by the Cyanobacterium *Anabaena* sp. Strain 7120. In *JOURNAL OF BACTERIOLOGY* (Vol. 154, Issue 1).
- Steinauer, K., Chatzinotas, A., & Eisenhauer, N. 2016. Root exudate cocktails: the link between plant diversity and soil microorganisms? *Ecol. Evol.* 6, 7387–7396. doi: 10.1002/ece3.2454.
- Stevens, W.B., Hoefft, R.G., & Mulvaney, R.L. 2005. Fate of nitrogen-15 in a long-term nitrogen rate study: II. Nitrogen uptake efficiency. *Agron. J.* 97: 1046–1053. doi:10.2134/agronj2003.0313.
- Ström, L., Owen, A. G., Godbold, D. L., & Jones, D. L. 2002. Organic acid mediated P mobilization in the rhizosphere and uptake by maize roots. *Soil Biol. Biochem.* 34, 703–710. doi: 10.1016/S0038-0717(01)00235-8.
- Stuer-Lauridsen, B., & Nygaard, P. 1998. Purine salvage in two halophilic archaea: characterization of salvage pathways and isolation of mutants resistant to purine analogs. *J Bacteriol* 180:457–463.
- Su, W., Ahmad, S., Ahmad, I., & Han, Q. 2020. Nitrogen fertilization affects maize grain yield through regulating nitrogen uptake, radiation and water use efficiency, photosynthesis and root distribution. *PeerJ.* 8. <https://doi.org/10.7717/peerj.10291>
- Subbarao, G. V., Nakahara, K., Hurtado, M. P., Ono, H., Moreta, D. E., Salcedo, A. F., Yoshihashi, A. T., Ishikawa, T., Ishitani, M., Ohnishi-Kameyama, M., Yoshida, M., Rondon, M., Rao, I. M., Lascano, C. E., Berry, W. L., & Ito, O. 2009. Evidence for biological nitrification inhibition in *Brachiaria* pastures. *Proceedings of the National Academy of Sciences of the United States of*

America, 106(41), 17302–17307.  
<https://doi.org/10.1073/pnas.0903694106>

Subbarao, G. v., Nakahara, K., Ishikawa, T., Ono, H., Yoshida, M., Yoshihashi, T., Zhu, Y., Zakir, H. A. K. M., Deshpande, S. P., Hash, C. T., & Sahrawat, K. L. 2013. Biological nitrification inhibition (BNI) activity in sorghum and its characterization. *Plant and Soil*, 366(1–2), 243–259.  
<https://doi.org/10.1007/s11104-012-1419-9>.

Subbarao, G. V., Rondon, M., Ito, O., Ishikawa, T., Rao, I. M., Nakahara, K., Lascano, C., & Berry, W. L. 2007. Biological nitrification inhibition (BNI) - Is it a widespread phenomenon? *Plant and Soil*, 294(1–2), 5–18.  
<https://doi.org/10.1007/s11104-006-9159-3>.

Subbarao, G. V., Sahrawat, K. L., Nakahara, K., Ishikawa, T., Kishii, M., Rao, I. M., Hash, C. T., George, T. S., Srinivasa Rao, P., Nardi, P., Bonnett, D., Berry, W., Suenaga, K., & Lata, J. C. 2012. Biological nitrification inhibition-a novel strategy to regulate nitrification in agricultural systems. In *Advances in Agronomy* (1st ed., Vol. 114). Elsevier Inc. <https://doi.org/10.1016/B978-0-12-394275-3.00001-8>.

Subbarao, G.V., Ishikawa, T., Ito, O., Nakahara, K., Wang, H.Y., & Berry, W.L., 2006b. A bioluminescence assay to detect nitrification inhibitors released from plant roots: a case study with *Brachiaria humidicola*. *Plant and Soil* 288, 101e112

Subbarao, G.V., Ito, O., Sahrawat, K.L., Berry, W.L., Nakahara, K., Ishikawa, T., Watanabe, T., Suenaga, K., Rondon, M., & Rao, I.M. 2006a. Scope and strategies for regulation in agricultural systems challenges and opportunities. *Critical Review in Plant Science* 25: 303-335.

Sui, Y., Wang, Y., Xiao, W., Chang, C., Zhang, S., & Zhao, H. 2023. Proper Biochar Increases Maize Fine Roots and Yield via Altering Rhizosphere Bacterial Communities under Plastic Film Mulching. *Agronomy*, 13(1).  
<https://doi.org/10.3390/agronomy13010060>

Suliman, S. 2011. Does GABA increase the efficiency of symbiotic N<sub>2</sub> fixation in legumes. *Plant Signal & Behavior* 6, 32-36.

- Sulochana, C. B. 1962. B-vitamins in root exudates of cotton. In and Soil (Vol. 16, Issue 3). <https://www.jstor.org/stable/42932874>
- Sun, L., Lu, Y., Yu, F., Kronzucker, H. J., & Shi, W. 2016. Biological nitrification inhibition by rice root exudates and its relationship with nitrogen-use efficiency. *New Phytologist*, 212(3): 646–656. <https://doi.org/10.1111/nph.14057>.
- Sutoro (Balai Besar Penelitian dan Pengembangan Bioteknologi dan Sumberdaya Genetik Pertanian). 2015. Determinan agronomist produktivitas jagung (The agronomic factors determining maize productivity). *IPTEK Tanaman Pangan*, Vol.10., No.10: pp 39-46.
- Swiatkowski, Pakula, M., Biniak, S., & Walczyk, M. 2004. "Influence of the surface chemistry of modified activated carbon on its electrochemical behaviour in the presence of lead(II) ions," *Carbon*, vol. 42, no. 15, pp. 3057–3069, 2004.
- Sylvester-Bradley, R., Mosquera, D., Mendez, J.E. 1988. Inhibition of nitrate accumulation in tropical grass- land soils: effect of nitrogen fertilization and soil disturbance. *J Soil Sci* 39:407–416
- Tachibana ,S. 1982. Comparison of effects of root temperature on the growth and mineral nutrition of cucumber cultivars and figleaf gourd. *Engei Gakkai Zasshi.*, 51(3):299–308.
- Taghizadeh-Toosi, A., Clough, T.J., Condon, L.M., Sherlock, R.R., Anderson, C.R., & Craigie, R.A. 2011. Biochar Incorporation into Pasture Soil Suppresses in situ Nitrous Oxide Emissions from Ruminant Urine Patches. *J. Environ. Qual.* 40:468–476.
- Takeiuchi, et al. 1980. Nicotinamide-ammonium hydroxide plant growth regulator compositions. United Staes Patent.
- Tassoni, A., Antognoni, F., Sanvido, O., Bagni, N., Bagni, N., & Luisa Battistini M. 1998. Characterization of spermidine binding to solubilized plasma membrane proteins from zucchini hypocotyls. *Plant Physiol*;117:971-7; PMID:9662539; <http://dx.doi.org/10.1104/pp.117.3.971>.

- Taveira, G.B., Da Motta, O.V., Machado, O.L.T., Rodrigues, R., Carvalho, A.O., Teixeira-Ferreira, A., et al. 2014. Thionin-like peptides from *Capsicum annuum* fruits with high activity against human pathogenic bacteria and yeasts. *Biopolym - Pept Sci Sect*,102:30–9.
- Tegeder, M., and Ward, J. M. 2012. Molecular evolution of plant AAP and LHT amino acid transporters. *Frontiers in Plant Science* 3 :1 – 11 .
- Terce´-Laforgue, T., Dubois, F., Ferrario-Me´ry, S., Pou de Crezenzo, M.A., Sangwan, R., Hirel, B. 2004. Glutamate dehydrogenase of tobacco is mainly induced in the cytosol of phloem companion cells when ammonia is provided either externally or released during photorespiration. *Plant Physiology* 136, 4308–4317.
- Terras, F.R., Eggermont, K., Kovaleva, V., Raikhel, N.V., Osborn, R.W., Kester, A., Rees, S.B., Torrekens, S., Van Leuven, F., Vanderleyden, J. 1995. Small cysteine-rich antifungal proteins from radish: their role in host defense. *Plant Cell* 7:573–588.
- Tesfamariam, T., Yoshinaga, H., Deshpande, S.P., Rao, P.S., Sahrawat, K.L., Ando, Y., Nakahara, K., Hash, C.T., & Subbarao, G.V. 2014. Biological nitrification inhibition in sorghum: the role of sorgoleone production. *Plant Soil*, 379:325–335.
- Thangarajan, R., Bolan, N. S., Kunhikrishnan, A., Wijesekara, H., Xu, Y., Tsang, D. C. W., Song, H., Ok, Y. S., & Hou, D. 2018. The potential value of biochar in the mitigation of gaseous emission of nitrogen. *Science of the Total Environment*, 612, 257–268. <https://doi.org/10.1016/j.scitotenv.2017.08.242>.
- Tillard, P., Passama, L., & Gojon, A. 1998. Are phloem amino acids involved in the shoot to root control of NO<sub>3</sub> uptake in *Ricinus communis* plants? *J. Exp. Bot.* 49, 1371–1379. doi: 10.1093/jxb/49.325.1371
- Tofa, A.I., Kamara, A.Y., Babaji, B.A., Aliyu, K.T., Ademulegun, T.D., & Bebeley, J.F. 2022. Maize yield as affected by the interaction of fertilizer nitrogen and phosphorus in the Guinea savanna of Nigeria. *Heliyon*, 8: e11587. <https://doi.org/10.1016/j.heliyon.2022.e11587>.

- Tolessa, D., Du Preez, C.C., & Ceronio, G.M. Comparison of maize genotypes for grain yield, nitrogen uptake and use efficiency in Western Ethiopia. *S Afr J Plant Soil* (2007) 24: 70–76. <https://doi.org/10.1080/02571862.2007.10634784>.
- Tomar, P. C., Lakra, N., & Mishra, S. N. 2013. Cadaverine: A lysine catabolite involved in plant growth and development. In *Plant Signaling and Behavior* (Vol. 8, Issue 10). <https://doi.org/10.4161/psb.25850>
- Turk, H., Erdal, S., Dumlupinar, R. 2019. Exogenous carnitine application augments transport of fatty acids into mitochondria and stimulates mitochondrial respiration in maize seedlings grown under normal and cold conditions. *Cryobiology* 91:97–103. <https://doi.org/10.1016/j.cryobiol.2019.10.003>.
- Tzin, V., Galili, G., & Aharoni, A. 2012. Shikimate pathway and aromatic amino acid biosynthesis, eLS, pp. 1–10. doi: 10.1002/9780470015902.a0001315.pub2.
- Ubeda-Tomás, S., Swarup, R., Coates, J., Swarup, K., Laplaze, L., Beemster, G., et al. 2008. Root growth in *Arabidopsis* requires gibberellin/DELLA signalling in the endodermis. *Nature Cell Biology*. 2008; 10(5):625– 628. doi: 10.1038/ncb1726 PMID: 18425113.
- Udvardi, M.K., Price, G.D., Gresshoff, P.M., & Day, D.A. 1988. A dicarboxylate transporter on the peribacteroid membrane of soybean nodules. *FEBS Lett* 231:36–40. [https://doi.org/10.1016/0014-5793\(88\)80697-5](https://doi.org/10.1016/0014-5793(88)80697-5).
- Upchurch, R. G., & L. E. Mortenson. 1980. In vivo energetics and control of nitrogen fixation: changes in the adenylate energy charge and adenosine 5'-diphosphate/ adenosine 5'-triphosphate ratio of cells during growth on dinitrogen versus growth on ammonia. *J. Bacteriol.* 143:274-284.
- Uren, N. C. 2000. Types, amounts, and possible functions of compounds released into the rhizosphere by soil-grown plants. In *The Rhizosphere: Biochemistry and Organic Substances at the Soil-Plant Interface*. Eds. R Pinton, Z Varanini and P Nannipieri. pp. 19–40. Marcel Dekker, Inc, New York.
- Ussiri, D., & Lal, R. (2013). *Soil emission of nitrous oxide and its mitigation*. Springer Dordrecht Heidelberg: New York London.

- Ussiri, D.A.N., Lal, R., & Jarecki, M.K. 2009. Nitrous oxide and methane emissions from long-term tillage under a continuous corn cropping system in Ohio. *Soil Tillage Res.* (2009) 104: 247–255. <https://doi.org/10.1016/j.still.2009.03.001>.
- Vasantharajan, V., & Bhat, J. 1968. Interrelations of micro-organisms and mulberry. *Plant Soil* 29: 156–169.
- Vassileva, V., & Ignatov, G. 1999. Effect of polyamines on dicarboxylate and oxygen uptake by symbiosomes and free bacteroids from *Galega orientalis* nodules. *Symbiosis*; 27:59-71.
- Vidmar, J.J., Zhuo, D., Siddiqi, M.Y., Schoerring, J.K., Touraine, B. & Glass, A.D.M. 2000. Regulation of high-affinity nitrate transporter genes and high-affinity nitrate influx by nitrogen pools in roots of barley. *Plant Physiol.* 123: 307–318.
- Villegas, D., Arevalo, A., Nuñez, J., Mazabel, J., Subbarao, G., Rao, I., de Vega, J., & Arango, J. 2020. Biological Nitrification Inhibition (BNI): Phenotyping of a core germplasm collection of the tropical forage grass *Megathyrsus maximus* under greenhouse conditions. *Frontiers in Plant Science*, 11. <https://doi.org/10.3389/fpls.2020.00820>.
- Vincill, E. D., Clarin, A. E., Molenda, J. N., & Spalding, E. P. 2013. Interacting glutamate receptor-like proteins in phloem regulate lateral root initiation in *Arabidopsis*. *Plant Cell* 25, 1304–1313. doi: 10.1105/tpc.113.110668.
- Vitousek, P.M., Aber, J.D., Howarth, R.W., Likens, G.E., Matson, P.A., Schindler, D.W., Schlesinger, W.H., & Tilman, D.G. Human alteration of the global nitrogen cycle: Sources and consequences. *Ecol. Appl.* (1997) 7: 737–750. [https://doi.org/10.1890/1051-0761\(1997\)007\[0737:HAOTGN\]2.0.CO;2](https://doi.org/10.1890/1051-0761(1997)007[0737:HAOTGN]2.0.CO;2).
- Vogels, G.D., & Van der Drift, C. 1976. Degradation of purines and pyrimidines by microorganisms. *Bacteriol Rev* 40:403–468.
- Vranova, V., Rejsek, K., Skene, K.R. et al., 2013. Methods of collection of plant root exudates in relation to plant metabolism and purpose: a review. *J Plant Nutr Soil Sci* 176:175–199. <https://doi.org/10.1002/jpln.201000360>. <https://doi.org/10.1111/j.1365-313X.2007.03131.x>.

- Walch-Liu, P., Liu, L.-H., Remans, T., Tester, M., & Forde, B. G. 2006. Evidence that l-glutamate can act as an exogenous signal to modulate root growth and branching in *Arabidopsis thaliana*. *Plant Cell Physiol.* 47, 1045–1057. doi: 10.1093/pcp/pcj075.
- Walker, T.S., Bais, H.P., Grotewold, E., & Vivian, J.M. 2003. Root exudation and rhizosphere biology. *Plant Physiol.* Vol. 132, [www.plantphysiol.org](http://www.plantphysiol.org)
- Wan, H., Liu, X., Shi, Q., Chen, Y., Jiang, M., Zhang, J., Cui, B., Hou, J., Wei, Z., Hossain, M. A., & Liu, F. 2023. Biochar amendment alters root morphology of maize plant: Its implications in enhancing nutrient uptake and shoot growth under reduced irrigation regimes. *Frontiers in Plant Science*, 14. <https://doi.org/10.3389/fpls.2023.1122742>
- Wang, B., Lehmann, J., Hanley, K., Hestrin, R., & Enders, A., 2015. Adsorption and desorption of ammonium by maple wood biochar as a function of oxidation and pH. *Chemosphere* 138, 120–126. <https://doi.org/10.1016/j.chemosphere.2015.05.062>
- Wang, L., Meng, Y., Chen, G., Liu, X., Wang, L., & Chen, Y. 2019. Impact of maize growth on N<sub>2</sub>O emission from farmland soil. *Plant, Soil and Environment*, 65(4): 218–224. <https://doi.org/10.17221/774/2018-PSE>.
- Wang, S., Zhang, H., Huang, H., Xiao, R., Li, R., & Zhang, Z. 2020. Influence of temperature and residence time on characteristics of biochars derived from agricultural residues: A comprehensive evaluation. *Process Safety and Environmental Protection*, 139, 218–229. <https://doi.org/10.1016/j.psep.2020.03.028>
- Wang, Y.; Srinivasakannan, C.; Wang, H.; Xue, G.; Wang, L.; Wang, X.; Duan, X. Preparation of novel biochar containing graphene from waste bamboo with high methylene blue adsorption capacity. *Diam. Relat. Mater.* 2022, 125, 109034.
- Wang, Z., Zheng, H., Luo, Y., Deng, X., Herbert, S., & Xing, B. 2013. Characterization and influence of biochars on nitrous oxide emission from agricultural soil. *Environmental Pollution* 174 (2013) 289-296.
- Wang, Z., Zong, H., Zheng, H., Liu, G., Chen, L., & Xing, B. 2015. Reduced nitrification and abundance of ammonia-oxidizing bacteria in acidic soil amended with

biochar. *Chemosphere*, 138(3), 576–583.  
<https://doi.org/10.1016/j.chemosphere.2015.06.084>

- Wargo, M. J. 2013. Homeostasis and catabolism of choline and glycine betaine: lessons from *Pseudomonas aeruginosa*. *Appl. Environ. Microbiol.* 79: 2112-2120.
- Warnock, D.D., Lehmann, J., Kuyper, T. W., & Rillig, M.C. 2007 Mycorrhizal responses to biochar in soil—concepts and mechanisms *Plant Soil* 300 9–20
- Watanabe, M., M. Kusano, A. Oikawa, A. Fukushima, M. Noji, and K. Saito. 2008. “Physiological Roles of the Beta-Substituted Alanine Synthase Gene Family in *Arabidopsis*.” *Plant Physiology* 146 (1): 310–320. doi:10.1104/Pp.107.106831.
- Watson, R.J., Chan, Y.K., Wheatcroft, R., Yang, A.F., Han, S.H. 1988. *Rhizobium meliloti* genes required for C4-dicarboxylate transport and symbiotic nitrogen fixation are located on a megaplasmid. *J Bacteriol* 170: 927 – 934.
- Wells, N.S., & Baggs, E.M., 2014. Char amendments impact soil nitrous oxide production during ammonia oxidation. *Soil Sci. Soc. Am. J.* 78, 1656–1660
- West, P. M. 1939. Excretion of thiamine and biotin by the roots of higher plants. *Nature*, London 144, 1050-1051.
- Westergaard, B., Hansen, H.C.B. & Borggaard, O.K. 1998. Determination of anion in soil solution by capillary zone electrophoresis. *Analyst* 123: 721–724.
- White CS. 1988. Nitrification inhibition by monoterpenoids: theoretical mode of action based on molecular structures. *Ecology* 69:1631–1633
- White, C.S. 1991. The role of monoterpenes in soil nitrogen cycling in ponderosa pine. *Biogeochemistry* 12:43–68
- Wibisono M G, Sudarsono and Darmawan 2016 Karakteristik Andisol Berbahan Induk Breksi dan Lahar dari Bagian Timur Laut Gunung Gede, Jawa Barat [Characteristics of Andisol of Northeast Gunung Gede, West Java with Breccia and Volcanic Mudflow Parent Materials] *Jurnal Tanah dan Iklim* 40 1 pp 61-70

- Wijaya, R., Neumann, G.M., Condron, R., Hughes, A.B., Polya, G.M. 2000. Defense proteins from seed of *Cassia fistula* include a lipid transfer protein homologue and a protease inhibitory plant defensin. *Plant Sci* 159:243–255.
- Wingler, A., Lea, P. J., Quick, W. P. & Leegood, R. C. 2000 Photorespiration: metabolic pathways and their role in stress protection. *Phil. Trans. R. Soc. London Ser. B* 355, 1517–1529
- Worku, M., Bänziger, M., Erley, G.S.A.E., Friesen, D., Diallo, A.O., & Horst, W.J. 2007. Nitrogen uptake and utilization in contrasting nitrogen efficient tropical maize hybrids. *Crop Sci*, 47: 519–528. <https://doi.org/10.2135/cropsci2005.05.0070>.
- Wu, D., Feng, Y., Xue, I., Liu, M., Yang, B., Hu, F., & Yang, I. 2019. Biochar Combined with Vermicompost Increases Crop Production While Reducing Ammonia and Nitrous Oxide Emissions from a Paddy Soil. *Pedosphere*, 29(1), 82–94. [https://doi.org/10.1016/S1002-0160\(18\)60050-5](https://doi.org/10.1016/S1002-0160(18)60050-5).
- Xia, J., Psychogios, N., Young, N & Wishart, S. 2009. MetaboAnalyst: a web server for metabolomic data analysis and interpretation. *Nucleic Acids Research*, Vol. 37, Web Server issue.
- Xiang, Y., Deng, Q., Duan, H., & Guo, Y. 2017. Effects of biochar application on root traits: a meta-analysis. *GCB Bioenergy*, 9(10), 1563–1572. <https://doi.org/10.1111/gcbb.12449>
- Xiang-ling, L., Guo, L.G., Zhou, B.Y., Tang, X.M., Chen, C.C., Zhang, L., Zhang, S.Y., Li, C.F., Xiao, K., Dong, W.X., & Yin, B.Z. 2019. Characterization of low-N responses in maize (*Zea mays* L.) cultivars with contrasting nitrogen use efficiency in the North China Plain. *J. Integr. Agric.* (2019) 18: 2141–2152. [https://doi.org/10.1016/S2095-3119\(19\)62597-9](https://doi.org/10.1016/S2095-3119(19)62597-9).
- Xu, N., Tan, G., Wang, H., & Gai, X. 2016. European Journal of Soil Biology Effect of biochar additions to soil on nitrogen leaching, microbial biomass and bacterial community structure. *European Journal of Soil Biology*, 74, 1–8. <https://doi.org/10.1016/j.ejsobi.2016.02.004>
- Yamato, M., Okimori, Y., Wibowo, I.F., et al., 2006. Effects of the application of charred bark of *Acacia mangium* on the yield of maize, cowpea and peanut,

and soil chemical properties in South Sumatra, Indonesia. *Soil Science and Plant Nutrition*, 52, 489–495.

- Yang, H., Yan, R., Chen, H., Lee, D. H., & Zheng, C. 2007. Characteristics of hemicellulose, cellulose and lignin pyrolysis. *Fuel*, 86(12–13), 1781–1788. <https://doi.org/10.1016/j.fuel.2006.12.013>
- Yang, Z., Hu, Y., Zhang, S., Raza, S., Wei, X., and Zhao, X. 2022. The thresholds and management of irrigation and fertilization earning yields and water use efficiency in maize, wheat, and rice in China: A meta-analysis (1990–2020). *Agronomy*, 12: 709. <https://doi.org/10.3390/agronomy12030709>.
- Yeo, J.Y., Chin, B.L.F., Tan, J.K., & Loh, Y.S. 2017. Comparative studies on the pyrolysis of cellulose, hemicellulose, and lignin based on combined kinetics. *Journal of the Energy Institute* 92:27\_37.
- Yesbergenova-Cuny, Z., Dinant, S., Martin-Magniette, M.L., Quillere, I., Armengaud, P., Monfalet, P., et al. 2016. Genetic variability of the phloem sap metabolite content of maize (*Zea mays* L.) during the kernel-filling period. *Plant Sci.* 252: 347±357. <https://doi.org/10.1016/j.plantsci.2016.08.007> PMID: 27717471
- Yu, H., Gao, D., Khashi u Rahman, M., Chen, S., & Wu, F. 2023. L-phenylalanine in potato onion (*Allium cepa* var. *aggregatum* G. Don) root exudates mediates neighbor detection and trigger physio-morphological root responses of tomato. *Frontiers in Plant Science*, 14. <https://doi.org/10.3389/fpls.2023.1056629>
- Yu, Y., Jin, C., Sun, C., Wang, J., Ye, Y., Zhou, W., Lu, L., & Lin, X. 2016. Inhibition of ethylene production by putrescine alleviates aluminium-induced root inhibition in wheat plants. *Scientific Reports*, 6. <https://doi.org/10.1038/srep18888>
- Yufang, Lu, Xiaonan, Z., Jiafeng, J., Kronzucker, H.J., Weishou Shen, & Weiming Shi. 2019. Effects of the biological nitrification inhibitor 1,0-decanediol on nitrification and ammonia oxidizers in three agricultural soils. *Soil Biology and Biochemistry* 129: 48:59. <https://doi.org/10.1016/j.soilbio.2018.11.008>.
- Yurgel, S.N., & Kahn, M.L. 2004. Dicarboxylate transport by rhizobia. *J Exp Bot* 28: 489 – 501.

- Yuttitham, M., Chidthaisong, A., & Ruangchu, U. 2020. N<sub>2</sub>O fluxes and direct N<sub>2</sub>O emission factors from maize cultivation on oxisols in Thailand. *Geoderma Reg*, 20: e00244. <https://doi.org/10.1016/j.geodrs.2019.e00244>.
- Zablackis, E., Huang, J., Muller, B., Darvill, A. G., & Albersheim, P. 1995. Characterisation of the cell-wall polysaccharides of *Arabidopsis thaliana* leaves. *Plant Physiology*, 107, 1129–1138. <https://doi.org/10.1104/pp.107.4.1129>.
- Zakir, H. A. K. M., Subbarao, G. V., Pearse, S. J., Gopalakrishnan, S., Ito, O., Ishikawa, T., Kawano, N., Nakahara, K., Yoshihashi, T., Ono, H., & Yoshida, M. 2008. Detection, isolation and characterization of a root-exuded compound, methyl 3-(4-hydroxyphenyl) propionate, responsible for biological nitrification inhibition by sorghum (*Sorghum bicolor*). *New Phytologist*, 180(2), 442–451. <https://doi.org/10.1111/j.1469-8137.2008.02576.x>.
- Zhalnina, K., Louie, K.B., Hao, Z., Mansoori, N., da Rocha, U.N., Shi, S., Cho, H., Karaoz, U., Loque, D., Bowen, B.P., Firestone, M.K., Northen, T.R., & Brodie, E.L. 2018. Dynamic root exudate chemistry and microbial substrate preferences drive patterns in rhizosphere microbial community assembly. *Nature Microbiology* 3:470–480. DOI: <https://doi.org/10.1038/s41564-018-0129-3>, PMID: 29556109.
- Zhou, X. L., Liang, J. G., Luan, Y., Song, X. Y., & Zhang, Z. G. 2021. Characterisation of Bt maize IE09S034 in decomposition and response of soil bacterial communities. *Plant, Soil and Environment*, 67(5), 286–298. <https://doi.org/10.17221/629/2020-PSE>
- Zhu, M., Li, Q., Zhang, Y., Zhang, M., & Li, Z. 2022. Glycine betaine increases salt tolerance in maize (*Zea mays* L.) by regulating Na<sup>+</sup> homeostasis. *Front. Plant Sci.* 2022, 13, 978304. [CrossRef] [PubMed].
- Zhu, Q., Peng, X., & Huang, T. 2015. Contrasted effects of biochar on maize growth and N use efficiency depending on soil conditions. *International Agrophysics*, 29(2), 257–266. <https://doi.org/10.1515/intag-2015-0023>
- Zijian He, Wang, C., Cao, H., Liang, J., Pei, S., & Zhijun Li. 2023. Nitrate absorption and desorption by biochar. *Agronomy*, 13: 2440. <https://doi.org/10.3390/agronomy13092440>