UNIVERSITI PUTRA MALAYSIA

POTENTIAL USE OF FUNCTIONAL BACTERIA FROM TROPICAL REHABILITATED FOREST AS BIO-FERTILIZER

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FSPM 2017 3

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

August 2017

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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August 2017

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Rehabilitated forests are established in an effort to overcome the threat of major soil degradation and erosion. Soil cellulolytic, nitrogen-fixing (N-fixing), and phosphate-solubilizing microorganisms are very important functional microbial groups in regulating the elemental cycle, and plant nutrition in forest soil. Bacteria, reflected by their major abundance among microbial groups, make up a large constitution of biodiversity in soils, and they participate in soil key processes which eventually impact the whole terrestrial ecosystems operations. Relationship between soil cellulolytic, N-fixing, and phosphate-solubilizing bacterial counts, and forest stand ages of 4, 9, 14, and 19 were assessed as means to evaluate soil health of planted forests. All cellulolytic, N-fixing, and phosphate-solubilizing populations showed linear relationships with forest age. These functional bacterial populations demonstrated good potential to be adopted as soil health indicators in the rehabilitated forest. Assessment of functional bacterial population sizes should be ongoing with forest stand succession for better understanding their relationships, and growth trends. Out of 15 functional isolates, cellulolytic isolate *Serratia nematodiphila* C46d, N-fixing isolate *Burkholderia nodosa* NB1, and phosphate-solubilizing isolate *Burkholderia cepacia* PB3 with outstanding plant growth-promoting (PGP) activities were selected for a pot trial. The treatments evaluated in the pot trial were: 1) control with no bacterial inoculation, and no chemical fertilizer (Control); 2) no bacterial inoculation but with compost, and chemical fertilizer combination at 50% fertilization level (OM); 3) inoculation with C46d, and with compost and chemical fertilizer combination at 50% fertilization level (TC); 4) inoculation with NB1, and with compost, and chemical fertilizer combination at 50% fertilization level (TN); 5) inoculation with PB3, and with compost, and chemical fertilizer combination at 50% fertilization level (TP); 6) inoculation in consortium of C46d, NB1, and PB3, with compost, and chemical fertilizer combination at 50% fertilization level (TCNP); and 7) control with no bacterial inoculation, and no compost, but only with chemical fertilizer at 100% fertilization level (Chemical Fertilizer). Cellulolytic population was highest at all

bacterial treatments; N fixers dominant in TN, TP, and TCNP whereas phosphate-solubilizers fluorished in TP and TCNP. Only N fixers demonstrated significant effects on plant biomass, from positive relationships with plant N and P uptake. This present study indicated presence of some efficient and effective cellulolytic, N-fixing, and phosphate-solubilizing bacterial species among the natural rhizobacterial community in soils of tropical rehabilitated forest at Universiti Putra Malaysia Bintulu Campus. These attributes are indispensable growth promoting factors for the planted trees, and natural vegetation thriving amid ongoing threat of soil degradation. Treatment with N-fixing species *Burkholderia nodosa* NB1 alone resulted in higher root and total N use efficiencies, besides leaves, roots, and total P efficiencies by multiple folds than full chemical fertilizer treatment. Incorporating PGPR isolates with compost and chemical fertilizer proved sustainable in integrated nutrient management (INM) system with minimized usage of chemical fertilizers. *Burkholderia nodosa* NB1 demonstrates good potential in future field trials before application as bio-fertilizer. Future studies should include more thorough characterization of this particular isolate prior to practical field applications.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

POTENSI KEGUNAAN BAKTERIA BERFUNGSI DARI HUTAN DIPULIHARA TROPIKA SEBAGAI BIO-BAJA

Oleh

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Hutan dipulihara untuk menangani ancaman degradasi dan hakisan tanah yang menular. Mikroorganisma tanah yang terdiri daripada selulolitik, pengikat-nitrogen, dan pelarut-fosfat adalah kumpulan berfungsi yang amat penting dalam pengawalan kitaran elemen dan nutrisi tumbuhan dalam tanah hutan. Bakteria, melalui bilangannya yang terbesar di antara kumpulan-kumpulan mikrob membentuk badan biodiversiti terbesar di tanah, dan mengambil bahagian dalam proses-proses utama tanah yang akhirnya memberi impak ke atas keseluruhan operasi ekosistem daratan. Hubungan antara bilangan populasi bakteria tanah selulolitik, pengikat-nitrogen, dan pelarut-fosfat dan hutan berusia 4, 9, 14, dan 19 tahun telah dinilai untuk tujuan mengevaluasi kesihatan tanah hutan dipulihara. Populasi ketiga-tiga kumpulan bakteria iaitu selulolitik, pelarut-fosfat, dan pengikat-nitrogen menunjukkan hubungan linear dengan usia hutan. Ketiga-tiga kumpulan berfungsi bakteria ini menunjukkan potensi yang baik untuk diterima sebagai petunjuk kesihatan tanah hutan dipulihara. Penilaian saiz populasi bakteria berfungsi disarankan untuk dijalankan secara berterusan seiring dengan peningkatan usia hutan untuk lebih memahami perhubungan di antara mereka, beserta dengan aliran pertumbuhan mereka. Daripada 15 isolat berfungsi, isolat selulolitik *Serratia nematodiphila* C46d, isolat pengikat-nitrogen *Burkholderia nodosa* NB1, dan isolat pelarut-fosfat *Burkholderia cepacia* PB3 yang memberikan aktiviti meningkatkan pertumbuhan pokok terbaik telah dipilih dalam eksperimen pasu yang mempunyai tujuh rawatan: 1) kawalan, tanpa inokulasi bakteria, dan tanpa baja kimia (Kawalan); 2) tanpa inokulasi bakteria, dan ditambah campuran kompos dengan baja kimia dalam tahap pembajaan sebanyak 50% (OM); 3) inokulasi dengan isolat C46d, dan ditambah campuran kompos, dan baja kimia dalam tahap pembajaan sebanyak 50% (TC); 4) inokulasi dengan isolat NB1, dan ditambah campuran kompos, dan baja kimia dalam tahap pembajaan sebanyak 50% (TN); 5) inokulasi dengan isolat PB3, dan ditambah campuran kompos, dan baja kimia dalam tahap pembajaan sebanyak 50% (TP); 6) inokulasi dengan konsortia bakteria yang terdiri daripada isolat C46d,

NB1, dan PB3 dan ditambah campuran kompos, dan baja kimia dalam tahap pembajaan sebanyak 50% (TCNP); dan 7) kawalan, tanpa inokulasi bakteria, dan tanpa kompos, tetapi hanya ditambah baja kimia dengan tahap pembajaan sebanyak 100% (Chemical Fertilizer). Populasi bakteria selulolitik adalah tertinggi dalam keseluruhan rawatan bakteria; populasi bakteria pengikat-nitrogen adalah dominan dalam rawatan TN, TP, dan TCNP, manakala populasi bakteria pelarut-fosfat adalah tertinggi dalam rawatan TP dan TCNP. Hanya bakteria pengikat-nitrogen memberikan kesan signifikan ke atas biojisim pokok hasil hubungan positif dengan pengambilan nitrogen dan fosforus pokok. Kajian ini menunjukkan kehadiran beberapa spesies bakteria selulolitik, pengikat-nitrogen, dan pelarut-fosfat yang efisien dan efektif di antara komuniti rhizobakteria semula jadi dalam tanah hutan dipulihara tropika di Universiti Putra Malaysia Kampus Bintulu. Sifat-sifat ini adalah faktor peningkatan pertumbuhan yang penting untuk pokok-pokok yang ditanam dan tumbuhan asli yang bertumbuh dengan pesat di tengah-tengah ancaman kemerosotan tanah yang berterusan. Rawatan dengan spesies pengikat-nitrogen *Burkholderia nodosa* NB1 sahaja memberikan kecekapan penggunaan nitrogen akar, dan keseluruhan penggunaan nitrogen yang lebih tinggi, selain meningkatkan kecekapan penggunaan fosforus daun, akar, dan keseluruhan penggunaan fosforus sebanyak berkali ganda daripada rawatan penuh menggunakan baja kimia. Gabungan penggunaan isolat rhizobakteria yang meningkatkan pertumbuhan pokok dengan kompos dan baja kimia membuktikan kemampanan sistem pengurusan nutrien bersepadu dengan penggunaan baja kimia yang minima. *Burkholderia nodosa* NB1 menunjukkan potensi yang baik untuk ujian lapangan di masa hadapan sebelum diaplikasi sebagai bio-baja. Kajian masa hadapan disarankan untuk menerapkan lebih banyak pencirian yang lebih teliti ke atas isolat ini sebelum aplikasi lapangan praktikal.

ACKNOWLEDGEMENTS

First and foremost, all glory, dedication, praises and thanks be to Most High the Triune God, the source of Life, who richly bestowed upon me all the strength, courage, wisdom, resources and opportunity to endure all the challenges in completion of this work. Without the faith in Him or His blessings showered upon me, I could never have achieved this or anything possible.

I am deeply indebted to my supervisor Prof. Dr. Ahmed Osumanu Haruna, my co-supervisor, Prof. Dato Dr. Nik Muhamad Bin Nik Majid, and late Dr. Wong Sing King for their patience and guidance in helping me to complete this thesis.

I would like to express my utmost gratitude to my family, loved ones, my friends and to staffs of UPM Bintulu Campus for their assistance and support throughout my study.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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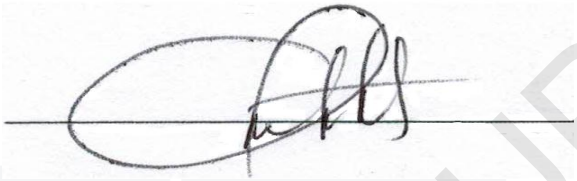
Signature: 
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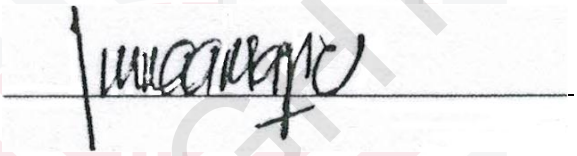
Signature: 
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LIST OF ABBREVIATIONS

BNF	Biological nitrogen fixation
PSB	Phosphate-solubilizing bacteria
PSM	Phosphate-solubilizing microorganisms
PGPR	Plant growth-promoting rhizobacteria
PGPB	Plant growth-promoting bacteria
PGP	Plant growth-promoting
16S rDNA	16S ribosomal deoxyribonucleic acid
IAA	Indole-3-acetic acid
OD	Optical density
SVI	Seedling vigor index
C/N	Carbon/nitrogen ratio
CEC	Cation exchange capacity
OM	Organic matter
INM	Integrated nutrient management
MOP	Muriate of potash or KCl
ERP	Egyptian Rock Phosphate
DAS	Days after sowing
AAS	Atomic absorption spectrophotometer
SAS	Statistical Analysis System

CHAPTER 1

INTRODUCTION

Soil, being one of the basic natural resources, apart from air and water, has long been acknowledged for its forest production roles, as well as its notable functions in conservation, and improvement of ecosystem services. Tropical forests, being a continuous flux and self-restructuring system are indispensable regulator of C cycle, soil, water, and biological preservation, as well as protection from erosion, drought, and flood, besides woody and non-woody production, *via* the establishment of forest plantations, and agroforestry programme (Karam *et al*., 2012; Aquilar-Amuchastequi and Henebry, 2007; González-Iturbe *et al*., 2002; Food and Agriculture Organization, 1995).

Soil microbial populations affect soil fertility and elemental cycle. According to Anderson (2003), the associations between functional microbial communities, and the cycles of crucial elements in particularly carbon (C), nitrogen (N), phosphorus (P), and sulfur (S), as well as their effects on development of plants could serve as key signs of soil health level in view of disturbances. Soil microorganisms, albeit their miniature volume, reflect the dominant populations in soil, and hence, play essential roles in soil processes involving transformation of nutrients, and rates of litter decomposition, which are vital elements of the biological balance in soils (Arias *et al*., 2005; Zak *et al*., 1994). Bacteria make up a large constitution of microbial diversity in soils, and participate in soil key processes that eventually impact the whole terrestrial ecosystems operations, by being involved in completing nutrient, and geochemical cycles (Bardgett *et al*., 2008; Fulthorpe *et al*., 2008; Roesch *et al*., 2007).

The forest floor is amassed with dead plant residue primarily consisting of plant cell wall constituents which include cellulose, the most abundant biopolymer, making up 20-30% of plant litter mass (Berg and Laskowski, 2006). Soil microorganisms are mainly responsible for the decomposition of cellulose by reducing the complex polysaccharides into simple sugars, in which they assimilate (Baldrian and Valášková, 2008; Lynd *et al*., 2002). With bacteria known to be more prolific over saprotrophic fungi with their capability to consume inherently dilute nutrients in tropical soils (Baldrian *et al*., 2012), the study of cellulolytic bacteria in tropical soils is significantly important.

Being one of the key elements for plant development and essentially soil fertility, plant requirement for N are supplied by processes of organic matter decomposition, atmospheric N deposition, and BNF, in which 97% of natural N input is attributed to BNF (Galloway *et al*., 2008; Dreyfus *et al*., 1987) by *Bacteria* and *Archaea* (Eady, 1992; Young, 1992). The N-fixing microorganisms

(diazotrophs) mostly prevail at free-living condition, and as much as 12.2 to 36.1 kg N ha^{-1} $year^{-1}$ could be produced by them in the N budget in tropical ecosystems (Cleveland *et al*., 1999), making them one of the most indispensable causes for studies, in particularly on their occurrence in tropical rehabilitated forests, which remains very lacking.

Phosphorus is one of the most commonly limiting macronutrients in most tropical soils with highest P fixation capacity area occupied 1,018 million hectares (ha) (Sanchez and Logan, 1992). The tropical soils are usually highly acidic, typically characterized by high Al and/or Fe contents which fix P as insoluble mineral complexes, rendering P to be unavailable for root uptake (Rengel and Marschner, 2005). The incorporation of microorganisms has been used over the years to enhance nutrient availability in soils (in particularly P) and reduce Al toxicity (Panhwar *et al*., 2014), apart from the application of chemical treatment. The acidic tropical soils contain low amount of total microorganisms, which differ substantially, based on vegetation type and soil management. There are only limited acid-tolerant plant species and microbes that are able to thrive in these soils, which warrant studies.

Major drawbacks of chemical fertilizer application alone in terms of its expenses, availability and environmental impacts in particularly from N fertilizers have created the urgent need for alternative and sustainable strategies. Harmful influences of conventional N and P fertilization alone could be mitigated with application of INM system. This approach boosts little chemical usage but enhances nutrient-use efficiency with natural and man-made origin complement of plant nutrients for improved crop yield in a productive and environmentally friendly way (Gruhn *et al*., 2000). The use of microbial inoculants (bio-fertilizers) possessing plant growth promotion traits is considered as an environmental-friendly alternative to further applications of chemical based fertilizers. Some of particular functional bacteria could have cross-functional abilities besides their principal functional ability, which could have other beneficial effects such as production of PGP phytohormones, polysaccharides and organic acids that are essential to plants and improve their growths (Panhwar *et al*., 2014).

A complex network of plants and microbes is embodied in soils in an uneven solid medium, which is with differing chemical and physical conditions at molecular and cellular level. Microorganisms influence the environment and *vice versa*; hence, the understanding obtained from both chemical and biological approaches are needed in comprehending the changes in soils. Despite the need of soil physical, chemical, and biological properties to be investigated concurrently in order to assess sustainability/unsustainability of varying management practices, numerous studies in developing countries have merely delved into physical and chemical properties only (Laishram *et al*., 2012).

The general objectives of this study were to: 1) evaluate functional bacterial populations in selected forest age as means to determine soil health of rehabilitated forest, and in understanding the association of the functional bacterial populations with selected soil properties in regulating forest soil ecology dynamics, as well as to: 2) characterize and identify selected functional bacteria, and assessing their potential use as bio-fertilizer.

This study was conducted to determine the: 1) relationship between cellulolytic, N-fixing, and phosphate-solubilizing bacterial populations with selected tropical rehabilitated forest stand age, as means to evaluate soil health of planted forest, 2) relationship between functional bacterial populations with some selected soil physico-chemical properties, with the intent of better understanding how these functional bacterial populations are associated or related to these soil properties in regulating the forest soil ecology dynamics, 3) isolate and identify beneficial cellulolytic, N-fixing, and phosphate-solubilizing bacteria from tropical rehabilitated forest soils, 4) characterize selected bacterial isolates for some phenotypic and biochemical properties, as well as PGP activities such as their respective functional activities, IAA production, and early plant growth promotion, and 5) potential bio-fertilizer effects of cellulolytic *Serratia nematodiphila* C46d, N-fixing *Burkholderia nodosa* NB1, and phosphate-solubilizing *Burkholderia cepacia* PB3, on functional rhizobacterial interactions, nutrient uptake and use efficiency of maize, and properties of Bekenu series by means of pot trial.

REFERENCES

Abril, A., Zurdo-Pineiro, J.L., Peix, A., Rivas, R. and Velazquez, E. 2007. Solubilization of phosphate by a strain of *Rhizobium leguminosarum* bv. *Trifolii* isolated from *Phaseolus vulgaris* in El Chaco Arido soil (Argentina). In: Developments in Plant and Soil Sciences. Velazquez, E., Rodriguez-Berrueco, C. (eds). The Netherlands. Springer. pp. 135–138.

Ahmad, F., Ahmad, I. and Khan, M.S. 2005. Indole acetic acid production by the indigenous isolates of *Azotobacter* and fluorescent *Pseudomonas* in the presence and absence of tryptophan. Turkish Journal of Biology 29: 29-34.

Ahmad, F., Ahmad, I. and Khan, M.S. 2008. Screening of free-living rhizospheric bacteria for their multiple plant growth promoting activities. Microbiology Research 163(2): 173–181.

Ahuja, A., Ghosh, S.B. and D'Souza, S.F. 2007. Isolation of a starch utilizing, phosphate solubilizing fungus on buffered medium and its characterization. Bioresource Technology 98: 3408–3411. doi: 10.1016/j.biortech.2006.10.041.

Aikio, S., Vare, H. and Strommer, R. 2000. Soil microbial activity and biomass in the primary succession of a dry heath forest. Soil Biology and Biochemistry 32(8-9): 1091-1100. doi:10.1016/S0038-0717(00)00019-5.

Aiza, J.S., Arifin, A., Hamid, H.A., Akbar, M.H., Banga, T.S., Jusop, S. and Majid, N.M. 2013. Assessing soil fertility status of rehabilitated degraded tropical rainforest. American Journal of Environmental Sciences 9(3): 280-291.

Akbar, M.H., Ahmed, O.H., Jamaluddin, A.S., Majid, N.M., Abdul-Hamid, H., Jusop, S., Hassan, A., Yusof, K.H. and Abdu, A. 2010. Differences in soil physical and chemical properties of rehabilitated and secondary forests. American Journal of Applied Sciences 7(9): 1200-1209. doi:10.3844/ajassp.2010.1200.1209.

Alexander, M. 1997. Introduction to Soil Microbiology, 2nd edition. John Wiley and Sons Inc. New York.

Ali, A., Hameed, S., Oresnik, I.J., Shahid, M., Tariq, M. and Ahmad, N. 2015. An improved method for bacterial identification through 16S rDNA sequencing using double set of primers: A case study. Pakistan Journal of Agriculture Science 52(2): 285-291.

Allison, V.J., Yermakov, Z., Miller, R.M., Jastrow, J.D. and Matamala, R. 2007. Using landscape and depth gradients to decouple the impact of correlated environmental variables on soil microbial community composition. Soil Biology and Biochemistry 39: 505–516.

Almario, J., Kyselková, M., Kopecký, J., Ságová-Marečková, M., Muller, D., Grundmann, G.L. and Moënne-Loccoz, Y. 2013a. Assessment of the relationship between geologic origin of soil, rhizobacterial community composition and soil receptivity to tobacco black root rot in Savoie region (France). Plant Soil 371: 397. doi: 10.1007/s11104-013-1677-1.

Almario, J., Prigent-Combaret, C., Muller, D. and Mënne-Loccoz, Y. 2013b. Effect of clay mineralogy on iron bioavailability and rhizosphere transcription of 2,4-diacetylphloroglucinol biosynthetic genes in biocontrol *Pseudomonas protegens*. Molecular Plant-Microbe Interactions 26: 566–574. doi: 10.1094/MPMI-11-12-0274-R.

Altomare, C. and Tringovska, I. 2011. Beneficial soil microorganisms, an ecological alternative for soil fertility management. In: Genetics, biofuels and local farming systems. Lichtfouse, E. (ed). Sustainable Agriculture Reviews. Netherlands. Springer. pp. 161–214.

Altomare, C., Norvell, W.A., Björkman, T. and Harman, G.E. 1999. Solubilization of phosphates and micronutrients by the plant-growth-promoting and biocontrol fungus *Trichoderma harzianum Rifai* 1295– 22. Applied and Environmental Microbiology 65(7): 2926–2933.

Amako, K., Takade, A., Taniai, H., and Yoshida, S.-I. 2008. Electron microscopic examination of uncultured soil–dwelling bacteria. Microbiology and Immunology 52: 265–269.

Amann, R.I., Ludwig, W. and Schleifer, K.-H. 1995. Phylogenetic identification and *in situ* detection of individual microbial cells without cultivation. Microbiology Reviews 59(1): 143-169.

Ambawade, M.S. and Pathade, G.R. 2013. Production of indole acetic acid (IAA) by *Stenotrophomonas maltophilia* BE25 isolated from roots of banana (*Musa* spp.). International Journal of Science and Research (IJSR) 2319-7064.

Anderson, T. 2003. Microbial eco-physiological indicators to assess soil quality. Agriculture, Ecosystems and Environment 98(1-3): 285-293.

Andrews, S.S. and Carroll, C.R. 2001. Designing a decision tool for sustainable agroecosystem management: Soil quality assessment of a poultry litter management case study. Ecological Applications 11(6): 1573-1585.

Andrews, S.S., Karlen, D.L. and Mitchell, J.P. 2002. A comparison of soil quality indexing methods for vegetable production systems in Northern California. Agriculture, Ecosystems and Environment 90: 25-45.

Andrus, A.D., Andam, C. and Parker, M.A. 2012. American origin of *Cupriavidus* bacteria associated with invasive *Mimosa* legumes in the Philippines. FEMS Microbiology Ecology 80: 747-750.

Anitha, K.G. and Thangaraju, M. 2010. Growth promotion of rice seedlings by *Gluconacetobacter diazotrophicus* under *in vitro* conditions. Journal of Cell and Plant Sciences 1(1): 6-12.

Anjum, M.A., Sajjad, M.R., Akhtar, N., Qureshi, M.A., Iqbal, A., Rehman, A. and Mahmud-ul-Hasan. 2007. Response of cotton to plant growth promoting rhizobacteria (PGPR) inoculation under different levels of nitrogen. Journal of Agriculture Research 45(2): 135-143.

Antoun, H. and Kloepper, J.W. 2001. Plant growth-promoting rhizobacteria (PGPR) Encyclopedia of Genetics. In: Encyclopedia of Genetics. Brenner, S. and Miller, J.H. (eds). Academic. New York. pp. 1477–1480.

Antoun, H. and Prevost, D. 2005. Ecology of plant growth promoting rhizobacteria. In: PGPR: Biocontrol and Biofertilization. Siddiqui, Z.A. (eds.) Springer. The Netherlands. pp. 1- 39.

Aon, M.A. and Colaneri, A.C. 2001. Temporal and spatial evolution of enzymatic activities and physico-chemical properties in an agricultural soil. Applied Soil Ecology 18: 255-270.

Aquilar-Amuchastequi, N. and Henebry, G.M. 2007. Assessing sustainability indicators for tropical forests: Spation-temporal heterogeneity, logging intensity and dung beetle communities. Forest Ecology and Management 253(1-3): 56-67. doi: 10.1016/j.foreco.2007.07.004.

Arias, M.E., González-Pérez, J.A., González-Vila, F.J. and Ball, A.S. 2005. Soil health- A new challenge for microbiologists and chemists. International Microbiology 8: 13-21.

Ariffin, H., Abdullah, N., Umi Kalsom, M.S., Shirai, Y. and Hassan, M.A. 2006. Production and characterisation of cellulase by *Bacillus pumilus* EB3. International Journal of Engineering and Technology 3(1): 47-53.

Abdu, A., Tanaka, S., Jusop, S., Majid, N.M., Ibrahim, Z., Sakurai, K. and Wasli, M.E. 2008a. Assessment on soil fertility status and growth performance of planted dipterocarp species in Perak, Peninsular Malaysia. Journal of Applied Sciences 8: 3795-3805.

Abdu, A., Tanaka, S., Jusop, S., Majid, N.M., Ibrahim, Z. and Sakurai, K. 2008b. Rehabilitation of degraded tropical rainforest in Peninsular Malaysia with a multi-storied plantation technique of indigenous dipterocarp species. Journal of Environments 50(2): 141-152.

Abdu, A., Tanaka, S., Jusop, S., Ibrahim, Z., Hattori, D., Majid, N.M. and Sakurai, K. 2007. Soil characteristics under rehabilitation of degraded forestland in Perak, Peninsular Malaysia. Pedologist 51(2): 76-88.

Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigor determination in soybean seed by multiple criteria. Crop Science 13(6):630–633.

Aro, N., Pakula, T. and Penttilä, M. 2005. Transcriptional regulation of plant cell wall degradation by filamentous fungi. FEMS Microbiology Reviews 4: 719-739.

Arpin, P., Ponge, J.F., Faille, A. and Blaudin, P. 1998. Diversity and dynamics of eco-units in the biological reserves of the Fontainebleau Forest (France): Contribution of soil biology to a functional approach. European Journal of Soil Biology 34: 167-177. doi: 10.1016/S1164-5563(00)86659-5.

Arshad, M. and Frankenberger, W.T. 1991. Microbial production of plant hormones. Plant Soil 133(1): 1-8. doi:10.1007/BF00011893.

Arshad, M.A. and Martin, S. 2002. Identifying critical limits for soil quality indicators in agroecosystems. Agriculture, Ecosystems and Environment 88(2): 153-160.

Asea, P.E.A., Kucey, R.M.N. and Stewart, J.W.B. 1988. Inorganic phosphate solubilization by two *Penicillium* species in solution culture and soil. Soil Biology and Biochemistry 20: 459–464. doi: 10.1016/0038-0717(88)90058-2.

Asghar, H.N., Zahir, Z.A. and Arshad, M. 2004. Screening rhizobacteria for improving the growth, yield, and oil content of canola (*Brassica napus* L). Australian Journal of Agriculture Research 55(2): 187-194.

Asghar, H.N., Zahir, Z.A., Khaliq, A. and Arshad, M. 2000. Assessment of auxin production from rhizobacteria isolated from different varieties of rapeseed. Pakistan Journal of Agriculture Science 37(3-4): 101-104.

Ashagrie, Y., Zech, W., Guggenberger, G. and Mamo, T. 2007. Soil aggregation and total and particulate organic matter following conversion of native forests to continuous cultivation in Ethiopia. Soil and Tillage Research 94: 101–108.

Atlas, R. and Bartha, R. 1997. Microbial ecology. New York: Addison Wesley Longman.

Atlas, R.M. 1984. Use of microbial diversity measurements to assess environmental stress. In: Current Perspectives in Microbial Ecology. Klug, M.J. and Reddy, C.A. (eds.). American Society for Microbiology, Washington, D.C. pp. 540–545.

Aweto, A.O. 2013. Shifting cultivation and secondary succession in the tropics. Technology and Engineering. CABI Publishing. pp. 40-41.

Azam, F. and Memon, G.H. 1996. Soil organisms. In: Soil science. Bashir, E. and Bantel, R. (eds). Islamabad. National Book Foundation. pp. 200–232.

Babalola, O.O. 2010. Beneficial bacteria of agricultural importance. Biotechnology Letters 32: 1559-1570.

Babu-Khan, S., Yeo, T.C., Martin, W.L., Rogers, R.D. and Goldstein, A.H. 1995. Cloning of a mineral phosphate-solubilizing gene from *Pseudomonas cepacia*. Applied and Environmental Microbiology 61: 972–976.

Bakker, A.W. and Schipperes, B. 1987. Microbial cyanide production in the rhizosphere in relation to potato yield reduction and *Pseudomonas* spp.-mediated plant growth-stimulation. Soil Biology and Biochemistry 19(4): 451-457. doi: 10.1016/0038-0717(87)90037-X.

Baldrian, P. and Valášková, V. 2008. Degradation of cellulose by basidiomycetous fungi. FEMS Microbiology Reviews 32: 501–521.

Baldrian, P., Kolařík, M., Stursová, M., Kopecký, J., Valášková, V., Větrovský, T., Zifčáková, L., Snajdr, J., Rídl, J., Vlček, C. and Voříšková, J. 2012. Active and total microbial communities in forest soil are largely different and highly stratified during decomposition. ISME Journal 6(2): 248–258. doi: 10.1038/ismej.2011.95.

Banning, N.C., Gleeson, D.B., Grigg, A.H., Grant, C.D., Andersen, G.L., Brodie, E.L. and Murphy, D.V. 2011. Soil microbial community successional patterns during forest ecosystem restoration. Applied and Environmental Microbiology 77(17): 6158-6164.

Barabasz, W., Albińska, D., Jaśkowska, M. and Lipiec, J. 2002. Biological effects of mineral nitrogen fertilization on soil microorganisms. Polish Journal of Environmental Studies 11(3): 193-198.

Barazani, O.Z. and Friedman, J. 1999. Is IAA the major root growth factor secreted from plant-growth mediating bacteria? Journal of Chemical Ecology 25(10): 2397- 2406.

Barber, D.A. 2012. Chapter 4 Nutrient uptake. In: Interactions Between Non-pathogenic Soil Microorganisms and Plants. Developments in Agricultural and Managed-Forest Ecology 4. Dommergues, Y.R. and Krupa, S.V. (eds).

Barber, S.A. 1995. Soil nutrient bioavailability. Wiley, New York: A mechanistic approach.

Bardgett, R.D., Kandeler, E., Tscherko, D., Hobbs, P.J., Jones, T.H., Thompson, L. and Bezemer, T.M. 1999. Below-ground microbial community development in a high temperature world. Oikos 85: 193–203.

Bardgett, R.D., Freeman, C. and Ostle, N.J. 2008. Microbial contributions to climate change through carbon cycle feedbacks. ISME Journal 2: 805–814.

Barea, J.M. and Brown, M.E. 1974. Effects on plant growth by *Azotobacter paspali* related to synthesis of plant growth regulating substances. Journal of Applied Bacteriology 37: 583-593.

Barley, K.P. 1970. The configuration of the root system in relation to nutrient uptake. Advances in Agronomy 22: 159-201.

Barriuso, J., Pereyra, M.T., Lucas Garcia, J.A., Megias, M., Gutiérrez Mañero, F.J. and Ramos, B. 2005. Screening for putative PGPR to improve establishment of the symbiosis *Lactarius deliciosus-Pinus* sp. Microbial Ecology 50: 82-89. doi: 10.1007/s00248-004-0112-9.

Bar-Tal, A., Yermiyahu, U., Beraud, J., Keinan, M., Rosenber, R., Zohar, D., Rosen, V. and Fine, P. 2004. Nitrogen, phosphorus, potassium uptake by wheat and their distribution in soil following succesive, annual compost applications. Journal of Environmental Quality 33: 1855-1865.

Bar-Yosef, B., Rogers, R.D., Wolfram, J.H. and Richman, E. 1999. *Pseudomonas cepacia*-mediated rock phosphate solubilization in kaolinite and montmorillonite suspensions. Soil Science Society of American Journal 63: 1703–1708. doi: 10.2136/sssaj1999.6361703x.

Bashan, Y., Kamnev, A.A. and de Bashan, L.E. 2013a. A proposal for isolating and testing phosphate-solubilizing bacteria that enhance plant growth. Biology and Fertility of Soils 49: 1-2. doi: 10.1007/s00374-012-0756-4.

Bashan, Y., Kamnev, A.A. and de Bashan, L.E. 2013b .Tricalcium phosphate is inappropriate as a universal selection factor for isolating and testing phosphate-solubilizing bacteria that enhance plant growth: A proposal for an alternative procedure. Biology and Fertility of Soils 49: 465-479. doi: 10.1007/s00374-012-0737-7.

Bastida, F., Moreno, J.L., Hernandez, T. and Garcia, C. 2006. Microbiological degradation index of soils in a semiarid climate. Soil Biology and Biochemistry 38: 3463-3473.

Bayer, E.A., Morag, E. and Lamed, R. 1994. The cellulosome-A treasure trove for biotechnology. Trends in Biotechnology 12: 379-386.

Becker, K., Harmsen, D., Mellmann, A., Meier, C., Schumann, P., Peters, G. and von Eiff, C. 2004. Development and evaluation of a quality-controlled ribosomal sequence database for 16S ribosomal DNA-based identification of *Staphylococcus* species. Journal of Clinical Microbiology 42(11): 4988–4995.

Berezova, E.F. 1965. Plant microbes relationships. Macura, J.and Vancura, V. (eds.). CSAV. Praha. pp. 171-177.

Berg, B. and Laskowski, R. 2006. Litter Decomposition: A Guide to Carbon and Nutrient Turnover. Academic Press, Amsterdam.

Bertrand, H., Nalin, R., Bally, R. and Cleyet-Marel, J.C. 2001. Isolation and identification of the most efficient plant growth-promoting bacteria associated with canola (*Brassica napus*). Biology and Fertility of Soils 33: 152–156. doi: 10.1007/s003740000305.

Bevivino, A., Sarrocco, S., Dalmastri, S., Tabacchioni, S., Cantale, C. and Chiarini, L. 1998. Characterization of a free-living maize rhizosphere population of *Burkholderia cepacia*: effect of seed treatment on disease suppression and growth promotion of maize. FEMS Microbiology Ecology 27: 225–237.

Bevivino, A., Tabacchioni, S., Chiarini, L., Carusi, M.V., Gallo, M.D. and Visca, P. 1994. Phenotypic comparison between rhizosphere and clinical isolates of *Burkholderia cepacia*. Microbiology 140: 1069-1077.

Beylich, A., Oberholzer, H.R., Schrader, S., Höper, H. and Wilke, B.M. 2010. Evaluation of soil compaction effects on soil biota and soil biological process in soils. Soil and Tillage Research 109(2): 133-143.

Bhat, M.K. 2000. Cellulases: Related enzymes in biotechnology. Biotechnology Advances 18(5): 355-383.

Bhattacharjee, R.B., Singh, A. and Mukhopadhyay, S.N. 2008. Use of nitrogen-fixing bacteria as biofertilizer for non-legumes: Prospects and challenges. Applied Microbiology and Biotechnology 80: 199-209.

Bhattacharyya, P.N. and Jha, D.K. 2012. Plant growth-promoting rhizobacteria (PGPR): emergence in agriculture. World Journal of Microbiology and Biotechnology 28: 1327-1350. doi:10.1007/s11274-011-0979-9.

Binkley, D. and Fisher, R. 2012. Chapter 5: Water, pore space and soil structure. In: Ecology and Management of Forest Soils. John Wiley and Sons.

Birch, H.F. 1958. The effect of soil drying on humus decomposition and nitrogen availability. Plant Soil 10: 9–31.

Blake, L., Mercik, S., Koerschens, M., Moskal, S., Poulton, P.R., Goulding, K.W.T., Weigel, A. and Powlson, D.S. 2000. Phosphorus content in soil, uptake by plants and balance in three European long-term field experiments. Nutrient Cycling in Agroecosystems 56(3): 263–275. doi: 10.1023/A:1009841603931.

Bloem, J., de Ruiter, P. and Bouwman, L.A. 1997. Soil food webs and nutrient cycling in agro-ecosystems. In: Modern Soil Microbiology. van Elsas, J.D., Trevors, J.T. and Wellington, H.M.E. (eds). Marcel Dekker, New York. pp. 245-278.

Borgonie, G., van Driessche, R., Leyns, F., Arnaut, G., De Waele, D. and Coomans, A. 1995. Germination of *Bacillus thuringiensis* spores in

bacteriophagous nematodes (Nematoda: *Rhabditida*). Journal of Invertebrates Pathology 65(1): 61-67. doi: 10.1006/jipa.1995.1008.

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analysis of soils. Agronomy Journal 54: 464-465.

Bowen, G.D. and Rovira, A.D. 1961. The effects of micro-organisms on plant growth. Plant Soil 15(2): 166-188. doi:10.1007/BF01347226.

Bowen, G.D. and Rovira, A.D. 1969. The influence of microorganisms on growth and metabolism of plant roots. In: Root Growth. Whittington, W.J. (ed). Butterworths, London.

Boyer, M. and Wisniewski-Dyé, F. 2009. Cell–cell signaling in bacteria: not simply a matter of quorum. FEMS Microbiology Ecology 70: 1–19. doi: 10.1111/j.1574-6941.2009.00745.x.

Brady, N.C. and Weil, R.R. 2004. Elements of the nature and properties of soils. Upper Saddle River, N.J: Prentice Hall.

Bremner, J.M. 1965. Inorganic forms of nitrogen. In: Methods of Soil Analysis, Part 2. Black, C.A. (ed-in-chief). Agronomy series No. 9. American Society of Agronomy, Inc., Publication, Madison, WI. pp. 1179-1237.

Bremner, J.M. and Keeney, D.R. 1966. A chemical index of soil nitrogen availability. Nature 20: 892–893.

Broadbent, F.E. N.d. Soil organic matter. Sustainable options: Land management. Bay of Plenty Regional Council.

Brook, B.W., Sodhi, N.S. and Ng, P.K.L. 2003. Catastrophic extinctions follow deforestation in Singapore. Nature 424: 420–423.

Brookes, P.C., McGrath, S.P. and Heijnen, C.E. 1986. Metal residues in soils previously treated with sewage sludge and their effects on growth and nitrogen fixation by blue-green algae. Soil Biology and Biochemistry 18: 345–352.

Brown, M.E. 1974. Seed and root bacterization. Annual Reviews in Phytopathology 12: 181– 197.

Brown, S., Gillespie, A.J.R. and Lugo, A.E. 1989. Biomass estimation methods for tropical forests with applications to forest inventory data. Forest Science 35: 88-92.

Brussaard, L., Bouwman, L.A., Geurs, M., Hassink, J. and Zwart, K.B. 1990. Biomass, composition and temporal dynamics of soil organisms of a silt loam soil under conventional and integrated management. Netherlands Journal of Agriculture Science 38: 283–302.

Buis, P. 1995. Bioremediation techniques for the removal of phosphorus from iron ore. PhD Dissertation. Mining engineering. Michigan Technological University. U.S.A.

Bürgmann, H., Meier, S., Bunge, M., Widmer, F. and Zeyer, J. 2005. Effects of model root exudates on structure and activity of a soil diazotroph community. Environmental Microbiology 7: 1711–1724. doi: 10.1111/j.1462-2920.2005.00818.x.

Burr, T.J., Caesar, A.M. and Schrolh, N. 1984. Beneficial plant bacteria. Critical Reviews in Plant Sciences 2(1): 1–20.

Burstyn, I. 2004. Principal component analysis is a powerful instrument in occupational hygiene inquiries. Annals of Occupational Hygiene 48(8): 655-661.

Caballero-Mellado, J., Onofre-Lemus, J., Estrada-de los Santos, P. and Martinez-Aguilar, L. 2007. The tomato rhizosphere, an environment rich in nitrogen-fixing *Burkholderia* species with capabilities of interest for agriculture and bioremediation. Applied and Environmental Microbiology 73: 5308–5319.

Cain, C.C., Henry, A.T., Waldo, R.H., Casida, L.J. and Falkinham, J.O. 2000. Identification and characteristics of a novel *Burkholderia* strain with broad-spectrum antimicrobial activity. Applied and Environmental Microbiology 66: 4139–4141.

Caporaso, J.G., Lauber, C.L., Walters, W.A., Berg-Lyons, D., Huntley, J., Fierer, N., Owens, S.M., Betley, J., Fraser, L., Bauer, M., Gormley, N., Gilbert, J.A., Smith, G. and Knight, R. 2012. Ultra-high-throughput microbial community analysis on the Illumina HiSeq and MiSeq platforms. ISME Journal 6(8): 1621–1624. doi: 10.1038/ismej.2012.8. pmid:22402401.

Cappuccino, J.G. and Sherman, N. 2005. Microbiology: A laboratory manual, 7th Edition. Pearson Education, Inc., San Francisco, CA. pp. 73.

Caravaca, F., Barea, J.M., Figueroa, D. and Roldan, A. 2002. Assessing the effectiveness of mycorrhizal inoculation and soil compost addition for enhancing reafforestation with *Olea europaea* subsp. *Sylvestris* through changes in soil biological and physical parameters. Applied Soil Ecology 20: 107-118. doi:10.1016/S0929-1393(02)00015-X.

Carney, K. and Matson, P. 2005. Plant communities, soil microorganisms, and soil carbon cycling: does altering the world belowground matter to ecosystem functioning? Ecosystems 8: 928–940.

Carrillo, A.E., Li, C.Y. and Bashan, Y. 2002. Increased acidification in the rhizosphere of cactus seedlings induced by *Azospirillum brasilense*. Naturwissenschaften 89(9): 428–432. doi: 10.1007/s00114-002-0347-6.

Carson, J.K., Rooney, D., Gleeson, D.B. and Clipson, N. 2007. Altering the mineral composition of soil causes a shift in microbial community structure. FEMS Microbiology Ecology 61: 414–423.

Carson, J.K., Gonzalez-Quiñones, V., Murphy, D.V., Hinz, C., Shaw, J.A. and Gleeson, D.B. 2010. Low pore connectivity increases bacterial diversity in soil. Applied and Environmental Microbiology 76(12): 3936–3942.

Carter, M.R. and Gregorich, E.G. 2008. Soil sampling and methods of analysis, 2nd edition. Canadian Society of Soil Science. Taylor and Francis Group. pp. 342-345.

Carter, M.R., Gregorich, E.G., Angers, D.A., Beare, M.H., Sparling, G.P., Wardle, D.A. and Voroney, R.P. 1999. Interpretation of microbial biomass measurements for soil quality assessment in humid temperate regions. Canadian Journal of Soil Science 79: 507-520.

Cassán, F., Perrig, D., Sgroy, V., Masciarelli, O., Penna, C. and Luna, V. 2009. *Azospirillum brasilense* Az39 and *Bradyrhizobium japonicum* E109, inoculated singly or in combination, promote seed germination and early seedling growth in corn (*Zea mays* L.) and soybean (*Glycine max* L.). European Journal of Soil Biology 45: 28–35.

Chang, C.C., Ng, C.C., Wang, C.Y. and Shyu, Y.T. 2009. Activity of cellulase from *Thermoactinomycetes* and *Bacillus* spp. isolated from *Brassica* waste compost. Science Agriculture (Piracicaba, Braz.) 66(3): 304-308.

Chang, C.H. and Yang, S.S. 2009. Thermo-tolerant phosphate-solubilizing microbes for multi-functional biofertilizer preparation. Bioresource Technology 100: 1648-1658.

Chau, J.F., Bagtzoglou, A.C. and Willig, M.R. 2011. The effect of soil texture on richness and diversity of bacterial communities. Environmental Forensics 12: 333-341. Taylor and Francis Group, LLC.

Chefetz, B., Hatcher, P.G., Hadar, Y. and Chen, Y. 1996. Chemical and biological characterization of organic matter during composting of municipal solid waste. Journal of Environmental Quality 25(4): 776-785.

Chen, F.S., Zeng, D.H., Fahey, T.J. and Liao, P.F. 2010a. Organic carbon in soil physical fractions under different-aged plantations of Mongolian pine in semi-arid region of Northeast China. Applied Soil Ecology 44: 42-48.

Chen, J.H. 2006. The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. International Workshop on Sustained Management of the Soil-Rhizosphere System for Efficient Crop Production and Fertilizer Use. Bangkok, Thailand.

Chen, L., Luo, S., Xiao, X., Guo, H., Chen, J., Wan, Y., Li, B., Xu, T., Xi, Q. and Rao, C. 2010b. Application of plant growth-promoting endophytes

(PGPE) isolated from *Solanum nigrum* L. for phytoextraction of Cd-polluted soils. Applied Soil Ecology 46: 383-389.

Chen, W.M., James, E.K., Prescott, A.R., Kierans, M. and Sprent, J.I. 2003. Nodulation of *Mimosa* spp. by the ß-Proteobacterium *Ralstonia taiwanensis*. Molecular Plant-Microbe Interactions 16: 1051–1061.

Chen, W.-M., de Faria, S.M., James, E.K., Elliott, G.N., Lin, K.-Y., Chou, J.-H., Sheu, S.-Y., Cnockaert, M., Sprent, J.I. *and* Vandamme, P. 2007. *Burkholderia nodosa* sp. nov., isolated from root nodules of the woody Brazilian legumes *Mimosa bimucronata* and *Mimosa scabrella*. International Journal of Systematic and Evolutionary Microbiology 57: 1055–1059.

Chen, Y.P., Rekha, P.D., Arun, A.B., Shen, F.T., Lai, W.-A. and Young, C.C. 2006. Phosphate solubilizing bacteria from subtropical soil and their tricalcium phosphate solubilizing abilities. Applied Soil Ecology 34: 33–41. doi: 10.1016/j.apsoil.2005.12.002.

Cho, S.T., Tsai, S.H., Ravindran, A., Selvam, A. and Yang, S.S. 2008. Seasonal variation of microbial populations and biomass in Tatachia grassland soils of Taiwan. Environmental Geochemistry and Health 30(3): 255-272.

Chou, W., Silver, W.L., Jackson, R.D., Thompson, A.W. and Allen-Diaz, B. 2008. The sensitivity of annual grassland carbon cycling to the quantity and timing of rainfall. Global Change Biology 14: 1382–1394.

Choudhury, A.T.M.A. and Kennedy, I.R. 2004. Prospects and potentials for systems of biological nitrogen fixation. Biology and Fertility of Soils 39: 219-227.

Chung, H., Park, M., Madhaiyan, M., Seshadri, S., Song, J., Cho, H. and Sa, T. 2005. Isolation and characterization of phosphate solubilizing bacteria from the rhizosphere of crop plants of Korea. Soil Biology and Biochemistry 37: 1970–1974. doi: 10.1016/j.soilbio.2005.02.025.

Clein, J.S. and Schimel, J.P. 1995. Microbial activity of tundra and taiga soils at sub-zero temperature. Soil Biology and Biochemistry 27: 1231–1234.

Cleveland, C.C., Townsend, A.R., Schimel, D.S., Fisher, H., Howarth, R.W., Hedin, L.O., Perakis, S.S., Latty, E.F., Von Fischer, J.C., Elseroad, A. and Wasson, M.F. 1999. Global patterns of terrestrial biological nitrogen fixation in natural ecosystems. Global Biogeochemical Cycles 13: 623-45.

Cloud, J.L., Conville, P.S., Croft, A., Harmsen, D., Witebsky, F.G. and Carroll, K.C. 2004. Evaluation of partial 16S ribosomal DNA sequencing for identification of *Nocardia* species by using the MicroSeq 500 system with an expanded database. Journal of Clinical Microbiology 42: 578–584.

Cloud, J.L., Neal, H., Rosenberry, R., Turenne, C.Y., Jama, M., Hillyard, D.R. and Carroll, K.C. 2002. Identification of *Mycobacterium* spp. by using a commercial 16S ribosomal DNA sequencing kit and additional sequencing libraries. Journal of Clinical Microbiology 40(2): 400–406.

Cocking, E.C. 2003. Endophytic colonization of plant roots by nitrogen-fixing bacteria. Plant Soil 252: 169-175.

Coenye, T. and Vandamme, P. 2003. Diversity and significance of *Burkholderia* species occupying diverse ecological niches. Environmental Microbiology 5: 719-729.

Cole, J.R., Wang, Q., Cardenas, E., Fish, J., Chai, B., Farris, R.J., Kulam-Syed-Mohideen, A.S., McGarrell, D.M., Marsh, T., Garrity, G.M. and Tiedje, J.M. 2009. The ribosomal database project: improved alignments and new tools for rRNA analysis. Nucleic Acids Research 37: 141–145. doi: 10.1093/nar/gkn879. pmid:19004872.

Cole, T.G., Yost, R.S., Kablan, R. and Olsen, T. 1996. Growth potential of twelve *Acacia* species on acid soils in Hawaii. Forest Ecology and Management 80: 175-186. doi: 10.1016/0378-1127(95)03610-5.

Combes-Meynet, E., Pothier, J.F., Moënne-Loccoz, Y. and Prigent-Combaret, C. 2011. The *Pseudomonas* secondary metabolite 2,4 diacetylphloroglucinol is a signal inducing rhizoplane expression of *Azospirillum* genes involved in plant-growth promotion. Molecular Plant-Microbe Interactions 24: 271–284. doi: 10.1094/MPMI-07-10-0148.

Compant, S., Nowak, J., Coenye, T., Clement, C. and Ait Barka, E. 2008. Diversity and occurrence of *Burkholderia* spp. in the natural environment. FEMS Microbiology Reviews 32: 607–626. doi:10.1111/j.15746976.2008.00113.x.

Compton, J.E., Watrud, L.S., Porteous, L.A. and DeGrood, S. 2004. Response of soil microbial biomass and community composition to chronic nitrogen additions at Harvard Forest. Forest Ecology and Management 196: 143-158.

Constanza, R., Funtowicz, S.O. and Ravetz, J.R. 1992b. Assessing and communicating data quality in policy relevant research. Environmental Management 16(1): 121-131.

Constanza, R., Norton, B.G. and Haskell, B.D. 1992a. Ecosystem Health: New goals for environmental management. Island Press, Washington, DC., USA.

Costello, E.K., Lauber, C.L., Hamady, M., Fierer, N., Gordon, J.I. and Knight, R. 2009. Bacterial community variation in human body habitats across space and time. Science 326(5960): 1694–1697. doi: 10.1126/science.1177486. pmid:19892944.

Cottenie, A. 1980. Soil testing and plant testing as a basis of fertilizer recommendation. FAO Soils Bulletin 38: 70-73.

Coughland, M.P. 1992. Enzymatic hydrolysis of cellulose: An overview. Bioresource Technology 39: 107-115.

Couillerot, O., Combes-Meynet, E., Pothier, J.F., Bellvert, F., Challita, E., Poirier, M.A., Rohr, R., Comte, G., Moënne-Loccoz, Y. and Prigent-Combaret, C. 2011. The role of the antimicrobial compound 2,4-diacetylphloroglucinol in the impact of biocontrol *Pseudomonas fluorescens* F113 on *Azospirillum brasilense* phytostimulators. Microbiology 157: 1694–1705. doi: 10.1099/mic.0.043943-0.

Crews, T.E., Farrington, H. and Vitousek, P.M. 2000. Changes in asymbiotic, heterotrophic nitrogen fixation on leaf litter of *Metrosideros polymorpha* with long-term ecosystem development in Hawaii. Ecosystems 3: 386-395.

Curl, E.A. and Truelove, B. 2012. The rhizosphere. Volume 15 of Advanced Series in Agricultural Sciences. Springer Science and Business Media.

Cusack, D.F., Silver, W. and McDowell, W.H. 2009. Biological nitrogen fixation in two tropical forests: Ecosystem-level patterns and effects of nitrogen fertilization. Ecosystems 12(8): 1299-1315.

Dantur, K., Enrique, R., Welin, B. and Castagnaro, A.P. 2015. Isolation of cellulolytic bacteria from the intestine of *Diatraea saccharalis* larvae and evaluation of their capacity to degrade sugarcane biomass. AMB Express 5: 15. PMCID: PMC4385043. doi: 10.1186/s13568-015-0101-z.

da Silva, K., Cassetari Ade, S., Lima, A.S., De Brandt, E., Pinnock, E., Vandamme, P. and Moreira, F.M. 2012. Diazotrophic *Burkholderia* species isolated from the Amazon region exhibit phenotypical, functional and genetic diversity. Systematic and Applied Microbiology 35(4): 253-262. doi: 10.1016/j.syapm.2012.04.001.

da Silva, K., Nóbrega, R.S.A., Lima, A.S., Barberi, A. and de Souza Moreira, F.M. 2011. Density and diversity of diazotrophic bacteria isolated from Amazonian soils using N-free semi-solid media. Science Agriculture (Piracicaba, Brazil) 68(5): 518-525.

Daljit, S.K., Arifin, A., Radziah, O., Shamshuddin, J. and Abdul-Hamid, H., Majid, N.M., Panicker, M. and Abdul Halim, N.H. 2011. Assessing soil biological properties of natural and planted forests in the Malaysian tropical lowland dipterocarp forest. American Journal of Applied Sciences 8(9): 854-859.

Damaso, M.C.T., Terzi, S.C., Farias, A.X., Oliveira, A.C.P., Fraga, M.E. and Couri, S. 2012. Selection of cellulolytic fungi isolated from diverse substrates. Brazilian Archives of Biology and Technology 55(4): 513-520.

Darbyshire, J.F. and Greaves, M.P. 1970. An improved method for the study of the interrelationships of soil microorganisms and plant roots. Soil Biology and Biochemistry 2: 63-71.

Darbyshire, J.F. and Greaves, M.P. 1971. The invasion of pea roots, *Pisum sutivunz* L., by soil microorganisms, *Acanthamoeba palesfinensis* (Reich) and *Pseudomonas* sp. Soil Biology and Biochemistry 3: 151-155.

Dardanelli, M.S., Manyani, H., González-Barroso, S., Rodríguez-Carvajal, M.A., Gil-Serrano, A.M., Espuny, M.R., López-Baena, F.J., Bellogín, R.A., Megías, M. and Ollero, F.J. 2010. Effect of the presence of the plant growth promoting rhizobacterium (PGPR) *Chryseobacterium balustinum* Aur9 and salt stress in the pattern of flavonoids exuded by soybean roots. Plant Soil 328(1): 483–493. doi: 10.1007/s11104-009-0127-6.

Darwin, C. and Darwin, F. 1880. The power of movement in plants. London: John Murray.

Dashtban, M., Maki, M., Leung, K.T., Mao, C. and Qin, W. 2010. Cellulase activities in biomass conversion: measurement methods and comparison. Critical Reviews in Biotechnology 30(4): 302-309.

Dastager, S.G., Deepa, C.K. and Pandey, A. 2011. Potential plant growth-promoting activity of *Serratia nematodiphila* NII-0928 on black pepper (*Piper nigrum* L.). World Journal of Microbiology and Biotechnology 27 (2): 259.

de Boer, W., Folman, L.B., Summerbell, R.C. and Boddy, L. 2005. Living in a fungal world: impact of fungi on soil bacterial niche development. FEMS Microbiology Reviews 29: 795–811.

de Freitas, J.R., Banerjee, M.R. and Germida, J.J. 1997. Phosphate-solubilizing rhizobacteria enhance the growth and yield but not phosphorus uptake of canola (*Brassica napus* L.). Biology and Fertility of Soils 24(4): 358-364. doi:10.1007/s003740050258.

de Goes, K.C.G.P., de Castro Fisher, M.L., Cattelan, A.J., Nogueira, M.A., Portela de Carvalho, C.G. and Martinez de Oliveira, A.L. 2012. Biochemical and molecular characterization of high population density bacteria isolated from sunflower. Journal of Microbiology and Biotechnology 22(4): 437-447.

Decaens, T., Jimenez, J.J., Measey, G.J. and Lavelle, P. 2006. The values of soil animals for conservation biology. European Journal of Soil Biology 42: S23-S38. doi: 10.1016/j.ejsobi.2006.07.001.

DeLuca, T.H., Drinkwater, L.E., Wiefling, B.A. and DeNicola, D.M. 1996. Free-living nitrogen-fixing bacteria in temperate cropping systems: influence of nitrogen source. Biology and Fertility of Soils 23: 140–144. doi: 10.1007/BF00336054.

Delvasto, P., Ballester, A., García, C., Igual, J.M., Muñoz, J., González, F. and Blázquez, M. 2006. Mineral-phosphate solubilization activity of iron ore associated microflora. In: Modern Multidisciplinary Applied Microbiology: Exploiting Microbes and Their Interactions. Mendez-Vilas, A. (ed). Wiley-VCH, Weinheim, Germany. pp. 241-245.

Denison, R.F. and Kiers, E.T. 2004. Lifestyle alternatives for rhizobia: mutualism, parasitism, and forgoing symbiosis. FEMS Microbiology Letters 237: 187–193.

DeSantis, T.Z., Hugenholtz, P., Larsen, N., Rojas, M., Brodie, E.L., Keller, K., Huber, T., Dalevi, D., Hu, P. and Andersen, G.L. 2006. Greengenes, a chimera-checked 16S rRNA gene database and workbench compatible with ARB. Applied and Environmental Microbiology 72(7): 5069–5072. pmid:16820507.

Dey, R., Pal, K.K., Bhatt, D.M. and Chauhan, S.M. 2004. Growth promotion and yield enhancement of peanut (*Arachishypogaea* L.) by application of plant growth promoting rhizobacteria. Microbiology Research 159: 371–394. doi:10.1016/j.micres.2004.08.004.

Dick, R.P., Breakwell, D.P. and Turco, R.F. 1996. Soil enzyme activities and biodiversity measurements as integrative microbiological indicators. In: Methods for Assessing Soil Quality. Doran, J.W. and Jones, A.J. (eds.). Soil Science Society of America, Madison. pp. 247–271.

Dighton, J. and Boddy, L. 1989. Role of fungi in nitrogen, phosphorus and sulfur cycling in temperate forest ecosystems. In: Nitrogen, Phosphorus and Sulfur Utilization by Fungi. Boddy, L., Marchant, R. and Read, D. (eds). Cambridge. Cambridge University Press. pp. 269–298.

Dilly, O. and Nannipieri, P. 2001. Response of ATP content, respiration rate and enzyme activities in arable and a forest soil to nutrient additions. Biology and Fertility of Soils 34: 34-64.

Dinesh, R., Ghoshal, S.C., Ganeshamurthy, A.N. and Chanchal, D. 2003. Changes in soil microbial indices and their relationships following deforestation and cultivation in wet tropical forests. Applied Soil Ecology 24: 17-26. doi: 10.1016/S09291393(03)00070-2.

Ding, L. and Yokota, A. 2004. Proposals of *Curvibacter gracilis* gen. nov., sp. nov. and *Herbaspirillum putei* sp. nov. for bacterial strains isolated from well water and reclassification of [*Pseudomonas*] *huttiensis*, [*Pseudomonas*] *lanceolata*, [*Aquaspirillum*] *delicatum* and [*Aquaspirillum*] *autotrophicum* as *Herbaspirillum huttiensecomb*. nov., *Curvibacter lanceolatus* comb. nov., *Curvibacter delicatus* comb. nov. and *Herbaspirillum autotrophicum* comb. International Journal of Systematic and Evolutionary Microbiology 54: 2223 -2230.

Di-Simine, C.D., Sayer, J.A. and Gadd, G.M. 1998. Solubilization of zinc phosphate by a strain of *Pseudomonas fluorescens* isolated from a

forest soil. Biology and Fertility of Soils 28: 87–94. doi: 10.1007/s003740050467.

Döbereiner, J. and Day, J.M. 1976. Associative symbioses in tropical grasses: Characterization of microorganisms and dinitrogen-fixing sites. In: Proceedings of the First International Symposium on N_2-fixation, Volume 2. Newton, W.E. and Nyman, C.J. (eds). Washington University Press, Pullman, WA. pp. 518–538.

Domínguez, J., Negrín, M.A. and Rodríguez, C.M. 2001. Aggregate water-stability, particle-size and soil solution properties in conductive and suppressive soil to *Fusarium* wilt of banana from Canary Islands (Spain). Soil Biology and Biochemistry 33: 449-455.

Domsch, K.H. 1963. Influence of plant protection chemicals on the soil microflora: Review of the literature. Mitt. Biologische Bundesanstalt Land-Forstirwch. Berlin Dahlem 105: 5.

Domsch, K.H. 1968. Microbial stimulation and inhibition of plant growth. International Society of Soil Science Transmission 3: 455-463.

Dong, Y.H., Zhang, X.F., Xu, J.L. and Zhang, L.H. 2004. Insecticidal *Bacillus thuringiensis* silences *Erwinia carotovora* virulence by a new form of microbial antagonism, signal interference. Applied and Environmental Microbiology 70: 954-960.

Doran, J.W. 2002. Soil health and global sustainability: Translating science into practice. Agriculture, Ecosystems and Environment 88: 119-127.

Doran, J.W. and Jones, A.J. 1996. Methods for assessing soil quality. Special publication No 49. Soil Science Society of America, American Society of Agronomy, Madison, WI.

Doran, J.W. and Parkin, T.B. 1994. Defining and assessing soil quality. In: Defining Soil Quality for a Sustainable Environment, Soil Science Society of America Special Publication no. 35. SSSA, Madison, Wisconsin.

Doran, J.W. and Zeiss, M.R. 2000. Soil health and sustainability: Managing the biotic component of soil quality. Applied Soil Ecology 15: 2-11.

Doran, J.W., Liebig, M.A. and Santana, D.P. 1998. Soil health and global sustainability. In: Proceedings of the 16th World Congress of Soil Science. Montepellier, France. Paper 1923.

Doran, J.W., Sarantonio, M. and Leibig, M. 1996. Soil health and sustainability. Advances in Agronomy 56: 1-54.

Drancourt, M., Bollet, C., Carlioz, A., Martelin, R., Gayral, J.P. and Raoult, D. 2000. 16S ribosomal DNA sequence analysis of a large collection of environmental and clinical unidentifiable bacterial isolates. Journal of Clinical Microbiology 38: 3623–3630.

Drenovsky, R.E., Vo, D., Graham, K.J. and Scow, K.M. 2004. Soil water content and organic carbon availability are major determinants of soil microbial community composition. Microbial Ecology 48(3): 424–430.

Dreyfus, B.L., Diem, H.G., Freire, J., Keya, S.O. and Drommergues, Y.R. 1987. Nitrogen fixation in tropical agriculture and forestry. *In:* Microbial Technology in the Developing World. da Silva, E.J., Dommergues, Y.R., Nyns, E.J. and Ratledge, C. (eds.). Oxford University Press, Oxford, New York, Toronto. pp. 7–50.

Drogue, B., Combes-Meynet, E., Mënne-Loccoz, Y., Wisniewski-Dyé, F. and Prigent-Combaret, C. 2013. Control of the cooperation between plant growth-promoting rhizobacteria and crops by rhizosphere signals, Chapter 27. In: Volume 1 and 2 Molecular Microbial Ecology of the Rhizosphere. de Bruijn, F.J. (ed). NJ, USA. John Wiley and Sons, Inc. pp. 281–294. doi: 10.1002/9781118297674.

Drogue, B., Dore, H., Borland, S., Wisniewski-Dyé, F. and Prigent-Combaret, C. 2012. Which specificity in cooperation between phytostimulating rhizobacteria and plants? Research Microbiology 163: 500–510. doi: 10.1016/j.resmic.2012.08.006.

Dubey, S.K. and Billore, S.D. 1992. Phosphate solubilizing microorganism (PSM) as inoculant and their role in augmenting crop productivity in India- a review. Crop Research Hisar 5: 11-17.

Dubinsky, E.A., Silver, W.L. and Firestone, M.K. 2010. Tropical forest soil microbial communities couple iron and carbon biogeochemistry. Ecology 91: 2604–2612.

Dumanski, J. and Pieri, C. 2000. Land quality indicators: Research plan. Agriculture, Ecosystems and Environment 81: 93-102.

Duponnois, R., Kisa, M. and Plenchette, C. 2006. Phosphate solubilizing potential of the nematophagous fungus *Arthrobotrys oligospora*. Journal of Plant Nutrition and Soil Science 169(2): 280–282. doi: 10.1002/jpln.200520551.

Dutta, D. and Gachhui, R. 2006. Novel nitrogen-fixing *Acetobacter nitrogenifigens* sp. nov., isolated from Kombucha tea. International Journal of Systematic and Evolutionary Microbiology 56: 1899-1903. doi: 10.1099/ijs.0.64101-0.

Dutta, S. and Podile, A.R. 2010. Plant growth promoting rhizobacteria (PGPR): the bugs to debug the root zone. Critical Reviews in Microbiology 36(3): 232-244. doi: 10.3109/10408411003766806.

Eady, R.R. 1992. The dinitrogen-fixing bacteria. Vol. 1. New York: In: The Prokaryotes, Springer-Verlag. pp. 534–553.

Edi-Premono, M., Moawad, A.M. and Vlek, P.L.G. 1996. Effect of phosphate solubilizing *Pseudomonas putida* on the growth of maize and its survival in the rhizosphere. Indonesian Journal of Crop Science 11: 13–23.

Edwards, D.P., Hodgson, J.A., Hamer, K.C., Mitchell, S.L., Ahmad, A.H., Cornell, S.J. and Wilcove, D.S. 2010. Wildlife-friendly oil palm plantations fail to protect biodiversity effectively. Conservation Letters 3: 236–242.

Edwards, D.P., Larsen, T.H., Docherty, T.D.S., Ansell, F.A., Hsu, W.W., Derhe, M.A., Hamer, K.C. and Wilcove, D.S. 2011. Degraded lands worth protecting: the biological importance of Southeast Asia's repeatedly logged forests. Proceedings of the Royal Society B. Biological Sciences 278: 82–90.

Egamberdieva, D. 2007. The effect of plant growth promoting bacteria on growth and nutrient uptake of maize in two different soils. Applied Soil Ecology 36(2-3): 184–189.

Egamberdieva, D. 2008. Plant growth promoting properties of rhizobacteria isolated from wheat and pea grown in loamy sand soil. Turkish Journal of Biology 32: 9-15.

Egamberdieva, D., Berg, G., Lindstrom, K. and Rasanen, L. 2013. Chapter 7: Alleviation of salt stress in cucumber and tomato by root colonising bacteria. In: Soil Microbiology and Biotechnology. Miransari, M. (ed). Studium Press, LLC. USA. pp. 113-126. ISBN: 1-626990-14-X.

Elliot, G.N., Chen, W.M., Chou, J.H., Wang, H.C., Sheu, S.Y., Perin, L., Reis, V.M., Moulin, L., Simon, M.F., Bontemps, C., Sutherland, J.M., Bessi, R., de Faria, S.M., Trinick, M.J., Prescott, A.R., Sprent, J.I. and James, E.K. 2007. *Burkholderia phymatum* is a highly effective nitrogen-fixing symbiont of *Mimosa* spp. and fixes nitrogen *ex planta*. New Phytology 173: 168-180.

Elliott, G.N., Chen, W.M., Bontemps, C., Chou, J.H., Young, J.P., Sprent, J.I. and James, E.K. 2007. Nodulation of *Cyclopia* spp. (Leguminosae, Papilionoideae) by *Burkholderia tuberum*. Annals of Botany 100(7): 1403-1411.

Elmerich, C. and Newton, W.E. 2007. Associative and Endophytic Nitrogen-fixing Bacteria and Cyanobacterial Associations. Springer Verlag.

Estrada-de los Santos, P., Bustillos-Cristales, R. and Caballero-Mellado, J. 2001. *Burkholderia*, a genus rich in plant-associated nitrogen fixers with wide environmental and geographic distribution. Applied and Environmental Microbiology 67(6): 2790–2798.

Estrada, P., Mavingui, P., Cournoyer, B., Fontaine, F., Balandreau, J. and Caballero-Mellado, J. 2002. A N_2-fixing endophytic *Burkholderia* sp.

associated with maize plants cultivated in Mexico. Canadian Journal of Microbiology 48(4): 285-294.

Fabre, B., Armau, E., Etienne, G., Legendre, F. and Tiraby, G. 1988. A simple screening method for insecticidal substances from actinomycetes. Journal of Antibiotics (Tokyo) 41(2): 212–219. doi: 10.7164/antibiotics.41.212.

Fang, M., Kremer, R.J., Motavalli, P.P. and Davis, G. 2005. Bacterial diversity in rhizospheres of nontransgenic and transgenic corn. Applied and Environmental Microbiology 71: 4132–4136.

FAO (Food and Agriculture Organization). 1995. Lessons from the green revolution-towards a new green revolution. Technical Paper for the World Food Summit. WFS 96/Tech/6. Rome:FAO.

Fierer, N. and Jackson, R.B. 2006. The diversity and biogeography of soil bacterial communities. Proceedings of National Academy Science of U.S.A. 103: 626–631.

Fierer, N. and Schimel, J.P. 2002. Effects of drying-rewetting frequency on soil carbon and nitrogen transformations. Soil Biology and Biochemistry 34: 777–787.

Fierer, N., Jackson, J.A., Vilgalys, R. and Jackson, R.B. 2005. Assessment of soil microbial community structure by use of taxon-specific quantitative PCR assays. Applied and Environmental Microbiology 71(7): 4117-4120.

Finnie, J.F. and Van Staden, J. 1985. Effect of seed weed concentrate and applied hormones on *in vitro* cultured tomato roots. Journal of Plant Physiology 120: 215-222.

Fisher, R.F. 1995. Amelioration of degraded rain forest soils by plantations of native trees. Soil Science Society of American Journal 59: 544–549. doi: 10.2136/sssaj1995.03615995005900020039x.

Fitzherbert, E.B., Struebig, M.J., Morel, A., Danielsen, F., Bruhl, C.A., Donald, P.F. and Phalan, B. 2008. How will oil palm expansion affect biodiversity? Trends in Evolutionary Ecology 23: 538–545.

Fließbach, A. and Widmer, F. 2006. Microbial biomass and numbers: Estimating soil microbial biomass. In: Microbiological Methods for Assessing Soil Quality. Bloem, J., Hopkins, D.W. and Benedetti, A. (eds). CABI Publishing. Biddles Ltd, King's Lynn, UK. pp. 73.

Foster, R.C. 1981. Polysaccharides in soil fabrics. Science 214: 665–667.

Foster, R.C. and Rovira, A.D. 1973. The rhizosphere of wheat roots studied by electron microscopy. Bulletin of Ecology Research Communication (Stockholm) 17: 93.

Fritscher, C., Messner, R. and Kubicek, C.P. 1990. Cellobiose metabolism and cellobiohydrolase I biosynthesis by *Trichoderma reesei*. Experimental Mycology 14: 405-415.

Frossard, E., Conron, L.M., Oberson, A., Sinaj, S. and Fardeau, J.C. 2000. Processes governing phosphorus availability in temperate soils. Journal of Environmental Quality 29: 15-23.

Fulthorpe, R.R., Roesch, L.F.W., Riva, A. and Triplett, E.W. 2008. Distantly sampled soils carry few species in common. ISME Journal 2: 901–910.

Gadd, G.M. 2010. Metals, minerals and microbes: geomicrobiology and bioremediation. Microbiology 156: 609-643.

Galloway, J.N., Townsend, A.R., Erisman, J.W., Bekunda, M., Cai, Z., Freney, J.R., Martinelli, L.A., Seitzinger, S.P. and Sutton, M.A. 2008. Transformation of the nitrogen cycle: recent trends, questions, and potential solutions. Science 320: 889–892.

Garau, G., Castaldi, P., Santona, L., Deiana, P. and Melis, P. 2007. Influence of red mud, zeolite and lime on heavy metal immobilization, culturable, heterotrophic microbial populations and enzyme activities in a contaminated soil. Geoderma 142: 4727. doi: 10.1016/j.geoderma.2007.07.011.

Garbeva, P., van Veen, J.A. and van Elsas, J.D. 2004. Microbial diversity in soil: Selection of microbial populations by plant and soil type and implications for disease suppressiveness. Annual Reviews of Phytopathology 42: 243–270.

Garrity, G.M. 2005. Bergey's Manual of Systematic Bacteriology, Volume 2: The Proteobacteria. Springer-Verlag. USA.

Gerzabek, M.H., Haberhauer, G., Kandeler, E., Sessitsch, A. and Kirchmann, H. 2002. Response of organic matter pools and enzyme activities in particle size fractions to organic amendments in a long-term field experiment. In: Proceedings of the Third Symposium ISMOM, Naples-Capri, Italy, in press.

Gilkes, N.R., Kilburn, D.G., Miller Jr., R.C. and Warren, R.A.J. 1991. Bacterial cellulases. Bioresource Technology 36(1): 21-35.

Gil-Sotres, F., Trasar-Cepeda, C., Leiros, M.C. and Seoane, S. 2005. Different approaches to evaluating soil quality using biochemical properties. Soil Biology and Biochemistry 37: 877-887.

Giongo, A., Beneduzi, A., Ambrosini, A., Vargas, L.K., Stroschein, M.R., Eltz, F.L., Bodanese-Zanettini, M.H. and Passaglia, L.M.P. 2010. Isolation and characterization of two plant growth-promoting bacteria from the rhizoplane of a legume (*Lupinus albescens*) in sandy soil. Revista Brasileira de Ciência do Solo 34(2): 361-369.

Gleeson, D., McDermott, F. and Clipson, N. 2006. Structural diversity of bacterial communities in a heavy metal mineralized granite outcrop. Environmental Microbiology 8: 383–393.

Glick, B.R. 1995. The enhancement of plant growth by free-living bacteria. Canadian Journal of Microbiology 41(2): 109–117. doi: 10.1139/m95-015.

Glick, B.R. and Bashan, Y. 1997. Genetic manipulation of plant growth promoting bacteria to enhance biocontrol of phytopathogens. Biotechnology Advances 15: 353–378.

Glick, B.R., Todorovic, B., Czarny, J., Cheng, Z., Duan, J. and McConkey, B. 2007. Promotion of plant growth by bacterial ACC deaminase. Critical Reviews of Plant Science 26: 227-242. doi: 10.1080/07352680701572966.

Goldstein, A.H. 1994. Involvement of the quinoprotein glucose dehydrohenase in the solubilization of exogenous phosphates by Gram-negative bacteria. In: Phosphate in Microorganisms: Cellular and Molecular Biology. Torriani-Gorini, A., Yagiland, E. and Silver, S. (eds). Washington (DC). ASM Press. pp. 197–203.

Goldstein, A.H. 1995. Recent progress in understanding the molecular genetics and biochemistry of calcium phosphate solubilization by Gram negative bacteria. Biological Agriculture and Horticulture 12(2): 185-193. doi: 10.1080/01448765.1995.9754736.

Gomaa, E.Z. 2012. Chitinase production by *Bacillus thuringiensis* and *Bacillus licheniformis*: their potential in antifungal biocontrol. Journal of Microbiology 50: 103-111.

Gomes, D.N.F. 2007. Diversidade e potencial biotenológico de fungos filamentosos isolados do manguezal Barras das Jangadas, Jaboatão do Guararapes, Pernambuco. {Dissertação de Mestrado]. Recife, Brasil: Universidade Federal de Pernambuco.

Gomez, A.A., Swete, D.E., Syers, J.K. and Couglan, K.J. 1996. Measuring sustainability of agricultural systems at the farm level. In: Methods for Assessing Soil Quality SSSA, Special Publication 49. Soil Science Society of America, Madison.

González-Iturbe, J.A., Olmsted, I. and Tun-Dzul, F. 2002. Tropical dry forest recovery after long term Henequen (sisal, *Agave fourcroydes* Lem.) plantation in northern Yucatan, Mexico. Forest Ecology and Management 167(1-3): 67-82. doi: 10.1016/S03781127(01)00689-2.

Gordon, A.S. and Weber, R.P. 1951. Colorimetric estimation of indole acetic acid. Plant Physiology 26: 192–195.

Goyal, A., Ghosh, B. and Eveleigh, D. 1991. Characteristics of fungal cellulases. Bioresource Technology 36: 37-50.

Grainger, A. 1993. Controlling Tropical Deforestation. Earthscan, 1st Edition, London, ISBN-10: 1853831425. pp. 310.

Greaves, M.P. and Darbyshire, J.F. 1972. The ultra-structure of the mucilaginous layer on plant roots. Soil Biology and Biochemistry 4: 443.

Greaves, M.P. and Darbyshire, J.F. 1975. Microbial decomposition of plant roots. Proceedings of 1st International Colloquium on Biodegradation and Humification. University of Nancy, 1974. Kilbertus, G., Reisinger, D., Mourey, A. and Concela de Fonesca, J.A. (eds). pp. 108-111.

Gregorich, E.G., Greer, K.J., Anderson, D.W. and Liang, B.C. 1998. Carbon distribution and losses: Erosion and deposition effects. Soil Tillage Research 47: 291-302. doi: 10.1016/S0167-1987(98)00117-2.

Gros, R., Monrozier, L.J. and Faivre, P. 2006. Does disturbance and restoration of alpine grassland soils affect the genetic structure and diversity of bacterial and N_2-fixing populations? Environmental Microbiology 8: 1889-1901. doi:10.1111/j.1462-2920.2006.01106.x.

Gruhn, P., Goletti, F. and Yudelman, M. 2000. Integrated nutrient management, soil fertility and sustainable agriculture: Current issues and future challenges. Food, Agriculture and the Environment-Discussion paper 32. International Food Policy Research Institute, Washington, D.C., USA. pp. 15-16.

Gulati, A., Rahi, P. and Vyas, P. 2008. Characterization of phosphate-solubilizing fluorescent pseudomonads from the rhizosphere of seabuckthorn growing in the cold deserts of Himalayas. Current Microbiology 56(1): 73–79.

Gulati, A., Sood, S., Rahi, P., Thakur, R., Chauhan, S. and nee Chadha, I.C. 2011. Diversity analysis of diazotrophic bacteria associated with the roots of tea [*Camellia sinensis* (L.) O. *Kuntze*]. Journal of Microbiology and Biotechnology 21(6): 545-555.

Gulledge, J. and Schimel, J.P. 1998. Low-concentration kinetics of atmospheric CH_4 oxidation in soil and the mechanism of NH_4^+ inhibition. Applied and Environmental Microbiology 64: 4291-4298.

Güneş, A., Ataoğlu, N., Turan, M., Eşitken, A. and Ketterings, Q.M. 2009. Effects of phosphate-solubilizing microorganisms on strawberry yield and nutrient concentrations. Journal of Plant Nutrition and Soil Science 172(3): 385–392. doi: 10.1002/jpln.200800121.

Gupta, R., Singal, R., Shankar, A., Kuhad, R.C. and Saxena, R.K. 1994. A modified plate assay for secreening phosphate solubilizing

microorganisms. Journal of General and Applied Microbiology 40(3): 255–260. doi: 10.2323/jgam.40.255.

Gutiérrez Mañero, F.J., Acero, N., Lucas, J.A. and Probanza, A. 1996. The influence of native rhizobacteria on European alder [*Alnus glutinosa* (L.) *Gaertan*] growth. II. Characterization of growth promoting and growth-inhibiting strains. Plant Soil 182: 67-74.

Gyaneshwar, P., Hirsch, A.M., Moulin, L., Chen, W.M., Elliott, G.N., Bontemps, C., Estrada-de los Santos, P., Gross, E., Bueno dos Reis, Jr., F., Sprent, J.I., Young, J.P.W. and James, E.K. 2011. Legume-nodulating Betaproteobacteria: diversity, host range, and future prospects. Molecular Plant-Microbe Interactions 24(11): 1276-1288.

Haberern, J. 1992. Viewpoint: A soil health index. Journal of Soil and Water Conservation 47: 6.

Hackl, E., Zechmeister-Boltenstern, S., Bodrossy, L. and Sessitsch, A. 2004. Comparison of diversities and compositions of bacterial populations inhabiting natural forest soils. Applied and Environmental Microbiology 70: 5057–5065.

Hai, B., Diallo, N.H., Sall, S., Haesler, F., Schauss, K., Bonzi, M., Assigbetse, K., Chotte, J.L., Munch, J.C. and Schloter, M. 2009. Quantification of key genes steering the microbial nitrogen cycle in the rhizosphere of sorghum cultivars in tropical agroecosystems. Applied and Environmental Microbiology 75: 4993–5000. doi:10.1128/AEM.02917-08.

Hall, L., Doerr, K.A., Wohlfiel, S.L. and Roberts, G.D. 2003. Evaluation of the MicroSeq system for identification of mycobacteria by 16S ribosomal DNA sequencing and its integration into a routine clinical mycobacteriology laboratory. Journal of Clinical Microbiology 41: 1447–1453.

Hamarashid, N.H., Othman, M.A. and Hussain, M.A.H. 2010. Effects of soil texture on chemical compositions, microbial populations and carbon mineralization in soil. Egyptian Journal of Experimental Biology (Botany) 6(1): 59-64. The Egyptian Society of Experimental Biology.

Hamdali, H., Bouizgarne, B., Hafidi, M., Lebrihi, A., Virolle, M.J. and Ouhdouch, Y. 2008a. Screening for rock phosphate solubilizing actinomycetes from Moroccan phosphate mines. Applied Soil Ecology 38: 12–19. doi: 10.1016/j.apsoil.2007.08.007.

Hamdali, H., Hafidi, M., Virolle, M.J. and Ouhdouch, Y. 2008b. Growth promotion and protection against damping-off of wheat by two rock phosphate solubilizing actinomycetes in a P-deficient soil under greenhouse conditions. Applied Soil Ecology 40: 510–517. doi: 10.1016/j.apsoil.2008.08.001.

Hameeda, B., Harini, G., Rupela, O.P., Wani, S.P. and Reddy, G. 2008. Growth promotion of maize by phosphate-solubilizing bacteria isolated from composts and macrofauna. Microbiology Research 163(2): 234-242.

Hameeda, B., Rupela, O., Reddy, G. and Satyavani, K. 2006. Application of plant growth-promoting bacteria associated with composts and macrofauna for growth promotion of Pearl millet (*Pennisetum glaucum* L.). Biology and Fertility of Soils 43(2): 221-227.

Han, J., Sun, L., Dong, X., Cai, Z., Sun, X., Yang, H., Wang, Y. and Song, W. 2005. Characterization of a novel plant growth promoting bacteria strain *Delftia tsuruhatensis* HR4 both as a diazotroph and a potential biocontrol agent against various plant pathogens. Systematic and Applied Microbiology 28: 66–76.

Hansen, M.C., Stehman, S.V., Potapov, P.V., Loveland, T.R., Townshend, J.R.G., DeFries, R.S., Pittman, K.W., Arunarwati, B., Stolle, F., Steininger, M.K., Carroll, M. and DiMiceli, C. 2008. Humid tropical forest clearing from 2000 to 2005 quantified by using multitemporal and multiresolution remotely sensed data. Proceedings in National Academic Science USA 105: 9439–9444.

Hartel, P.G. and Alexander, M. 1986. Role of extracellular polysaccharide production and clays in the desiccation tolerance of cowpea bradyrhizobia. Soil Science Society of American Journal 50: 1193–1198.

Hassan, N.M., Mansour, N.A., Fayez-Hassan, M. and Sedqy, E. 2013. Elemental analysis of Egyptian phosphate fertilizer components samples by TGA, DTA and IR Methods. IOSR Journal of Environmental Science, Toxicology and Food Technology 7(3): 98-106.

Hassink, J., Bouwman, L.A., Zwart, K.B. and Brussaard, L. 1993. Relationships between habitable pore space, soil biota and mineralization rates in grassland soils. Soil Biology and Biochemistry 25: 47–55.

Hassink, J. 1997. The capacity of soils to preserve organic C and N by their association with clay and silt particles. Plant Soil 191(1): 77-87.

Havlin, J., Beaton, J., Tisdale, S.L. and Nelson, W. 1999. Soil fertility and fertilizers. In: An Introduction to Nutrient Management. Upper Saddle River, NJ: Prentice Hall.

He, Z.L., Wu, J., O'Donnell, A.G. and Syers, J.K. 1997. Seasonal responses in microbial biomass carbon, phosphorus and sulphur in soils under pasture. Biology and Fertility of Soils 24(4): 421-428. doi: 10.1007/s003740050267.

Hebbar, K.P., Martel, M.H. and Heulin, T. 1998. Suppression of pre and post-emergence damping-off in corn by *Burkholderia cepacia*. European Journal of Plant Pathology 104: 29–36.

Hendricks, C.W., Doyle, J.D. and Hugley, B. 1995. A new solid medium for enumerating cellulose-utilizing bacteria in soil. Applied and Environmental Microbiology 61(5): 2016-2019.

Henrissat, B. and Davies, G.J. 2000. Glycoside hydrolases and glycosyltransferases: Families, modules and implications for genomics. Plant Physiology 124: 1515-1519.

Henrissat, B., Teeri, T.T. and Warren, R.A.J. 1998. A scheme for designating enzymes that hydrolyse the polysaccharides in the cell walls of plants. FEBS Letters 425: 352-354.

Heulin, T., Guckert, A. and Balandreau, J. 1987. Stimulation of root exudation of rice seedlings by *Azospirillum* strains– carbon budget under gnotobiotic conditions. Biology and Fertility of Soils 4: 9–14.

Heydari, A. and Misaghi, I.J. 1998. Biocontrol activity of *Burkholderia cepacia* against *Rhizoctonia solani* in herbicide-treated soils. Plant Soil 202: 109–116.

Hicks, W.T., Harmon, M.E. and Griffiths, R.P. 2003. Abiotic controls on nitrogen fixation and respiration in selected woody debris from the Pacific Northwest, USA. Ecoscience 10: 66-73.

Hirai, H., Matsumura, H., Hirotani, H., Sakurai, K., Ogino, K. *et al*. 1997. Soils and distribution of *Drybalanops aromatic* and *D. lanceolata* in mixed dipterocarp forest. A case study at Lambir National Park, Malaysia. Tropics 7: 21-33.

Hoffmann, M. *et al*. 2010. The impact of conservation on the status of the world's vertebrates. Science 330(6010): 1503–1509. doi: 10.1126/science.1194442.

Hofmockel, K.S. and Schlesinger, W.H. 2007. Carbon dioxide effects on heterotrophic dinitrogen fixation in a temperate pine forest. Soil Science Society of American Journal 71: 140-144.

Höfte, H. and Whiteley, H.R. 1989. Insecticidal crystal proteins of *Bacillus thuringiensis*. Microbiology Reviews 53: 242-255.

Holt, J.G., Krieg, N.R., Sneath, P.H.A., Staley, J.T. and Williams, S.T. 1994. Bergey's Manual of Determinative Bacteriology Ninth Edition. Lippincott Williams & Wilkins. USA. pp. 787.

Houlton, B., Wang, Y., Vitousek, P. and Field, C. 2008. A unifying framework for dinitrogen fixation in the terrestrial biosphere. Nature 454: 327–331.

Hsu, S.F. and Buckley, D.H. 2009. Evidence for the functional significance of diazotroph community structure in soil. ISME Journal 3: 124–136. doi:10.1038/ismej.2008.82.

Human Microbiome Project Consortium. 2012. Structure, function and diversity of the healthy human microbiome. Nature 486: 207–214. doi: 10.1038/nature11234. pmid:22699609.

Huse, S.M., Dethlefsen, L., Huber, J.A., Mark Welch, D., Relman, D.A. and Sogin, M.L. 2008. Exploring microbial diversity and taxonomy using SSU rRNA hypervariable tag sequencing. PLoS Genet 4(11): e1000255. doi: 10.1371/journal.pgen.1000255. pmid:19023400.

Hwangbo, H., Park, R.D., Kim, Y.W., Rim, Y.S., Park, K.H., Kim, T.H., Suh, J.S. and Kim, K.Y. 2003. 2-Ketogluconic production and phosphate solubilization by *Enterobacter intermedium*. Current Microbiology 47: 87–92.

Idris, S.E., Iglesias, D.J., Talon, M. and Borriss, R. 2007. Tryptophan-dependent production of indole-3-acetic acid (IAA) affects level of plant growth promotion by *Bacillus amyloliquefaciens* FZB42. Molecular Plant-Microbe Interactions 20(6): 619–626.

Illmer, P.A. and Schinner, F. 1992. Solubilization of inorganic phosphates by microorganisms isolated from forest soil. Soil Biology and Biochemistry 24: 389–395. doi: 10.1016/0038-0717(92)90199-8.

Illmer, P.A., Barbato, A. and Schinner, F. 1995. Solubilization of hardly soluble $AlPO_4$ with P-solubilizing microorganisms. Soil Biology and Biochemistry 27: 260–270.

Ilmen, M., Saloheimo, A., Onnela, M.L. and Penttila, M.E. 1997. Regulation of cellulase gene expression in the filamentous fungus *Trichoderma reesei*. Applied and Environmental Microbiology 63(4): 1298-1306.

Ilstedt, U., Malmer, A., Noldgren, A. and Liau, P. 2004. Soil rehabilitation following tractor logging: early results on amendments and tilling in a second rotation *Acacia mangium* plantation in Sabah, Malaysia. Ecology Management 194: 215-224. doi: 10.1016/j.foreco.2004.02.032.

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

Ishizuka, S., Tanaka, S., Sakurai, K., Hirai, H., Hirotani, H., Ogino, K., Lee, H.S. and Kendawang, J.J. 1998. Characterization and distribution of soils at Lambir Hills National Park in Sarawak, Malaysia, with special reference to soil hardness and soil textures. Tropics 8(1-2): 31-44.

Islam, M.R., Madhaiyan, M., Deka Boruah, H.P., Yim, W., Lee, G., Saravanan, V.S., Fu, Q., Hu, H. and Sa, T. 2009. Characterization of plant growth-promoting traits of free-living diazotrophic bacteria and their inoculation effects on growth and nitrogen uptake of crop plants. Journal of Microbiology and Biotechnology 19(10): 1213–1222.

Jacobs, H., Boswell, G.P., Ritz, K., Davidson, F.A. and Gadd, G.M. 2002. Solubilization of calcium phosphate as a consequence of carbon translocation by *Rhizoctonia solani*. FEMS Microbiology Ecology 40: 65–71. doi: 10.1111/j.1574-6941.2002.tb00937.x.

James, E.K., Moulin, L., Klonowska, A., de Faria, S.M., Simon, M.F. and Chen, W.-M. 2014. Beta-rhizobial symbioses with legumes. In: The 17th Australian Nitrogen Fixation Proceedings. Gupta, V.V.S.R., Unkovich, M. and Kaiser, B.N.(eds). ASNF, Adelaide. pp. 49-53.

Janda, J.M. and Abbott, S.L. 2007. 16S rRNA gene sequencing for bacterial identification in the diagnostic laboratory: pluses, perils, and pitfalls. Journal of Clinical Microbiology 45(9): 2761-2764. doi: 10.1128/JCM.01228-07.

Janssen, P.H. 2006. Identifying the dominant soil bacteria taxa in libraries of 16S rRNA and 16S rRNA genes. Applied and Environmental Microbiology 72: 1719–1728.

Jastrow, J.D. and Miller, R.M. 1991. Methods for assessing the effects of biota on soil structure. In: Modern Techniques in Soil Ecology: Proceedings of the International Workshop on Modern Techniques in Soil Ecology Relevant to Organic Matter Breakdown, Nutrient Cycling and Soil Biological Processes. Crossley, D.A., Coleman Jr., D.C., Hendrix, P.F., Cheng, W., Wright, D.H., Beare, M.H. and Edwards, C.A. (eds). University of Georgia, Athens. Elsevier, Amsterdam. pp. 279–303.

Jenkinson, D.S. and Ladd, J.N. 1981. Microbial biomass in soil: Measurement and turnover. In: Soil Biochemistry Volume 5. Paul, E.A. and Ladd, J.N. (eds.). Marcel Dekker, New York.

Jeon, J.S., Lee, S.S., Kim, H.Y., Ahn, T.S. and Song, H.G. 2003. Plant growth promotion in soil by some inoculated microorganisms. Journal of Microbiology 41: 271–276.

Jha, C.K. and Saraf, M. 2015. Plant growth-promoting rhizobacteria (PGPR): A review. E3 Journal of Agricultural Research and Development 5(2): 0108-0119.

Jha, D.K., Sharma, G.D. and Mishra, R.R. 1992. Soil microbial population numbers and enzyme activities in relation to altitude and forest degradation. Soil Biology and Biochemistry 24(8): 761-767.

Jin, F., Ding, Y., Ding, W., Reddy, M.S., Fernando, W.G.D. and Du, B. 2011. Genetic diversity and phylogeny of antagonistic bacteria against *Phytophthora nicotianae* isolated from tobacco rhizosphere. International Journal of Molecular Sciences 12(5): 3055-3071. doi:10.3390/ijms12053055.

Johansson, M.-B. 1994. Decomposition rates of Scots pine needle litter related to site properties litter quality, and climate, and climate. Canadian Journal of Forest Resource 24: 1771-1781.

Jongman, R.H.G., ter Braak, C.J.F. and van Tongeren, O.F.R. 1995. Data analysis in community and landscape ecology. Cambridge University Press, Cambridge, UK. pp. 324.

Joo, G.-J., Kim, Y.-M., Lee, I.-J., Song, K.-S. and Rhee, I.-K. 2004. Growth promotion of red pepper plug seedlings and the production of gibberellins by *Bacillus cereus*, *Bacillus macroides* and *Bacillus pumilus*. Biotechnology Letters 26: 487-491. doi: 10.1023/B:BILE.0000019555.87121.34. PMID: 15127789.

Jordan, C.F. 1985. Nutrient cycling in tropical forest ecosystems: principles and their application in management and conservation. Wiley. Chichester, UK.

Jordan, D., Li, F., Jr., F.P., Berry, E.C., Hubbard, V.C. and Kim, K.Y. 1999. The effects of forest practices on earthworm populations and soil microbial biomass in a hardwood forest in Missouri. Applied Soil Ecology 13(1): 31-38. doi: 10.1016/S09291393(99)00017-7.

Joseph, B., Patra, R.R. and Lawrence, R. 2007. Characterization of plant growth promoting rhizobacteria associated with chickpea (*Cicer arietinum* L). International Journal of Plant Production 1(2): 141-152.

Jürgens, K., Pernthaler, J., Schalla, S. and Amann, R. 1999. Morphological and compositional changes in a planktonic bacterial community in response to enhanced protozoan grazing. Applied and Environmental Microbiology 65: 1241–1250.

Kaiser, H.F. 1960. The application of electronic computers to factor analysis. Educational and Psychological Measurement 29: 141-151.

Kalininskaya, T.A. 1989. The influence of different forms of combined nitrogen on nitrogen-fixing activity of *Azospirilla* in the rhizosphere of rice plants. In: Proceedings of the International Symposium on Interrelationships between Microorganisms and Plants in Soil. Vancura, V. and Kunc, F. (eds.). Elsevier Science Publishing, New York, NY. pp. 283–286.

Kandeler, E., Tscherko, D., Bruce, K.D., Stemmer, M., Hobbs, P.J., Bardgett, R.D. and Amelung, W. 2000. Structure and function of the soil microbial community in microhabitats of a heavy metal polluted soil. Soil Biology and Biochemistry 32: 390–400.

Kang, S.M., Khan, A.L., Waqas, M., Young, H.Y., Hamayun, M., Joo, G.J., Shahzad, R., Choi, K.S. and Lee, I.J. 2015. Gibberellin-producing *Serratia nematodiphila* PEJ1011 ameliorates low temperature stress in *Capsicum anuum* L. European Journal of Soil Biology 68: 85-93.

Karakurt, H., Aslantas, R., Ozkan, G. and Guleryuz, M. 2009. Effects of indole–3-butyric acid (IBA), plant growth promoting rhizobacteria (PGPR) and carbohydrates on rooting of hardwood cutting of MM106 apple rootstock. African Journal of Agriculture Research 4(2): 060-064.

Karam, D.S., Arifin, A., Radziah, O., Shamshuddin, J., Majid, N.M., Hazandy, A.H., Zahari, I., Nor Halizah, A.H. and Rui, T.X. 2012. Impact of long-term forest enrichment planting on the biological status of soil in a deforested dipterocarp forest in Perak, Malaysia. The Scientific World Journal 2012: 641346. doi: 10.1100/2012/641346.

Karlen, D.L., Mausbach, M.J., Doran, J.W., Cline, R.G., Harris, R.F. and Schuman, G.E. 1997. Soil quality: A concept, definition and framework for evaluation. Soil Science Society of American Journal 61: 4-10.

Karnwal, A. 2009. Production of indole acetic acid by Fluorescent *Pseudomonas* in the prescence of L-tryptophan and rice root exudates. Journal of Plant Pathology 91(1): 61-63.

Kasim, S., Ahmed, O.H., Majid, N.M.A., Yusop, M.K. and Jalloh, M.B. 2009. Effect of organic based N fertilizer on dry matter (*Zea mays* L.), Ammonium and nitrate recovery in an acid soil of Sarawak, Malaysia. American Journal of Applied Sciences 6(7): 1289–1294.

Katznelson, H., Lochhead, A.G. and Timonin, M.I. 1948. Soil microorganisms and the rhizosphere. Botanical Review 14(9): 543–587.

Kendawang, J.J., Tanaka, S., Ishihara, J., Shibata, K., Sabang, J., Ninomiya, I., Ishizuka, S. and Sakurai, K. 2004. Effects of shifting cultivation on soil ecosystems in Sarawak, Malaysia: I. Slash and burning at Balai Ringin and Sabal experimental sites and effect on soil organic matter. Soil Science and Plant Nutrition 50(5): 677-687. doi:10.1080/00380768.2004.10408524.

Keeney, D.R. and Nelson, D.W. 1982. Nitrogen-inorganic forms. In: Method of Soil Analysis, Part 2 (2nd edition). Page, A.L., Keeney, D.R., Baker, D.E., Miller, R.H., Ellis, R. and Rhoades, J.D. (eds). Agronomy Monograph 9. ASA and SSSA, Madison, Wisconsin.

Kennedy, A.C. and Papendick, R.I. 1995. Microbial characteristics of soil quality. Journal of Soil and Water Conservation (May-June): 243–248.

Kennedy, A.C. and Smith, K.L. 1995. Soil microbial diversity and the sustainable agricultural soils. Plant Soil 170: 75-86.

Kennedy, I.R., Choudhury, A.T.M.A. and Keeskes, M.L. 2004. Non-symbiotic bacterial diazotrophs in crop farming systems: Can their potential for plant growth promotion be better exploited? Soil Biology and Biochemistry 36: 1229-1244.

Khalid, A., Arshad, M. and Zahir, Z.A. 2004. Screening plant growth-promoting rhizobacteria for improving growth and yield of wheat. Journal of Applied Microbiology 96(3): 473-480.

Khan, A.G. 2005. Role of soil microbes in the rhizospheres of plants growing on trace metal contaminated soils in phytoremediation. Journal of Trace Elements in Medicine and Biology 18(4): 355–364. doi: 10.1016/j.jtemb.2005.02.006.

Khan, M.Q., Abbasi, M.W., Zaki, M.J. and Khan, S.A. 2010. Evaluation of *Bacillus thuringiensis* isolates against root-knot nematodes following seed application in okra and mungbean. Pakistan Journal of Botany 42(4): 2903-2910.

Khan, M.S., Zaidi, A. and Wani, P.A. 2007. Role of phosphate solubilizing microorganisms in sustainable agriculture-A review. Agronomy of Sustainable Development 27: 29–43.

Khiari, L. and Parent, L.E. 2005. Phosphorus transformations in acid light-textured soils treated with dry swine manure. Canadian Journal of Soil Science Society 85: 75–87.

Kim, K.Y., McDonald, G.A. and Jordan, D. 1997. Solubilization of hydroxyapatite by *Enterobacter agglomerans* and cloned *Escherichia coli* in culture medium. Biology and Fertility of Soils 24: 347–352. doi: 10.1007/s003740050256.

Kin, M.K.K, Bujang, J.S., Ahmed, O.H., Majid, N.M.A and Heng, R.K.J. and Jemat, S. 2011. Comparison of carbon and selected macronutrients in forest-floor litter of rehabilitated and secondary forests. American Journal of Applied Sciences 8(10): 967-972.

Kizza, C.L., Majaliwa, J.G.M., Nakileza, B., Eilu, G., Bahat, I., Kansiime, F. and Wilson, J. 2013. Soil and nutrient lossess along the chronosequential forest recovery gradient in Mabira Forest Reserve, Uganda. African Journal of Agricultural Research 8(1): 77-85.

Kjoller, A. and Struwe, S. 2002. Fungal communities, succession, enzymes, and decomposition. Enzymes in the Environment: Activity, Ecology and Applications. Burns, R.G. and Dick, R.P. (eds). Marcel Dekker, New York. pp. 267–284.

Klemm, D., Schmauder, H.P. and Heinze, T. 2002. In: Biopolymers, Volume VI. Vandamme, E., De Beats, S. and Stein, A. (eds). Wiley-VCH, Weinheim. pp. 290-292.

Klindworth, A., Pruesse, E., Schweer, T., Peplies, J., Quast, C., Horn, M. and Glöckner, F.O. 2013. Evaluation of general 16S ribosomal RNA gene PCR primers for classical and next-generation sequencing-based diversity studies. Nucleic Acids Research 41(1): e1. doi: 10.1093/nar/gks808. pmid:22933715.

Kloepper, J.W., Lifshitz, R. and Zablotowicz, R.M. 1989. Free-living bacterial inocula for enhancing crop productivity. Trends in Biotechnology 7: 39–43.

Knoepp, J.D., Coleman, D.C., Crossley Jr., D.A. and Clark, J.S. 2000. Biological indices of soil quality: an ecosystem case study of their use. Forest Ecology and Management 138: 357-368.

Kögl, F. and Kostermans, D. 1934. Hetero-auxin als Stoffwechselprodukt niederer pflanzlicher Organismen. XIII. Isolierung aus Hefe. Zeitschriftfűr Physikalische Chemie 228: 113–121.

Koh, L.P. and Wilcove, D.S. 2008. Is oil palm agriculture really destroying tropical biodiversity? Conservation Letters 1: 60–64.

Kokal, H. 1990. The origin of phosphorus in iron-making raw materials and methods of removal- A review. Sixty third annual meeting Minnesota section AIME. pp. 225-257.

Krishnaraj, P.U., Khanuja, S.P.S. and Sadashivam, K.V. 1998. Mineral phosphate solubilization (MPS) and mps genes-components in eco-friendly P fertilization. Bangalore: Abstracts of Indo US Workshop on Application of Biotechnology for Clean Environment and Energy, National Institute of Advanced Studies. pp. 27.

Kuan, K.B., Othman, R., Abdul Rahim, K. and Shamsuddin, Z.H. 2016. Plant growth-promoting rhizobacteria inoculation to enhance vegetative growth, nitrogen fixation and nitrogen remobilisation of maize under greenhouse conditions. PLoS ONE 11(3): e0152478. doi:10.1371/journal.pone.0152478.

Kubicek, C.P. and Penttila, M.E. 1998. Regulation of production of plant polysaccharide degrading enzymes by *Trichoderma*. In: *Trichoderma* and *Gliocladium* volume 2G. Harman, E. and Kubicek, C.P. (eds). Taylor and Francis Ltd. London. pp. 49-72.

Kucey, R.M.N. 1983. Phosphate solubilizing bacteria and fungi in various cultivated and virgin Alberta soils. Canadian Journal of Soil Science 63: 671-678. doi:10.4141/cjss83-068.

Kumar, A., Maurya, B.R. and Raghuwanshi, R. 2014. Isolation and characterization of PGPR and their effect on growth, yield and nutrient content in wheat (*Triticum aestivum* L.). Biocatalysis and Agricultural Biotechnology 3(4): 121–128.

Kumar, V., Behl, R.K. and Narula, N. 2001. Establishment of phosphate-solubilizing strains of *Azotobacter chroococcum* in the rhizosphere and their effect on wheat cultivars under greenhouse conditions. Microbiology Research 156: 87–93. doi: 10.1078/0944-5013-00081.

Kyselková, M., Kopecký, J., Frapolli, M., Défago, G., Ságová-Marečková, M., Grundmann, G.L. and Moënne-Loccoz, Y. 2009. Comparison of rhizobacterial community composition in soil suppressive or conducive to tobacco black root rot disease. ISME Journal 3(10): 1127–1138. doi: 10.1038/ismej.2009.61.

Ladha, J.K. and Reddy, P.M. 2000. Steps for nitrogen-fixation in rice. In: The Quest for Nitrogen Fixation in Rice. Proceedings of the Third Working Group Meeting on Assessing Opportunities for Nitrogen Fixation in Rice, Makai City. Philippines. Ladha, J.K. and Reddy, P.M. (eds). pp. 359.

Laishram, J., Saxena, K.G., Maikhuri, R.K. and Rao, K.S. 2012. Soil quality and soil health: A review. International Journal of Ecology and Environmental Sciences 38(1): 19-37.

Lamb, D., Erskine, P.D. and Parrotta, J.A. 2005. Restoration of degraded tropical forest landscapes. Science 310(5754): 1628–1632.

Lappartient, A.G. and Touraine, B. 1996. Demand-driven control of root ATP sulfurylase activity and SO_4^{2-} uptake in intact canola (the role of phloem-translocated glutathione). Plant Physiology 111: 147–157.

Lappartient, A.G., Vidmar, J.J., Leustek, T., Glass, A.D.M. and Touraine, B. 1999. Inter-organ signaling in plants: regulation of ATP sulfurylase and sulfate transporter genes expression in roots mediated by phloem-translocated compound. Plant Journals 18: 89–95. doi: 10.1046/j.1365-313X.1999.00416.x.

Lavania, M., Chauhan, P.S., Chauhan, S.V., Singh, H.B. and Nautiyal, C.S. 2006. Induction of plant defense enzymes and phenolics by treatment with plant growth-promoting rhizobacteria *Serratia marcescens* NBRI1213. Current Microbiology 52: 363–368. doi: 10.1007/s00284-005-5578-2.

Leaungvutiviroj, C., Piriyaprin, S., Limtong, P. and Sasaki, K. 2010. Relationships between soil microorganisms and nutrient contents of *Vetiveria zizanioides* (L.) *Nash* and *Vetiveria nemoralis* (A.) *Camus* in some problem soils from Thailand. Applied Soil Ecology 46: 95-102.

Lee, K.D., Gray, E.J., Mabood, F., Jung, W.-J., Charles, T., Clark, S.R.D., Ly, A., Souleimanov, A., Zhou, X. and Smith, D.L. 2009. The class *IId* bacteriocin thuricin-17 increases plant growth. Planta 229(4): 747-755.

Li, W., Roberts, D.P., Dery, P.D., Meyer, S.L.F., Lohrke, S., Lumsden, R.D. and Hebbar, K.P. 2002. Broad spectrum antibiotic activity and disease suppression by the potential biocontrol agent *Burkholderia ambifaria* BC-F. Crop Protection 21: 129–135.

Li, X., Quan, C.S., Yu, H.-Y., Wang, J.H. and Fan, S.D. 2009. Assessment of antifungal effects of a novel compound from *Burkholderia cepacia*

against *Fusarium solani* by fluorescent staining. World Journal of Microbiology and Biotechnology 25: 151-154.

Lima, F.S., Stamford, N.P., Sousa, C.S., Lira Junior, M.A., Malheiros, S.M.M. and Van Straaten, P. 2010. Earthworm compound and rock biofertilizer enriched in nitrogen by inoculation with free living diazotrophic bacteria. World Journal of Microbiology and Biotechnology 26: 1769-1775.

Lima, J.A., Nahas, E. and Gomes, A.C. 1996. Microbial populations and activities in sewage sludge and phosphate fertilizer-amended soil. Applied Soil Ecology 4: 75-82. doi: 10.1016/09291393(96)00094-7.

Limmer, C. and Drake, H.L. 1996. Non-symbiotic N_2 fixation in acidic and pH-neutral forest soils: aerobic and anaerobic differentials. Soil Biology and Biochemistry 28: 177–183. doi: 10.1016/0038-0717(95)00118-2.

Limmer, C. and Drake, H.L. 1998. Effects of carbon, nitrogen, and electron acceptor availability on anaerobic N_2-fixation in a beech forest soil. Soil Biology and Biochemistry 30: 153–158. doi: 10.1016/S0038-0717(97)00099-0.

Lin, T.F., Huang, H.I., Shen, F.T. and Young, C.C. 2006. The protons of gluconic acid are the major factor responsible for the dissolution of tricalcium phosphate by *Burkholderia cepacia* CC-A174. Bioresource Technology 97: 957–960.

Lindsay, W.L., Vlek, P.L.G. and Chien, S.H. 1989. Phosphate minerals. In: Minerals in Soil Environment 2. Dixon, J.B. and Weed, S.B. (eds). USA. Soil Science Society of America, Madison, WI. pp. 1089–1130.

Liu, Y., Wang, H., Sun, X., Yang, H., Wang, Y. and Song, W. 2011. Study on mechanisms of colonization of nitrogen-fixing PGPB, *Klebsiella pneumonia* NG14 on the root surface of rice and the formation of biofilm. Current Microbiology 6: 1113-1122.

Lotter, D. 1997. New tests of soil quality: evaluating the health of your soil's microbial community. Farmer to Farmer Magazine.

Lu, W.J., Wang, H.T., Yang, S.J., Wang, Z.C. and Yong, F.N. 2005. Isolation and characterization of mesophilic cellulose-degrading bacteria from flower stalks-vegetable waste co-composting system. Journal of General and Applied Microbiology 51: 353-360.

Lucy, M., Reed, E. and Glick, B.R. 2004. Applications of free living plant growth-promoting rhizobacteria. Antonie van Leeuwenhoek 86(1): 1-25. doi:10.1023/B:ANTO.0000024903.10757.6e.

Lugtenberg, B. and Kamilova, F. 2009. Plant growth-promoting rhizobacteria. Annual Reviews in Microbiology 63: 541–556.

Lynch, J. 1990. The Rhizosphere. John Wiley and Sons. New York.

Lynd, L.R., Weimer, P.J., van Zyl, W.H. and Pretorious, I.S. 2002. Microbial cellulose utilization: fundamentals and biotechnology. Microbiology and Molecular Biology Reviews 66: 506–577.

McNamara, S., Tinh, D.V., Erskine, P.D., Lamb, D., Yates, D. and Brown, S. 2006. Rehabilitating degraded forest land in central Vietnam with mixed native species plantings. Forest Ecology and Management 233(2-3): 358-365. doi: 10.1016/j.foreco.2006.05.033.

Magee, C.M., Rodeheaver, G., Edgerton, M.T. and Edlich, R.F. 1975. A more reliable Gram staining technique for diagnosis of surgical infections. The American Journal of Surgery 130(3): 341-346.

Mahaffee, W.F. and Kloepper, J.W. 1994. Applications of plant growth-promoting rhizobacteria in sustainable agriculture. In: Soil Biota: Management in Sustainable Farming Systems. Pankhurst, C.E., Doube, B.M., Gupta, V.V.S.R. and Grace, P.R. (eds). CSIRO, Melbourne, Australia. pp. 23-31.

Maheswaran, J. and Gunatilleke, I.A.U.N. 1990. Nitrogenase activity in soil and litter of a tropical lowland rainforest and an adjacent fernland in Sri Lanka. Journal of Tropical Ecology 6: 281–289.

Majeed, A., Abbasi, M.K., Hameed, S., Imran, A. and Rahim, N. 2015. Isolation and characterization of plant growth-promoting rhizobacteria from wheat rhizosphere and their effect on plant growth promotion. Frontiers in Microbiology 6: 198. doi: 10.3389/fmicb.2015.00198.

Maki, M., Leung, K.T. and Qin, W. 2009. The prospects of cellulase-producing bacteria for the bioconversion of lignocellulosic biomass. International Journal of Biological Sciences 5(5): 500-516.

Maki, M.L., Broere, M., Leung, K.T. and Qin, W. 2011. Characterization of some efficient cellulase producing bacteria isolated from paper mill sludges and organic fertilizers. International Journal of Biochemistry and Molecular Biology 2(2): 146-154.

Malhotra, M. and Srivastava, S. 2008. Stress-responsive indole-3-acetic acid biosynthesis by *Azospirillum brasilense* SM and its ability to modulate plant growth. European Journal of Soil Biology 45(1): 73-80.

Mandels, M. and Reese, E.T. 1957. Induction of cellulase in *Trichoderma viride* as influenced by carbon sources and metals. Journal of Bacteriology 73: 269-278.

Mangels, J.I., Cox, M.E. and Lindberg, L.H. 1984. Methanol fixation: An alternative to heat fixation of smears before staining. Diagnostic Microbiology and Infectious Disease 2: 129-137.

Mantelin, S. and Touraine, B. 2004. Plant growth-promoting bacteria and nitrate availability: impacts on root development and nitrate uptake.

Journal of Experimental Botany 55(394): 27–34. PMID: 14623902. doi: 10.1093/jxb/erh010.

Marcarelli, A.M. and Wurtsbaugh, W.A. 2007. Effects of upstream lakes and nutrient limitation on periphytic biomass and nitrogen fixation in oligotrophic, subalpine streams. Freshwater Biology 52: 2211-2225.

Marchessault, R.H. and Sundararajan, P.R. 1993. Cellulose. In: The Polysaccharides Volume 2. Aspinall, G.O. (ed). Academic Press. New York. pp. 11-95.

Margolles-Clark, M., Ilmen, M. and Penttila, M. 1997. Expression patterns of 10 hemicellulase genes from filamentous fungus *Trichoderma reesei* on various carbon sources. Journal of Biotechnology 57: 167-179.

Marques, A.P.G.C., Pires, C., Moreira, H., Rangel, A.O.S.S. and Castro, P.M.L. 2010. Assessment of the plant growth promotion abilities of six bacterial isolates using *Zea mays* as indicator plant. Soil Biology and Biochemistry 42(8): 1229-1235. doi:10.1016/j.soilbio.2010.04.014.

Marra, L.M., Oliveira, S.M., Soares, C.R.F.S. and Moreira, F.M.S. 2011. Solubilisation of inorganic phosphates by inoculant strains from tropical legumes. Scientia Agricola 68(5): 603–609.

Martensson, A.M. and Witter, E. 1990. The influence of various soil amendments on nitrogen fixing microorganisms in a long-term field experiment, with special reference to sewage sludge. Soil Biology and Biochemistry 2: 977–982.

Martinelli, L.A., Piccolo, M.C., Townsend, A.R., Vitousek, P.M., Cuevas, E., McDowell, W.H., Robertson, G.P., Santos, O.C. and Treseder, K. 1999. Nitrogen stable isotopic composition of leaves and soil: tropical *versus* temperate forests. Biogeochemistry 46: 45–65.

Martinez, L., Caballero-Mellado, J., Orozco, J. and Martinez-Romero, E. 2003. Diazotrophic bacteria associated with banana (*Musa* spp.). Plant Soil 257: 35-47.

Martínez-Nieto, O., Orozco-Jaramillo, C. and Martínez-Nieto, P. 2009. Evaluación de la inoculación con microorganismos fijadores de nitrógeno asimbióticos aislados de la rizósfera de Pinus patula en Colombia. Bosque. 30: 70-77.

Mat, P.B., Hanif, A.H.M. and Yusof, I.M. 1984. Report and map of the detailed soil survey of UPM farm, Bintulu Campus, Sarawak. Jabatan Pertanian First Edition. Kuching. pp. 73.

Matias, S.R., Passos, R., Scotti, M.R.M. and Sa, N.H. 2007. Soil phosphate solubilizing microorganisms and cellulolytic population as biological indicators of iron mined land rehabilitation. In: First International Meeting

on Microbial Phosphate Solubilization. Vela´zquez, E. and Rodri´guez-Barrueco, C. (eds). pp. 337–340.

Matsumoto, L.S., Martines, A.M., Avanzi, M.A., Albino, U.B., Brasil, C.B., Saridakis, D.P., Rampazo, L.G.L., Zangaro, W. and Andrade, G. 2005. Interactions among functional groups in the cycling of carbon, nitrogen and phosphorus in the rhizosphere of three successional species of tropical woody trees. Applied Soil Ecology 28: 57-65.

Matus, F.J., Lusk, C.H. and Maire, C.R. 2008. Effects of soil texture, carbon input rates, and litter quality on free organic matter and nitrogen mineralization in Chilean rain forest and agricultural soils. Communications in Soil Science and Plant Analysis 39(1-2): 187-201. doi: 10.1080/00103620701759137.

McBride, G.B., Loftis, J.C. and Adkins, N.C. 1993. What do significance tests really tell us about the environment? Environmental Management 17: 423–432.

McGill, W.B. and Cole, C.V. 1981. Comparative aspects of cycling of organic C, N, S and P through soil organic matter. Geoderma 26: 267–268. doi: 10.1016/0016-7061(81)90024-0.

McMurtrie, R.E. and Dewar, R.C. 2013. New insights into carbon allocation by trees from the hypothesis that annual wood production is maximized. New Phytology 199: 981–990. doi: 10.1111/nph.12344.

Mehlich, A. 1953. Determination of P, K, Ca, Mg, and NH_4^+. Soil Test Division Mimeo, North Carolina Department of Agriculture, Raleigh. Retrieved 4 August 2010 from www.ncagr.com/agronomi/pdffiles/mehlich53.pdf.

Mehnaz, S. and Lazarovits, G. 2006. Inoculation effects of *Pseudomonas putida*, *Gluconacetobacter azotocaptans*, and *Azospirillum lipoferum* on corn plant growth under greenhouse conditions. Microbial Ecology 51: 326–335.

Mellmann, A., Cloud, J.L., Andrees, S., Blackwood, K., Carroll, K.C., Kabani, A., Roth, A. and Harmsen, D. 2003. Evaluation of RIDOM, MicroSeq, and Genbank services in the molecular identification of *Nocardia* species. International Journal of Medicine Microbiology 293(5): 359–370.

Mergel, A., Kloos, K. and Bothe, H. 2001. Seasonal fluctuations in the population of denitrifying and N_2-fixing bacteria in an acid soil of a Norway spruce forest. Plant Soil 230: 145–160. doi: 10.1023/A:1004826116981.

Mignard, S. and Flandrois, J. 2006. 16S rRNA sequencing in routine bacterial identification: a 30-month experiment. Journal of Microbiology Methods 67(3): 574-581.

Mishra, P.K., Mishra, S., Selvakumar, G., Bisht, J.K., Kundu, S. and Gupta, H.S. 2009. Coinoculation of *Bacillus thuringiensis*-KR1 with *Rhizobium leguminosarum* enhances plant growth and nodulation of pea (*Pisum sativum* L.) and lentil (*Lens culinaris* L.). World Journal of Microbiology and Biotechnology 25(5): 753-761.

Mooreman, T.B. and Harper, S.S. 1989. Transformation and mineralization of metribuzin in surface and subsurface horizons of a Mississippi Delta soil. Journal of Environmental Quality 18(3): 302-306.

Mulder, E.G. 1975. Physiology and ecology of free-living, nitrogen-fixing bacteria. In: Nitrogen Fixation by Free-Living Micro-Organisms. Stewart, W.D. (ed.). Cambridge: Cambridge University Press. pp. 3–29.

Mullan, A., Quinn, J.P. and McGrath, J.W. 2002. Enhanced phosphate uptake and polyphosphate accumulation in *Burkholderia cepacia* grown under low pH conditions. Microbial Ecology 44: 69-77.

Murphy, J. and Riley, J.P. 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta 27: 31-36.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. and Kent, J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Nadporozhskaya, M.A., Mohren, G.M.J., Chertov, O.G., Komarov, A.S. and Mikhailov, A.V. 2006. Dynamic of soil organic matter in primary and secondary forest succession on sandy soils in The Netherlands: An application of the ROMUL model. Ecology Modelling 190: 399-418. doi: 10.1016/j.ecomodel.2005.03.025.

Nahon, D. and Trompette, R. 1982. Origin of siltstones: glacial grinding *versus* weathering. Sedimentology 29: 25–35. doi: 10.1111/j.1365-3091.1982.tb01706.x.

Nannipieri, P. and Badalucco, L. 2002. Biological processes. In: Handbook of Processes and Modelling in the Soil-Plant System. Kenbi, D.K. and Nieder, R. (eds). The Haworth Press Inc. Binghampton, New York. pp. 57-82.

Nannipieri, P., Kandeler, E. and Ruggiero, P. 2001. Enzyme activities and microbiological and biochemical processes in soil. In: Enzymes in the Environment. Burns, R.G. and Dick, R. (eds). Marcel and Dekker, New York. pp. 1-33.

Narula, N., Deubel, A., Gans, W., Behl, R.K. and Merbach, W. 2006. Paranodules and colonization of wheat roots by phytohormone producing bacteria in soil. Plant, Soil and Environment 52(3): 119–129.

Nautiyal, C.S. 1999. An efficient microbiological growth medium for screening of phosphate solubilizing microorganisms. FEMS Microbiology Letters 170(1): 265–270. doi: 10.1111/j.1574-6968.1999.tb13383.x.

Nazoa, P., Vidmar, J.J., Tranbarger, T.J., Mouline, K., Damiani, I., Tillard, P., Zhuo, D., Glass, A.D.M. and Touraine, B. 2003. Regulation of the nitrate transporter gene *AtNRT2.1* in *Arabidopsis thaliana*: responses to nitrate, amino acids and developmental stage. Plant Molecular Biology 52(3): 689-703. doi: 10.1023/A:1024899808018.

Nester, E.W., Thomashow, L.S., Metz, M. and Girdon, M. 2002. 100 years of *Bacillus thuringiensis*. A Critical Scientific Assessment. ASM/Washington. D.C.

Ng, T.K. and Zeikus, J.G. 1982. Differential metabolism of cellobiose and glucose by *Clostridium thermocellum* and *Clostridium thermohydrosulfuricum*. Journal of Bacteriology 150: 1391-1399.

Nielsen, M.N. and Winding, A. 2002. Microorganisms as indicators of soil health. Technical Report no. 388. National Environmental Research Institute, Denmark.

Nion, Y.A. and Toyota, K. 2008. Suppression of bacterial wilt and *Fusarium* wilt by a *Burkholderia nodosa* strain isolated from Kalimantan soils, Indonesia. Microbes and Environments 23(2): 134-141.

Noel, T.C., Sheng, C., Yost, C.K., Pharis, R.P. and Hynes, M.F. 1996. *Rhizobium leguminosarum* as a plant growth-promoting rhizobacterium: direct growth promotion of canola and lettuce. Canadian Journal of Microbiology 42: 279–283.

Nogawa, M., Goto, M., Okada, H. and Morikawa, Y. 2001. L-Sorbose induces cellulase gene transcription in the cellulolytic fungus *Trichoderma reesei*. Current Genetics 38: 329-334.

Norrish, K. and Rosser, H. 1983. Soils: an Australian viewpoint. In: Mineral Phosphate. CSIRO/London, UK, Australia. Academic Press. pp. 335–361.

Noumavo, P.A., Kochoni, E., Didagbé, Y.O., Adjanohoun, A., Allagbé, M., Sikirou, R., Gachomo, E.W., Kotchoni, S.O. and Baba-Moussa, L. 2013. Effect of different plant growth promoting rhizobacteria on maize seed germination and seedling development. American Journal of Plant Sciences 4: 1013-1021. doi: 10.4236/ajps.2013.45125.

Nye, P.H. and Greenland, D.J. 1964. Changes in the soil after clearing tropical forest. Plant Soil 21: 101-112. doi: 10.1007/BF01373877.

O'Donnell, A.G., Seasman, M., Macrae, A., Waite, I. and Davies, J.T. 2001. Plants and fertilisers as drivers of change in microbial community structure and function in soils. Plant Soil 232: 135-145.

Odum, E.P. 1965. Ecology. Holt, Rinehart and Winston Inc, New York.

Ohta, S. and Effendi, S. 1992. Ultisols of “Lowland dipterocarp forest” in East Kalimantan, Indonesia.II. Status of carbon, nitrogen and phosphorus. Soil Science and Plant Nutrition 39: 1-12. doi: 10.1080/00380768.1992.10416483.

Ohta, S., Effendi, S., Tanaka, N. and Miura, S. 1993. Ultisols of lowland dipterocarp forest in East Kalimantan, Indonesia: III. Clay minerals, free oxides and exchangeable cations. Soil Science and Plant Nutrition 39: 1-12. doi:10.1080/00380768.1993.10416969.

Okon, Y. and Kapulnik, Y. 1986. Development and function of *Azospirillum* inoculated roots. Plant Soil 90: 3–16.

Okon, Y. and Vanderleyden, J. 1997. Root-associated *Azospirillum* species can stimulate plants. Applied and Environmental Microbiology (New York) 63(7): 366-370.

Omar, S.A. 1998. The role of rock phosphate solubilizing fungi and vesicular arbuscular mycorrhiza (VAM) in growth of wheat plants fertilized with rock phosphate. World Journal of Microbiology and Biotechnology 14: 211–219. doi: 10.1023/A:1008830129262.

Orozco-Jaramillo, C. and Martínez-Nieto, P. 2009. Evaluación de la inoculación con microorganismos fijadores de nitrógeno asimbióticos aislados de la rizósfera de Pinus patula en Colombia. Bosque 30: 70-77.

Orr, C.H., James, A., Leifert, C., Cooper, J.M. and Cummings, S.P. 2011. Diversity and activity of free-living nitrogen-fixing bacteria and total bacteria in organic and conventionally managed soils. Applied and Environmental Microbiology 77: 911–919. doi:10.1128/AEM.01250-10.

Oseni, O.A., Ekperigin, M.M., Akindahunsi, A.A. and Oboh, G. 2007. Studies of physiochemical and microbial properties of soils from rainforest and plantation in Ondo state, Nigeria. African Journal of Agricultural Research 2(11): 605-609.

Othman, R., Naher, U.A. and Yusoff, S.Z. 2013. Effect of urea-N on growth and indoleacetic acid production of *Stenotrophomonas maltophilia* (Sb16) isolated from rice growing soils in Malaysia. Chilean Journal of Agricultural Research 73(2): 187-192.

Otto, G. 1965. The influence exerted by fungi in the rhizosphere on the density of ramification of cucumber roots. In: Plant Microbe Relationships. Macura, J. and Vancura, V. (eds). Czechoslovakia Academy of Science, Prague. pp. 209.

Páez, M., Martínez-Nieto, P. and Bernal-Castillo, J. 2005. Siderophore producing *Pseudomonas* as pathogenic *Rhizoctonia solani* and *Botrytis cinerea* antagonists. Universitas Scientiarum 10(1): 65-74.

Palleroni, N.J. and Doudoroff, M. 1971. Phylogenetic characterization and deoxyribonucleic acid homologies of *Pseudomonas solanacearum*. Journal of Bacteriology 107: 690-696.

Pandey, A., Trivedi, P., Kumar, B. and Palni, L.M. 2006. Characterization of a phosphate solubilizing and antagonistic strain of *Pseudomonas putida* (B0) isolated from a subalpine location in the Indian Central Himalaya. Current Microbiology 53(2): 102-107.

Pandey, P. and Maheshwari, D.K. 2007. Two-species microbial consortium for growth promotion of *Cajanus cajan*. Current Science 92(8): 25.

Panhwar, Q.A., Naher, U.A., Jusop, S., Othman, R., Latif, M.A. and Ismail, M.R. 2014. Biochemical and molecular characterization of potential phosphate-solubilizing bacteria in acid sulfate soils and their beneficial effects on rice growth. PlosOne 9(10): e97241.

Panhwar, Q.A., Radziah, O., Zaharah, A.R., Sariah, M. and Mohd Razi, I. 2012. Isolation and characterization of phosphorus solubilizing bacteria from aerobic rice. African Journal of Biotechnology 11(11): 2711–2719.

Paniagua, A., Kammerbauer, J., Avedillo, M. and Andrews, A.M. 1999. Relationship of soil characteristics to vegetation successions on a sequence of degraded and rehabilitated soils in Honduras. Agriculture, Ecosystems and Environment 72(3): 215-225. doi: 10.1016/S01678809(98)00183-2.

Pankhurst, C.E., Hawke, B.G., McDonald, H.J., Kirkby, C.A., Buckerfield, J.C., Michelsen, P., O'Brien, K.A., Gupta, V.V.S.R. and Doube, B.M. 1995. Evaluation of soil biological properties as potential bioindicators of soil health. Australian Journal of Experimental Agriculture 35: 1015–1028.

Pankratov, T.A., Ivanova, A.O., Dedysh, S.N. and Liesack, W. 2011. Bacterial populations and environmental factors controlling cellulose degradation in an acidic sphagnum peat. Environmental Microbiology 13: 1800–1814.

Paramananthan, S. 2000. Soil of Malaysia: Their Characteristics and Identification Volume 1. Academy of Science Malaysia, Kuala Lumpur.

Parisi, V., Menta, C., Gardi, C., Jacomini, C. and Mozzanica, E. 2005. Microarthropod communities as a tool to assess soil quality and biodiversity: A new approach in Italy. Agriculture, Ecosystems and Environment 105: 323-333.

Park, K.H., Lee, C.Y. and Son, H.J. 2009. Mechanism of insoluble phosphate solubilization by *Pseudomonas fluorescens* RAF15 isolated from ginseng rhizosphere and its plant growth-promoting activities. Letters of Applied Microbiology 49: 222–228. doi: 10.1111/j.1472-765X.2009.02642.x.

Park, M., Kim, C., Yang, J., Lee, H., Shin, W., Kim, S. and Sa, T. 2005. Isolation and characterization of diazotrophic growth promoting bacteria

from rhizosphere of agricultural crops of Korea. Microbiological Research 160(2): 127-133.

Parker, M.A., Wurtz, A. and Paynter, Q. 2007. Nodule symbiosis of invasive *Mimosa pigra* in Australia and in ancestral habitats: A comparative analysis. Biological Invasions 9: 127-138.

Parks, E.J., Olson, G.J., Brinckman, F.E. and Baldi, F. 1990. Characterization by high performance liquid chromatography (HPLC) of the solubilization of phosphorus in iron ore by a fungus. Journal of Industrial Microbiology 5(2): 183–189. doi:10.1007/BF01573868.

Parton, W., Silver, W.L., Burke, I.C., Grassens, L., Harmon, M.E., Currie, W.S., King, J.Y., Adair, E.C., Brandt, L.A., Hart, S.C. and Fasth, B. 2007. Global-scale similarities in nitrogen release patterns during long-term decomposition. Science 315(5810): 361-364.

Patel, J.B. 2001. 16S rRNA gene sequencing for bacterial pathogen identification in the clinical laboratory. Molecular Diagnostic 6: 313-321.

Patel, J.B., Leonard, D.G., Pan, X., Musser, J.M., Berman, R.E. and Nachamkin, I. 2000. Sequence-based identification of *Mycobacterium* species using the MicroSeq 500 16S rDNA bacterial identification system. Journal of Clinical Microbiology 38: 246–251.

Patra, A.K., Abbadie, L., Clays-Josserand, A., Degrange, V., Grayston, S.J., Guillaumaud, N., Loiseau, P., Louault, F., Mahmood, S., Nazaret, S., Philippot, L., Poly, F., Prosser, J.I. and Le Roux, X. 2006. Effects of management regime and plant species on the enzyme activity and genetic structure of N-fixing, denitrifying and nitrifying bacterial communities in grassland soils. Environmental Microbiology 8: 1005–1016. doi: 10.1111/j.1462-2920.2006.00992.x.

Pedraza, R.O. 2008. Recent advances in nitrogen-fixing acetic acid bacteria. International Journal of Food Microbiology 6: 25-35.

Peech, H.M. 1965. Hydrogen-ion activity. In: Methods of Soil Analysis -Part 2. Black, C.A., Evants, D.D., Ensminger, L.E., White, J.L., Clark, F.E. and Dinauer, R.C. (eds). Madison, Wisconsin. American Society of Agronomy. pp. 914-926.

Peix, A., Mateos, P.F., Rodriguez-Barrueco, C., Martinez-Molina, E. and Velazquez, E. 2001. Growth promotion of common bean (*Phaseolus vulgaris* L.) by a strain of *Burkholderia cepacia* under growth chamber conditions. Soil Biology and Biochemistry 33: 1927–1935.

Pengnoo, A., Wiwattanapattapee, R., Chumthong, A. and Kanjanamaneesathian, M. 2006. Bacterial antagonist as seed treatment to control leaf blight disease of Bambara groundnut (*Vigna subterranea*). World Journal of Microbiology and Biotechnology 22: 9-14.

Pennanen, T., Liski, J., Bååth, E., Kitunen, V., Uotila, J., Westman, C.J. and Fritze, H. 1999. Structure of the microbial communities in coniferous forest soils in relation to site fertility and stand development stage. Microbial Ecology 38(2): 168–179.

Pennanen, T., Caul, S., Daniell, T.J., Griffiths, B.S., Ritz, K. and Wheatley, R.E. 2004. Community-level responses of metabolically-active soil microorganisms to the quantity and quality of substrate inputs. Soil Biology and Biochemistry 36(5): 841–848.

Pérez-Montaño, F., Alías-Villegas, C., Bellogín, R.A., del Cerro, P., Espuny, M.R., Jiménez-Guerrero, I., López-Baena, F.J., Ollero, F.J. and Cubo, T. 2014. Plant growth promotion in cereal and leguminous agricultural important plants: From microorganism capacities to crop production. Microbiology Research 169: 325-336.

Perrott, K.W., Sarathchandra, S.U. and Waller, J.E. 1990. Seasonal storage and release of phosphorus and potassium by organic matter and the microbial biomass in a high-producing pastoral soil. Australian Journal of Soil Research 28: 593-608. doi: 10.1071/SR9900593.

Phillips, D.A., Fox, T.C., King, M.D., Bhuvaneswari, T.V. and Teuber, L.R. 2004. Microbial products trigger amino acid exudation from plant roots. Plant Physiology 136: 2887–2894. doi: 10.1104/pp.104.044222.

Piccoli, P. and Bottini, R. 1994. Effects of C/N ratio, N-content, pH, and incubation time on growth and gibberellin production by *Azospirillum lipoferum*. Symbiosis 17: 229–236.

Pierson, E.A., Wood, D.W., Cannon, J.A., Blachere, F.M., and Pierson, L.S. 1998. Interpopulation signaling via N-acyl-homoserine lactones among bacteria in the wheat rhizosphere. Molecular Plant-Microbe Interactions 11: 1078–1084. doi: 10.1094/MPMI.1998.11.11.1078.

Pikovskaya, R.I. 1948. Mobilization of phosphorus in soil in connection with vital activity of some microbial species. Microbiology 17: 362–370.

Podile, A.R. and Kishore, K.G. 2007. Plant growth-promoting rhizobacteria. In: Plant-Associated Bacteria. Gnanamanickam, S.S. (ed). Springer, Dordrecht. The Netherlands. pp. 195-230.

Poly, F., Monrozier, L.J. *and* Bally, R. 2001. Improvement in the RFLP procedure for studying the diversity of *nifH* genes in communities of nitrogen fixers in soil. Research in Microbiology 152(1): 95–103.

Pomares-Garcia, F. and Pratt, P.F. 1978. Recovery of 15N-labelled fertilizer from manures and sludge-amended soil. Soil Science Society of American Journal 42: 717-720.

Pothier, J.F., Prigent-Combaret, C., Haurat, J., Mënne-Loccoz, Y. and Wisniewski-Dyé, F. 2008. Duplication of plasmid-borne nitrite reductase

gene *nirK* in the wheat-associated plant growth-promoting rhizobacterium *Azospirillum brasilense* Sp245. Molecular Plant-Microbe Interactions 21(6): 831–842. doi: 10.1094/MPMI-21-6-0831.

Poulsen, O.M. and Petersen, L.W. 1988. Growth of *Cellulomonas* sp. ATCC 21399 on different polysaccharides as sole carbon source induction of extracellular enzymes. Applied Microbiology and Biotechnology 29: 480-484.

Prasad, R. and Power, J.F. 1997. Soil fertility management for sustainable agriculture. New York, USA. Lewis Publishers. pp. 356.

Prigent-Combaret, C., Blaha, D., Pothier, J.F., Vial, L., Poirier, M.A., Wisniewski-Dyé, F. and Moënne-Loccoz, Y. 2008. Physical organization and phylogenetic analysis of *acdR* as leucine-responsive regulator of the 1-aminocyclopropane-1-carboxylate deaminase gene *acdS* in phytobeneficial *Azospirillum lipoferum* 4B and other Proteobacteria. FEMS Microbiology Ecology 65(2): 202–219. doi: 10.1111/j.1574-6941.2008.00474.x.

Prinsen, E., Costacurta, A., Michiels, K., Vanderleyden, J. and Van Onckelen, H. 1993. *Azospirillum brasilense* indole-3-acetic acid biosynthesis: Evidence for a non-tryptophan dependent pathway. Molecular Plant-Microbe Interactions 6: 609–615.

Pruesse, E., Quast, C., Knittel, K., Fuchs, B.M., Ludwig, W., Peplies, J. and Glöckner, F.O. 2007. SILVA: a comprehensive online resource for quality checked and aligned ribosomal RNA sequence data compatible with ARB. Nucleic Acids Research 35(21): 7188–7196. pmid:17947321.

Quiquampoix, H. and Mousain, D. 2005. Enzymatic hydrolysis of organic phosphorus. In: Organic Phosphorus in the Environment. Turner, B.L., Frossard, E. and Baldwin, D.S. (eds). Wallingford UK. CAB International. pp. 89-112.

Raddadi, N., Cherif, A., Boudabous, A. and Daffonchio, D. 2008. Screening of plant growth promoting traits of *Bacillus thuringiensis*. Annals of Microbiology 58: 47-52.

Raich, J.W., Clark, D.A., Schwendenmann, L. and Wood, T.E. 2014. Aboveground tree growth varies with belowground carbon allocation in a tropical rainforest environment. PLoS ONE 9(6): e100275. doi:10.1371/journal.pone.0100275.

Rajoka, M.I. and Malik, K.A. 1997. Cellulase production by *Cellulomonas biazotea* cultured in media containing different cellulosic substrates. Bioresource Technology 59: 21-27.

Rashid, M., Khalil, S., Ayub, N., Alam, S. and Latif, F. 2004. Organic acids production and phosphate solubilization by phosphate solubilizing

microorganisms (PSM) under *in vitro* conditions. Pakistan Journal of Biological Sciences 7(2): 187–196. doi: 10.3923/pjbs.2004.187.196.

Rediers, H., Vanderleyden, J. and De-Mot, R. 2004. *Azotobacter vinelandii*: a *Pseudomonas* in disguise? Microbiology 6: 1117-1119.

Reed, S.C., Cleveland, C.C. and Townsend, A.R. 2007. Controls over leaf litter and soil nitrogen fixation in two lowland tropical rain forests. Biotropica 39: 585-592.

Reed, S.C., Townsend, A.R., Cleveland, C.C. and Nemergut, D.R. 2010. Microbial community shifts influence patterns in tropical forest nitrogen fixation. Oecologia 164: 521–531. doi: 10.1007/s00442-010-1649-6.

Reiners, W.A., Bouwman, A.F., Parsons, W.F.J. and Keller, M. 1994. Tropical rain forest conversion to pasture: Changes in vegetation and soil properties. Ecological Applications 4(2): 363–377. doi: 10.2307/1941940.

Reinhardt, E.L., Ramos, P.L., Manfio, G.P., Barbosa, H.R., Pavan, C. and Moreira-Filho, C.A. 2008. Molecular characterization of nitrogen-fixing bacteria isolated from Brazilian agricultural plants at São Paulo state. Brazilian Journal of Microbiology 39(3): 414-422. doi: 10.1590/S1517-83822008000300002.

Rengel, Z. and Marschner, P. 2005. Nutrient availability and management in the rhizosphere: Exploiting genotypic differences. New Phytologist 168: 305-312.

Reyes, I., Bernier, L., Simard, R.R. and Antoun, H. 1999. Effect of nitrogen source on the solubilization of different inorganic phosphates by an isolate of *Penicillium rugulosum* and two UV-induced mutants. FEMS Microbiology Ecology 28(3): 281–290. doi: 10.1111/j.1574-6941.1999.tb00583.x.

Rice, C.W. 2002. Organic matter and nutrient dynamics. In: Encyclopedia of Soil Science. New York, USA. Marcel Dekker Inc. pp. 925– 928.

Richardson, A.E. 1994. Soil microorganisms and phosphorus availability. In: Soil Biota: Management in Sustainable Farming Systems. Pankhurst, C.E., Doubeand, B.M. and Gupta, V.V.S.R. (eds). Victoria, Australia: CSIRO. pp. 50–62.

Richardson, A.E. and Simpson, R.J. 2011. Soil microorganisms mediating phosphorus availability update on microbial phosphorus. Plant Physiology 156(3): 989-996.

Riggs, P.J., Chelius, M.K., Iniguez, A.L., Kaeppler, S.M. and Triplett, E.W. 2001. Enhanced maize productivity by inoculation with diazotrophic bacteria. Australian Journal of Plant Physiology 28: 829–836.

Roberson, E.B. and Firestone, M.K. 1992. Relationship between desiccation and exopolysaccharide production in a soil *Pseudomonas* sp. Applied and Environmental Microbiology 58(4): 1284–1291.

Rodriguez, H. and Fraga, R. 1999. Phosphate solubilizing bacteria and their role in plant growth promotion. Biotechnology Advances 17(4-5): 319–339. doi: 10.1016/S0734-9750(99)00014-2. PMID:14538133.

Roesch, L.F., Fulthorpe, R.R., Riva, A., Casella, G., Hadwin, A.K.M., Kent, A.D., Daroub, S.H., Camargo, F.A.O., Farmerie, W.G. and Triplett, E.W. 2007. Pyrosequencing enumerates and contrasts soil microbial diversity. ISME Journal 1: 283–290.

Roper, M.M. and Smith, N.A. 1991. Straw decomposition and nitrogenase activity (C_2H_2 reduction) by free-living microorganisms from soil: Effects of pH and clay content. Soil Biology and Biochemistry 23: 275–283. doi: 10.1016/0038-0717(91)90064-Q.

Rosolem, C.A., Calonego, J.C. and Foloni, J.S.S. 2005. Potassium leaching from millet straw as affected by rainfall and potassium rates. Communications in Soil Science and Plant Analysis 36: 1063-1074.

Ross, D.S. and Ketterings, Q. 2011. Chapter 9: Recommended methods for determining soil cation exchange capacity. Cooperative Bulletin No. 493. Recommended Soil Testing Procedures for the Northeastern United States. pp. 75.

Rousk, J., Bååth, E., Brookes, P.C., Lauber, C.L., Lozupone, C., Caporaso, J.G., Knight, R. and Fierer, N. 2010. Soil bacterial and fungal communities across a pH gradient in an arable soil. ISME Journal 4(10): 1340–1351.

Rudnick, P., Meletzus, D., Green, A., He, L.H. and Kennedy, C. 1997. Regulation of nitrogen fixation by ammonium in diazotrophic species of Proteobacteria. Soil Biology and Biochemistry 29: 831–841. doi: 10.1016/S0038-0717(96)00238-6.

Ruppel, S., Torsvik, V., Daae, F.L., Ovreas, L. and Ruhlmann, J. 2007. Nitrogen availability decreases prokaryotic diversity in sandy soils. Biology and Fertility of Soils 43: 449–459.

Ryu, C., Farag, M.A., Hu, C., Reddy, M.S., Wei, H., Paré, P.W. and Kloepper, J.W. 2003. Bacterial volatiles promote growth in *Arabidopsis*. Proceedings of the National Academy of Sciences (PNAS) 100(8): 4927-4932.

Saber, K., Nahla, L.D. and Chedly, A. 2005. Effect of P on nodule formation and N fixation in bean. Agronomy of Sustainable Development 25: 389-393. doi: 10.1051/agro:2005034.

Sachdev, D., Agarwal, V., Verma, P., Shouche, Y., Dhakephalkar, P. and Chopade, B. 2009. Assessment of microbial biota associated with rhizosphere of wheat (*Triticum aestivum*) during flowering stage and their plant growth promoting traits [Electronic version]. The Internet Journal of Microbiology 7(2): 26.

Sadfi, N., Chérif, M., Fliss, I., Boudabbous, A. and Antoun, H. 2001. Evaluation of bacterial isolates from salty soils and *Bacillus thuringiensis* strains for the biocontrol of *Fusarium* dry rot of potato tubers (*Solanum tuberosum* L.). Journal of Plant Pathology 83: 101–108.

Safura, B.K., Yeo, T.C., Martin, W.L., Duron, M.R., Robert, D.R. and Goldstein, A.H. 1995. Cloning of a mineral phosphate-solubilizing gene from *Pseudomonas cepacia*. Applied and Environmental Microbiology 61: 972-978.

Saghir, K.M., Zaidi, A. and Wani, P.A. 2007. Role of phosphate-solubilizing microorganisms in sustainable agriculture: A review. Agronomy of Sustainable Development 27: 29–43.

Saha, S., Roy, R.N., Sen, S.K. and Ray, A.K. 2006. Characterization of cellulase-producing bacteria from the digestive tract of tilapia, *Oreochromis mossambica* (Peters) and grass carp, *Ctenopharyngodon idella* (Valenciennes). Aquaculture Research 37(4): 380-388.

Saharan, B.S. and Nehra, V. 2011. Plant growth promoting rhizobacteria: A critical review. Life Sciences and Medicine Research LSMR-21.

Sahin, F., Cakmakci, R. and Kanta, F. 2004. Sugar beet and barley yields in relation to inoculation with N_2-fixing and phosphate solubilizing bacteria. Plant Soil 265: 123–129. doi: 10.1007/s11104-005-0334-8.

Sakurai, K., Tanaka, S., Ishizuka, S. and Kanzaki, M. 1998. Differences in soil properties of dry evergreen and dry deciduous forests in the Sakaerat environmental research station. Tropics 8: 61-80.

Salisbury, F.B. 1994. The role of plant hormones. In: Plant-Environment Interactions. Wilkinson, R.E. (eds). Marcel Dekker. New York, USA. pp. 39-81.

Sanchez, P. and Logan, T. 1992. Myths and science about the chemistry and fertility of soils in the tropics. In: Myths and Science of Soils of the Tropics. Lal, R. and Sanchez, P. (eds). Madison, WI: Soil Science Society of America. pp. 35-46.

Sarita, S., Priefer, U.B., Prell, J. and Sharma, P.K. 2008. Diversity of *nifH* gene amplified from rhizosphere soil DNA. Current Science 94: 109-115.

Sarr, P.S., Yamakawa, T., Asatsuma, S., Fujimoto, S. and Sakai, M. 2010. Investigation of endophytic and symbiotic features of *Ralstonia* sp. TSC1

isolated from cowpea nodules. African Journal of Microbiology Research 4(19): 1959-1963.

SAS. 2008. SAS/STAT Software, SAS Institute, Cary, NY, USA.

Sato, A., Watanabe, T., Unno, Y., Purnomo, E., Osaki, M. and Shinano, T. 2009. Analysis of diversity of diazotrophic bacteria associated with the rhizosphere of a tropical arbor, *Melastoma malabathricum* L. Microbes Environment 24: 81-87.

Satya, V.K., Vijayasamundeeswari, A., Paranidharan, V. and Velazhahan, R. 2011. *Burkholderia* sp. strain TNAU-1 for biological control of root rot in mung bean (*Vigna radiata* L.) caused by *Macrophomina phaseolina*. Journal of Plant Protection Research 51(3): 273-278.

Schimel, J.P., Gulledge, J.M., Clein-Curley, J.S., Lindstrom, J.E. and Braddock, J.F. 1999. Moisture effects on microbial activity and community structure in decomposing birch litter in the Alaskan taiga. Soil Biology and Biochemistry 31: 831–838.

Schmidt, S.K. and Gier, M.J. 1989. Dynamics of microbial populations in soil: Indigenous microorganisms degrading 2,4-dinitrophenol. Microbial Ecology 18: 285-296.

Schnepf, E., Crickmore, N., Van Rie, J., Lereclus, D., Baum, J., Feitelson, J., Zeigler, D.R. and Dean, D.H. 1998. *Bacillus thuringiensis* and its pesticidal crystal proteins. Microbiology and Molecular Biology Reviews 62(3): 775-806.

Schnurer, J., Clarholm, M., Bostrom, S. and Rosswall, T. 1986. Effects of moisture on soil microorganisms and nematodes: a field experiment. Microbial Ecology 12: 217–230.

Schulein, M. 1997. Enzymatic properties of cellulases from *Humicola insolens*. Journal of Biotechnology 57: 71-81.

Schwarz, W.H. 2001. The cellulosome and cellulose degradation by anaerobic bacteria. Applied Microbiology and Biotechnology 56: 634-649.

Seiboth, B., Hartl, L., Pail, M., Fekete, E., Karaffa, L. and Kubicek, C.P. 2004. The galactokinase of *Hypocrea jecorina* is essential for cellulase induction by lactose but dispensable for growth on D-galactose. Molecular Microbiology 51: 1015-1025.

Sessitsch, A., Weilharter, A., Gerzabek, M.H., Kirchmann, H. and Kandeler, E. 2001. Microbial population structures in soil particle size fractions of a long-term fertilizer field experiment. Applied and Environmental Microbiology 67(9): 4215-4224.

Sethi, S., Datta, A., Lal Gupta, B. and Gupta, S. 2013. Optimization of cellulase production from bacteria isolated from soil. ISRN Biotechnology 2013: 985685.

Setiadi, Y. 1989. Pemanfaatan mikroorganisme dalam kehutanan, Bogor: Institut Pertanian Bogor.

Shaffer, B.T., Widmer, F., Porteous, L.A. and Seidler, R.J. 2000. Temporal and spatial distribution of the *nifH* gene of N_2 fixing bacteria in forests and clearcuts in western Oregon. Microbiology Ecology 39: 12–21. doi: 10.1007/s002489900183.

Shahzad, S.M., Khalid, A., Arshad, M., Khalid, M. and Mehboob, I. 2008. Integrated use of plant growth promoting bacteria and P-enriched compost for improving growth, yield and nodulating of chickpea. Pakistan Journal of Botany 40(4): 1735-1741.

Sharma, S.B., Sayyed, R.Z., Trivedi, M.H. and Gobi, T.A. 2013. Phosphate solubilizing microbes: sustainable approach for managing phosphorus deficiency in agricultural soils. Springer Plus 2: 587. doi:10.1186/2193-1801-2-587.

Shaw, L.J., Morris, P. and Hooker, J.E. 2006. Perception and modification of plant flavonoid signals by rhizosphere microorganisms. Environmental Microbiology 8: 1867–1880. doi: 10.1111/j.1462-2920.2006.01141.x.

Sheldon, F.H., Styring, A. and Hosner, P.A. 2010. Bird species richness in a Bornean exotic tree plantation: a long-term perspective. Biology Conservation 143: 399–407.

Sheng, X.F. and He, L.Y. 2006. Solubilization of potassium-bearing minerals by a wild-type strain of *Bacillus edaphicus* and its mutants and increased potassium uptake by wheat. Canadian Journal of Microbiology 52: 66-72. doi: 10.1139/w05-117. PMID: 16541160.

Sheng, X.F. and Huang, W.Y. 2001. Physiological characteristics of strain NBT of silicate bacterium. Acta Pedologica Sinica 38(4): 569-574.

Sheng, X.F. and Huang, W.Y. 2002. Mechanism of potassium release from feldspar affected by the strain NBT of silicate bacterium. Acta Pedologica Sinica 39: 863–871.

Shigematsu, T., Yumihara, K., Ueda, Y., Numaguchi, M., Morimura, S. and Kida, K. 2003. *Delftia tsuruhatensis* sp. nov., a terephthalate-assimilating bacterium isolated from activated sludge. International Journal of Systematic and Evolutionary Microbiology 53(5): 1479–1483.

Shoham, Y., Lamed, R. and Bayer, E.A. 1999. The cellulosome concept as an efficient microbial strategy for the degradation of insoluble polysaccharides. Trends in Microbiology 7(7): 275-281.

Simmon, K.E., Croft, A.C. and Petti, C.A. 2006. Application of SmartGene IDNS software to partial 16S rRNA gene sequences for a diverse group of bacteria in a clinical laboratory. Journal of Clinical Microbiology 44: 4400–4406.

Simmon, K.E., Mirrett, S., Reller, L.B. and Petti, C.A. 2008. Genotypic diversity of anaerobic isolates from bloodstream infections. Journal of Clinical Microbiology 46: 1596-1601.

Sims, J.T. and Pierzynski, G.M. 2005. Chemistry of phosphorus in soil. In: Chemical Processes in Soil. Tabatabai, A.M. and Sparks, D.L. (eds). SSSA book series 8. Madison. SSSA. pp. 151–192.

Singer, M.J. and Munns, D.N. 2006. Soils: An introduction. Pearson, Prentice Hall, Upper Saddle River, New Jersey, Columbus, Ohio. ISBN: 0-13-119019-9.

Singh, A. and Sharma, S. 2003. Effect of microbial inocula on mixed solid wasted composting, vermicomposting and plant response. Compost Science and Utilization 11(3): 190-199.

Singh, S., Moholkar, V.S. and Goyal, A. 2013. Isolation, identification, and characterization of a cellulolytic *Bacillus amyloliquefaciens* strain SS35 from rhinoceros dung. ISRN Microbiology 2013: 728134.

Smiley, R.W. and Cook, R.J. 1973. Relationship between Take-all of wheat and rhizosphere pH in soils fertilized with ammonium *versus* nitrate- nitrogen. Phytopathology 63: 882-890.

Smith, J.L., McNeal, B.L. and Cheng, H.H. 1985. Estimation of soil microbial biomass: an analysis of the respiratory response of soils. Soil Biology and Biochemistry 17: 11-16.

Soares, R.A., Roesch, L.F.W., Zanatta, G., de Oliveira Camargo, F.A. and Passaglia, L.M.P. 2006. Occurrence and distribution of nitrogen fixing bacterial community associated with oat (*Avena sativa*) assessed by molecular and microbiological techniques. Applied Soil Ecology 33(3): 221–234. doi: 10.1016/j.apsoil.2006.01.001.

Sodhi, N.S., Koh, L.P., Brook, B.W. and Ng, P.K.L. 2004. Southeast Asian biodiversity: an impending disaster. Trends in Ecology and Evolution 19(12): 654–660.

Somogyi, M. 1952. Notes on sugar determination. Journal of Biological Chemistry 195(1): 19-23.

Song, O.R., Lee, S.J., Lee, Y.S., Lee, S.C., Kim, K.K. and Choi, Y.L. 2008. Solubilization of insoluble inorganic phosphate by *Burkholderia cepacia* DA23 isolated from cultivated soil. Brazilian Journal of Microbiology 39: 151–156. doi: 10.1590/S1517-838220080001000030 PMID: 24031195.

Soto, B. and Diazfierroz, F. 1993. Interactions between plant ash leachates and soil. International Journal of Wildland Fire 3(4): 207-216. doi: 10.1071/WF9930207.

Spaepen, S. and Vanderleyden, J. 2010. Auxin and plant-microbe interactions. Estelle, M., Weijers, D., Leyser, O. and Ljung, K. (eds). Cold Spring Harbor. Perspectives in Biology. Cold Spring Harbor Laboratory Press. doi: 10.1101/cshperspect.a001438.

Spaepen, S., Vanderleyden, J. and Remans, R. 2007. Indole-3-acetic acid in microbial and microorganism-plant signalling. FEMS Microbiology Reviews 31(4): 425-448.

Sparling, G.P. and Schipper, L.A. 2002. Soil quality at a national scale in New Zealand. Journal of Environmental Quality 31: 1848-1857.

Sparling, G.P., Schipper, L.A., Bettjeman, W. and Hill, R. 2004. Soil quality monitoring in New Zealand: Practical lessons from a 6-year trial. Agriculture, Ecosystems and Environment 104: 523-534.

Sprent, J. and Sprent, P. 1990. Nitrogen fixing organisms. Chapman and Hall. New York.

Sridevi, M., Mallaiah, K.V. and Yadav, N.C.S. 2007. Phosphate solubilization by *Rhizobium* isolates from *Crotalaria* species. Journal of Plant Sciences 2: 635–639. doi: 10.3923/jps.2007.635.639.

Srinivasan, R., Karaoz, U., Volegova, M., MacKichan, J., Kato-Maeda, M., Miller, S., Nadarajan, R., Brodie, E.L. and Lynch, S.V. 2015. Use of 16S rRNA gene for identification of a broad range of clinically relevant bacterial pathogens. PLoS ONE 10(2): e0117617. doi: 10.1371/journal.pone.0117617.

Steidle, A., Sigl, K., Schuhegger, R., Ihring, A., Schmid, M., Gantner, S., Stoffels, M., Riedel, K., Givskov, M., Hartmann, A., Langebartels, C. and Eberl, L. 2001. Visualization of N-acylhomoserine lactone-mediated cell–cell communication between bacteria colonizing the tomato rhizosphere. Applied and Environmental Microbiology 67(12): 5761–5770. doi: 10.1128/AEM.67.12.5761-5770.2001.

Sternberg, D. and Mandels, G.R. 1979. Induction of cellulolytic enzymes in *Trichoderma reesei* by sophorose. Journal of Bacteriology 139: 761-769.

Stevenson, F.J. 1994. Humus chemistry: Genesis, composition, and reactions. Second Edition. Wiley Inter-science. New York, USA. pp. 496.

Stevenson, F.J. 1982. Organic matter and nutrient availability. In: Non-Symbiotic Nitrogen Fixation and Organic Matter in the Tropics. Transactions of 12th International Congress of Soil Science. New Delhi, India. pp. 137-151.

Suárez-Moreno, Z.R., Caballero-Mellado, J., Coutinho, B.G., Mendonca-Previato, L., James, E.K. and Venturi, V. 2012. Common features of environmental and potentially beneficial plant-associated *Burkholderia*. Microbial Ecology 63(2): 249-266.

SubbaRao, N.S. 1982. Advances in agricultural microbiology. India: Oxford and IBH Publications Company. pp. 229–305.

Subhani, A., Huang, C.Y., Xie, Z.M., Liao, M. and El-Ghamry, A.M. 2001. Impact of soil environment and agronomic practices on microbial/dehydrogenase enzyme activity in soil- A Review. Pakistan Journal of Biological Sciences 4(3): 333-338.

Sudhakar, P., Chattopadhyay, G.N., Gangwar, S.K. and Ghosh, J.K. 2000. Effect of foliar application of *Azotobacter*, *Azospirillum* and *Beijerinckia* on leaf yield and quality of mulberry (*Morus alba*). Journal of Agriculture Science 134: 227–234.

Sukumaran, R.K., Singhania, R.R. and Pandey, A. 2005. Microbial cellulases: Production, applications and challenges. Journal of Scientific and Industrial Research 64: 832-844.

Suliasih, S.W. 2005. Isolation and identification of phosphate solubilizing and nitrogen fixing bacteria from soil in Wamena Biological Garden, Jayawijaya, Papua. Biodiversitas 6: 175–177.

Sun, Y. and Cheng, J. 2003. Hydrolysis of lignocellulosic materials for ethanol production: A review. Chemical Information 34: 1-11.

Supraja, Y., Reddy, R.S., Reddy, S.S. and Durga Rani, C.H.V. 2011. Plant growth promotion and biocontrol properties of local isolates of fluorescent Pseudomonads. Journal of Research ANGRAU. 39(3): 1-5.

Susyan, E.A., Wirth, S., Anayeva, N.D. and Stolnikova, E.V. 2011. Forest succession on abandoned arable soils in European Russia-Impacts on microbial biomass fungal bacteria ratio and basal CO respiration activity. European Journal of Soil Biology 47: 169-174. doi: 10.1016/j.ejsobi.2011.04.002.

Swaby, R.J. and Sperber, J.I. 1958. Phosphate-dissolving micro-organisms in the rhizosphere of legumes. In: Nutrition of the Legumes. Proceedings in University of Nottingham 5th Easter School of Agriculture Science. Hallsworth, E.G. (ed). CSIRO Adelaide.

Tan, K.H. 2005. Soil Sampling, Preparation and Analysis, 2nd Edition. CRC Press. Taylor and Francis Group, USA. ISBN: 0849334993.

Tanaka, S., Wasli, M.E.B., Kotegawa, T., Seman, L., Sabang, J., Kendawang, J.J., Sakurai, K. and Morooka, Y. 2007. Soil properties of secondary forests under shifting cultivation by the Iban of Sarawak, Malaysia in relation to vegetation condition. Tropics 16(4): 385-398.

Taylor, B.R. and Parkinson, D. 1988. Aspen and pine leaf litter decomposition in laboratory microcosms. II. Interactions of temperature and moisture level. Canadian Journal of Botany 66: 1966-1973.

Taylor, J.P., Wilson, B., Mills, M.S. and Burns, R.G. 2002. Comparison of microbial numbers and enzymatic activities in surface soils and subsoils using various techniques. Soil Biology and Biochemistry 34(3): 387-401.

Teale, W.D., Paponov, I.A. and Palme, K. 2006. Auxin in action: signalling, transport and the control of plant growth and development. Nature Reviews Molecular Cell Biology 7: 847–859. doi: 10.1038/nrm2020.

Thayer, D.W. 1978. Carboxymethylcellulase produced by facultative bacteria from the hind-gut of the termite *Reticulitermes hesperus*. Journal of General Microbiology 106(1): 13-18.

Thornley, J.H.M. 1972. A balanced quantitative model for root: shoot ratios in vegetative plants. Annals of Botany 36: 431–441.

Thurston, B., Dawson, K.A. and Strobel, H.J. 1993. Cellobiose *versus* glucose utilization by the ruminal bacterium *Ruminococcus albus*. Applied and Environmental Microbiology 59: 2631-2637.

Tien, T.M., Gaskin, M.H. and Hubbell, D.H. 1979. Plant growth substances produced by *Azospirillum brasilense* and their effect on the growth of pearl millet (*Pennisetum americanum* L). Applied and Environmental Microbiology 37(5): 1016-1024.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., Schindler, D., Schlesinger, W.H., Simberloff, D. and Wackhamer, D. 2001. Forecasting agriculturally driven global environmental change. Science 292: 281–284. doi: 10.1126/science.1057544.

Tiquia, S.M., Wan, H.C. and Tam, N.F.Y. 2002. Microbial population dynamics and enzyme activities during composting. Compost Science and Utilization 10(2): 150-161.

Tisdale, S.L., Nelson, W.L. and Beaton, J.D. 1985. Soil fertility and fertilizers. Macmillan Publishing Company. New York, USA.

Touraine, B. 2004. Nitrate uptake by roots–transporters and root development. In: *Nitrogen Acquisition and Assimilation in Higher Plants.* De Kok, L.J. and Stulen, I. (eds). Dordrecht: Kluwer Academic Publishers. pp. 1–34. doi: 10.1007/978-1-4020-2728-4_1.

Tailor, R., Tippett, J., Gibb, G., Pells, S., Pike, D., Jordan, L. and Ely, S. 1992. Identification and characterization of a novel *Bacillus thuringiensis* delta-endotoxin entomocidal to coleopteran and lepidopteran larvae. Molecular Microbiology 6(9): 1211-1217.

Treves, D.S., Xia, B., Zhou, J. and Tiedje, J.M. 2003. A two–species test of the hypothesis that spatial isolation influences microbial diversity in soil. Microbial Ecology 45(1): 20–28.

Tripathi, B.M., Kim, M., Singh, D., Lee-Cruz, L., Lai-Hoe, A., Ainuddin, A.N., Go, R., Abdul Rahim, R., Husni, M.H.A., Chun, J. and Adams, J.M. 2012. Tropical soil bacterial communities in Malaysia: pH dominates in the equatorial tropics too. Microbial Ecology 64: 474-484.

Trolove, S.N., Hedley, M.J., Kirk, G.J.D., Bolan, N.S. and Loganathan, P. 2003. Progress in selected areas of rhizosphere research on P acquisition. Australian Journal of Soil Research 41: 471–499. doi: 10.1071/SR02130.

Tsai, S.H., Selvam, A. and Yang, S.S. 2007. Microbial diversity of topographical gradient profiles in Fushan forest soils of Taiwan. Ecology Research 22: 814-824.

Tsavkelova, E.A., Cherdyntseva, T.A., Klimova, S.Y., Shestakov, A.I., Botina, S.G. and Netrusov, A.I. 2007. Orchid-associated bacteria produce indole-3-acetic acid, promote seed germination, and increase their microbial yield in response to exogenous auxin. Archives of Microbiology 188(6): 655-664.

Uehara, G. and Gilman, G. 1981. The mineralogy, chemistry and physics of tropical soils with variable charge clays. Boulder, USA. Westview Press. pp. 170.

Ulrich, J.M. and McLaren, A.D. 1971. Effects of degradative microbial enzymes on the growth and structure of young carrot roots. Journal of Phytopathology 70(4): 295-305.

Upadhyay, S.K., Singh, D.P. and Saikia, R. 2009. Genetic diversity of plant growth promoting rhizobacteria isolated from rhizospheric soil of wheat under saline condition. Current Microbiology 59: 489-496. doi: 10.1007/s00284-009-9464-1.

Urrego-Layton, J., Rodríguez-Aponte, D., Bernal-Castillo, J. and Martínez-Nieto, P. 2006. Inmovilización de bacterias diazotróficas y solubilizadoras de fósforo aisladas de un Bosque Alto Andino Cundinamarqués. In: Universidad Pedagógica y Tecnológica de Colombia (ed). Memorias Primer Congreso Nacional en Sistemas de Alta Montaña Tropical. Tunja, Boyacá. pp. 111.

USDA. 1999. Soil quality test kit guide. United States Department of Agriculture, Agricultural Research Service and Natural Resources Conservation Service. Soil Quality Institute, Auburn, AL.

Vacheron, J., Desbrosses, G., Bouffaud, M.L., Touraine, B., Moënne-Loccoz, Y., Muller, D., Legendre, L., Wisniewski-Dye, F. and Prigent-Combaret, C. 2013. Plant growth-promoting rhizobacteria and root system

functioning. Frontiers in Plant Science 4: 356. doi: 10.3389/fpls.2013.00356.

Vaheri, M., Leisola, M. and Kauppinen, V. 1979. Transglycosylation products of cellulase system of *Trichoderma reesei*. Biotechnology Letters 1(1): 41-46.

Validov, S., Kamilova, F., Qi, S., Stephen, D., Wang, J.J., Makarova, N. and Lugtenberg, B. 2007. Selection of bacteria able to control *Fusarium oxysporum* f. sp. *Radicus-lycopersici* in stone substrate. Journal of Applied Microbiology 102: 461–471.

van Bruggen, A.H.C. and Grunwald, N.J. 1996. Tests for risk assessment of root infection by plant pathogens. In: Methods for Assessing Soil Quality. Doran, W. and Jones, A.J. (eds). Soil Science Society of America, Madison, WI. pp. 293-310.

van Bruggen, A.H.C. and Semenov, A.M. 2000. In search of biological indicators for soil health and disease suppression. Applied Soil Ecology 15: 13-24.

Van de Werf, H. and Verstraete, W. 1987. Estimation of active soil microbial biomass by mathematical analysis of respiration curves: calibration of the test procedure. Soil Biology and Biochemistry 19: 261-265.

van Dobben, W.H. and McConnell, R. 1975. Unifying concepts in ecology. First edition. Junk, W. (ed). The Hague. ISBN9022005240. pp. 302.

Van Keulen, G., Alderson, J., White, J. and Sawers, R.G. 2007. The obligate aerobic actinomycete *Streptomyces coelicolor* A3(2) survives extended periods of anaerobic stress. Environmental Microbiology 9: 3143–3149.

Vardharajula, S., Ali, S.Z., Grover, M., Reddy, G. and Bandi, V. 2011. Drought-tolerant plant growth promoting *Bacillus* spp.: effect on growth, osmolytes and antioxidant status of maize under drought stress. Journal of Plant Interactions 6: 1-14.

Vassilev, N., Vassileva, M., Azcon, R. and Medina, A. 2001. Preparation of gel-entrapped mycorrhizal inoculum in the presence or absence of *Yarowia lipolytica*. Biotechnology Letters 23: 907–909. doi: 10.1023/A:1010599618627.

Vazquez, P., Holguin, G., Puente, M., Lopez-cortes, A. and Bashan, Y. 2000. Phosphate solubilizing microorganisms associated with the rhizosphere of mangroves in a semi-arid coastal lagoon. Biology and Fertility of Soils 30: 460–468. doi: 10.1007/s003740050024.

Venkateswarlu, B., Rao, A.V., Raina, P. and Ahmad, N. 1984. Evaluation of phosphorus solubilization by microorganisms isolated from arid soil. Journal of Indian Society in Soil Science 32: 273–277.

Vessey, J.K. 2003. Plant growth promoting rhizobacteria as biofertilizers. Plant Soil 255(2): 571–586.

Vidal-Quist, J.C., Rogers, H.J., Mahenthiralingam, E. and Berry, C. 2013. *Bacillus thuringiensis* colonises plant roots in a phylogeny-dependent manner. FEMS Microbiology Ecology 86(3): 474-489. doi: 10.1111/1574-6941.12175.

Vijayasamundeeswari, A., Vijayanandraj, S., Paranidharan, V., Samiyappan, R. and Velazhahan, R. 2010. Integrated management of aflatoxin B1 contamination of groundnut (*Arachis hypogaea* L.) with *Burkholderia* sp. and zimmu (*Allium sativum* L. x *Allium cepa* L.) intercropping. Journal of Plant Interactions 5: 59–68.

Vitousek, P.M. 1994. Potential nitrogen-fixation during primary succession in Hawaii Volcanoes National Park. Biotropica 26: 234-240.

Vitousek, P.M. and Field, C.B. 1999. Ecosystem constraints to symbiotic nitrogen fixers: a simple model and its implications. Biogeochemistry 46: 179–202.

Vitousek, P.M. and Hobbie, S. 2000. Heterotrophic nitrogen fixation in decomposing litter: patterns and regulation. Ecology 81: 2366–2376.

Vitousek, P.M. and Sanford, R.L. 1986. Nutrient cycling in moist tropical forest. Annual Reviews of Ecology and Systematics 17: 137–167.

Vitousek, P.M., Cassman, K., Cleveland, C., Crews, T., Field, C.B., Grimm, N.B., Howarth, R.W., Marino, R., Martinelli, L., Rastetter, E.B. and Sprent, J.I. 2002. Towards an ecological understanding of biological nitrogen fixation. Biogeochemistry 57(1): 1–45.

Wagener, S.M. and Schimel, J.P. 1998. Stratification of ecological processes: a study of the birch forest floor in the Alaskan taiga. Oikos 81: 63–74.

Wakelin, S.A., MacDonald, L.M., Rogers, S.L., Gregg, A.L., Bolger, T.P. and Baldock, J.A. 2008. Habitat selective factors influencing the structural composition and functional capacity of microbial communities in agricultural soils. Soil Biology and Biochemistry 40(3): 803–813.

Wakelin, S.A., Gregg, A.L., Simpson, R.J., Li, G.D., Riley, I.T. and McKay, A.C. 2009. Pasture management clearly affects soil microbial community structure and N-cycling bacteria. Pedobiologia 52: 237–251. doi: 10.1016/j.pedobi.2008.10.001

Wakelin, S.A., Warren, R.A., Harvey, P.R. and Ryder, M.H. 2004. Phosphate solubilization by *Penicillium* sp. closely associated with wheat roots. Biology and Fertility of Soils 40: 36–43. doi: 10.1007/s00374-004-0750-6.

Wan, Y., Luo, S., Chen, J., Xiao, X., Chen, L., Zeng, G., Liu, C. and He, Y. 2012. Effect of endophyte-infection on growth parameters and Cd-induced phytotoxicity of Cd-hyperaccumulator *Solanum nigrum* L. Chemosphere 89(6): 743-750.

Wander, M.M. and Bollero, G.A. 1999. Soil quality assessment of tillage impacts in Illinois. Soil Science Society of American Journal 63: 961-971.

Wani, P.A., Zaidi, A., Khan, A.A. and Khan, M.S. 2005. Effect of phorate on phosphate solubilization and indole acetic acid (IAA) releasing potentials of rhizospheric microorganisms. Annals of Plant Protection Science 13: 139-144.

Ward, N.L., Challacombe, J.F., Janssen, P.H., Henrissat, B., Coutinho, P.M., Wu, M., Xie, G., Haft, D.H., Sait, M., Badger, J., Barabote, R.D., Bradley, B., Brettin, T.S., Brinkac, L.M., Bruce, D., Creasy, T., Daugherty, S.C., Davidsen, T.M., DeBoy, R.T., Detter, J.C., Dodson, R.J., Durkin, A.S., Ganapathy, A., Gwinn-Giglio, M., Han, C.S., Khouri, H., Kiss, H., Kothari, S.P., Madupu, R., Nelson, K.E., Nelson, W.C., Paulsen, I., Penn, K., Ren, Q., Rosovitz, M.J., Selengut, J.D., Shrivastava, S., Sullivan, S.A., Tapia, R., Thompson, L.S., Watkins, K.L., Yang, Q., Yu, C., Zafar, N., Zhou, L. and Kuske, C.R. 2009. Three genomes from the phylum *Acidobacteria* provide insight into the lifestyles of these microorganisms in soils. Applied and Environmental Microbiology 75(7): 2046–2056.

Wei, J.Z., Hale, K., Carta, L., Platzer, E., Wong, C., Fang, S.C. and Aroian, R.V. 2003. *Bacillus thuringiensis* Crystal proteins that target nematodes. PNAS 100: 2760-2765.

Wei, X. and Kimmins, J.P. 1998. Asymbiotic nitrogen fixation in harvested and wildfire-killed lodgepole pine forests in the central interior of British Columbia. Forest Ecology and Management 109(1-3): 343-353.

Went, F.W. and Thimann, K.V. 1937. Phytohormones. Macmillan, New York.

Whitelaw, M.A. 1999. Growth promotion of plants inoculated with phosphate solubilizing fungi. Advances in Agronomy 69: 99–151. doi: 10.1016/S0065-2113(08)60948-7.

Whitelaw, M.A., Harden, T.J. and Helyar, K.R. 1999. Phosphate solubilization in solution culture by the soil fungus *Penicillium radicum*. Soil Biology and Biochemistry 32: 655–665. doi: 10.1016/S0038-0717(98)00130-8.

Widada, J., Damarjaya, D.I. and Kabirun, S. 2007. The interactive effects of arbuscular mycorrhizal fungi and rhizobacteria on the growth and nutrients uptake of sorghum in acid soil. In: First International Meeting on Microbial Phosphate Solubilization. Rodriguez-Barrueco, C. and Velazquez, E. (eds). Springer. pp. 173–177.

Widmer, F., Shaffer, B.T., Porteous, L.A. and Seidler, R.J. 1999. Analysis of *nifH* gene pool complexity in soil and litter at a Douglas fir forest site in

the Oregon Cascade Mountain Range. Applied and Environmental Microbiology 65: 374–380.

Wierckx, N., Koopman, F., Ruijssenaars, H.J. and de Winde, J.H. 2011. Microbial degradation of furanic compounds: biochemistry, genetics, and impact. Applied Microbiology and Biotechnology 92(6): 1095-1105.

Woese, C.R., Kandler, O. and Wheelis, M.L. 1990. Towards a natural system of organisms: proposal for the domains *Archaea*, *Bacteria* and *Eucarya*. Proceedings of Natural Academy Sciences 87: 4576-4579.

Woo, P.C.Y., Lau, S.K.P., Teng, J.L.L., Tse, H. and Yuen, K.-Y. 2008. Then and now: use of 16S rDNA gene sequencing for bacterial identification and discovery of novel bacteria in clinical microbiology laboratories. Clinical Microbiology and Infection 14(10): 908-934. doi: 10.1111/j.1469-0691.2008.02070.x.

Wood, T.M. and Bhat, K.M. 1988. Methods for measuring cellulase activities. Methods in Enzymology 160: 87-112.

Woodward, A.W. and Bartel, B. 2005. Auxin: regulation, action, and interaction. Annals of Botany 95: 707–735.

Wu, S.C., Cao, Z.H., Li, Z.G., Cheung, K.C. and Wong, M.H. 2005. Effects of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: a greenhouse trial. Geoderma 125: 155-166. doi: 10.1016/j.geoderma.2004.07.003.

Yabuuchi, E., Kosako, Y., Oyaizu, H., Yano, I., Hotta, H., Hashimoto, Y., Ezaki, T. and Arakawa, M. 1992. Proposal of *Burkholderia* gen. nov. and transfer of seven species of genus *Pseudomonas* homology group II to the new genus, with the type species *Burkholderia cepacia* (Palleroni and Holmes, 1981) comb. nov. Microbiology and Immunology 36(12): 1251-1275.

Yang, C.K. and Yang, S.S. 2001. Microbial ecology of soils surrounding nuclear and thermal power plants in Taiwan. Environment International 26(5-6): 315-322.

Yang, S.S., Fan, H.Y., Yang, C.K. and Lin, I.C. 2003. Microbial population of spruce soil in Tatachia mountain of Taiwan. Chemosphere 52: 1489-1498.

Yang, X.D., Warren, M. and Zou, X.M. 2007. Fertilization responses of soil litter fauna and litter quantity, quality, and turnover in low and high elevation forests of Puerto Rico. Applied Soil Ecology 37: 63–71.

Yanni, Y.G., Rizk, R.Y., Corich, V., Squartini, A., Ninke, K., Philip-Hollingsworth, S., Orgambide, G., DeBruijn, F., Stoltzfus, J., Buckley, D., Schmidt, T.M., Mateos, P.F., Ladha, J.K. and Dazzo, F.B. 1997. Natural endophytic association between *Rhizobium leguminosarum* bv. *Trifolii*

and rice roots and assessment of its potential to promote rice growth. Plant Soil 194: 99-114.

Yarza, P., Richter, M., Peplies, J., Euzeby, J., Amann, R., Schleifer, K.-H., Ludwig, W., Glockner, F.O. and Rossello-Mora, R. 2008. The all-species living tree project: A 16S rRNA-based phylogenetic tree of all sequenced type strains. Systematic and Applied Microbiology 31: 241-250.

Yasmin, F., Othman, R., Saad, M.S. and Sijam, K. 2007. Screening for beneficial properties of rhizobacteria isolated from sweet potato rhizosphere. Journal of Biotechnology 6(1): 49-52.

Yasmin, F., Othman, R., Sijam, K. and Saad, M.S. 2009. Characterization of beneficial properties of plant growth-promoting rhizobacteria isolated from sweet potato rhizosphere. African Journal of Microbiology Research 3(11): 815-821.

Young, J.P.W. 1992. Phylogenetic classification of nitrogen fixing organisms. In: Biological Nitrogen Fixation. Stacey, G., Burris, R.H. and Evans, H.J. (eds). Chapman and Hall, New York. pp. 43–86.

Yrjälä, K., Mancano, G., Fortelius, C., Akerman, M.-L. and Sipila, T.P. 2010. The incidence of *Burkholderia* in epiphytic and endophytic bacterial cenoses in hybrid aspen grown on sandy peat. Boreal Environment Research 15(1): 81-96.

Zaidey, A.K., Arifin, A., Zahari, I., Hazandy, A.H., Zaki, M.H., Affendy, H., Wasli, M.E., Khairul Hafiz, Y., Shamshuddin, J. and Nik Muhamad, M. 2010. Characterizing soil properties of lowland and hill dipterocarp forests at Peninsular Malaysia. International Journal of Soil Science 5(3): 112-130. doi: 10.3923/ijss.2010.112.130.

Zaidi, A., Khan, M.S., Ahemad, M., Oves, M. and Wani, P.A. 2009. Recent advances in plant growth promotion by phosphate-solubilizing microbes. In: Microbial Strategies for Crop Improvement. Khan, M.S., Zaidi, A. and Musarrat, J. (eds). Berlin Heidelberg: Springer-Verlag. pp. 23–50. ISBN: 978-3-642-01979-1.

Zak, D.R., Tilman, D., Parmenter, R.R., Rice, C.W., Fisher, F.M., Vose, J., Milchunas, D. and Martin, C.W. 1994. Plant production and soil microorganisms in late successional ecosystems- A continental scale study. Ecology 75(8): 2333-2347.

Zehr, J.P. 2011. Nitrogen fixation by marine cyanobacteria. Trends in Microbiology 6: 162-173.

Zhang, Y.H.P., Himmel, M.E. and Mielenz, J.R. 2006. Outlook for cellulose improvement: screening and selection strategies. Biotechnology Advances 24: 452-481.

Zhang, C.X., Yang, S.Y., Xu, M.X., Sun, J., Liu, H., Liu, J.R., Liu, H., Kan, F., Sun, J., Lai, R. and Zhang, K.Y. 2009. *Serratia nematodiphila* sp. nov., associated symbiotically with the entomopathogenic nematode *Heterorhabditidoides chongmingensis* (Rhabditida: Rhabditidae). International Journal of Systematic and Evolutionary Microbiology 59: 1603-1608.

Zhang, G.X., Peng, G.X., Wang, E.T., Yan, H., Qing, H.Y., Zhang, W., Lou, X., Wu, H. and Tan, Z.Y. 2008. Diverse endophytic nitrogen-fixing bacteria isolated from wild rice *Oryza rufipogon* and description of *Phytobacter diazotrophicus* gen. nov. sp. nov. Archives of Microbiology 189: 431-439.

Zhang, P., Zheng, J., Pan, G., Zhang, X., Li, L. and Rolf, T. 2007. Changes in microbial community structure and function within particle size fractions of a paddy soil under different long-term fertilization treatments from the Tai Lake region, China. Colloids and Surfaces B: Biointerfaces 58(2): 264–270.

Zhu, F., Qu, L., Hong, X. and Sun, X. 2011. Isolation and characterization of a phosphate-solubilizing halophilic bacterium *Kushneria* sp. YCWA18 from Daqiao Saltern on the coast of Yellow Sea of China. Evidence-Based Complementary and Alternative Medicine 2011(615032): 6.

Zou, X., Binkley, D. and Doxtader, K.G. 1992. A new method for estimating gross phosphorus mineralization and immobilization rates in soils. Plant Soil 147: 243–250. doi:10.1007/BF00029076.