BIBLIOGRAPHY

Acinas, S. G., Marcelino, L. A., Klepac-Ceraj, V. & Polz, M. F. (2004). Divergence and redundancy of 16S rRNA sequences in genomes with multiple rrn operons. *J Bacteriol* **186**, 2629–2635.

Allen, O. & Allen, E. (1981).*The Leguminosae. A Source Book of Characteristics, Use and Nodulation*. London: Macmillan.

Amel, B., Nourelhouda, A. & Faiza, B. (2013). Diversity of rhizobia nodulating *Lablab purpureus* and the effect of the acidity, aluminum and ferric deficit on their symbiosis. *Int J Adv Biotechnol Res* **4**, 586–598.

Ansari, P. G., Rao, D. L. N. & Pal, K. K. (2014). Diversity and phylogeny of soybean rhizobia in central India. *Ann Microbiol* **64**, 1553–1565.

Appelbaum, E. R., Thompson, D. V, Idler, K. & Chartrain, N. (1988). *Rhizobium japonicum* USDA 191 has two *nodD* genes that differ in primary structure and function. *J Bacteriol* **170**, 12–20.

Appunu, C., Ganesan, G., Kalita, M., Kaushik, R., Saranya, B., Prabavathy, V. R. & Sudha, N. (2011). Phylogenetic diversity of rhizobia associated with horsegram [*Macrotyloma uniflorum* (Lam.) Verdc.] grown in South India based on *glnII*, *recA* and 16S-23S intergenic sequence analyses. *Curr Microbiol* **62**, 1230–1238.

Appunu, C., Zoue, A. N. & Laguerre, G. (2008). Genetic diversity of native *Bradyrhizobia* isolated from Soybeans (*Glycine max* L.) in different agricultural-ecological-climatic regions of India. *Appl Environ Microbiol* **74 (19)**, 5991–5996.

Arun, A. B. & Sridhar K. R. (2005). Growth tolerance of rhizobia isolated from sand dune legumes of the southwest coast of India. *Eng Life Sci* **5 (2)**, 134 - 138

Barrett, C. F. & Parker, M. A. (2006). Coexistence of *Burkholderia*, *Cupriavidus*, and *Rhizobium* sp. nodule bacteria on two *Mimosa* spp. in Costa Rica. *Appl Environ Microbiol* **72**, 1198–1206.

Beijerinck, M. (1888). Cultur des *Bacillus radicola* aus den Knöllchen. *Bot Ztg* **46**, 740–750.

Berman-Frank, I., Lundgren, P. & Falkowski, P. (2003). Nitrogen fixation and photosynthetic oxygen evolution in cyanobacteria. *Res Microbiol* **154**, 157–164.

Bhargava, Y., Amel **Murthy, J. S. R., Rajesh Kumar, T. V & Narayana Rao, M. (2016).** Phenotypic, stress tolerance and plant growth promoting characteristics of rhizobial isolates from selected wild Legumes of semiarid region, Tirupati, India. *Adv Microbiol* **6**, 1–12.

Bhattacharyya, P. N. & Jha, D. K. (2012). Plant growth-promoting rhizobacteria (PGPR): Emergence in agriculture. *World J Microbiol Biotechnol* **28**, 1327–1350.

Bikrol, A, Saxena, N.& Singh, K. (2010). Characterization of *Bradyrhizobium* strains isolated from different varieties of soybean with 16SrDNA RFLP from agricultural land of Madhya Pradesh, India. *Indian J Microbiol* **50 (4)**, 404-11

Bordeleau, L. & Prévost, D. (1994). Nodulation and Nitrogen Fixation in Extreme Environments. In: Graham, P.H., Sadowsky, M.J. and Vance, C.P., Eds., *Symbiotic Nitrogen Fixation*, Springer, Dordrecht, 115-125.

Bric, J. M., Bostock, R. M., Silverstone, S. E., Bric, J. M., Bostock, R. M.

&Silverstonet, S. E. (1991). Rapid in situ assay for indoleacetic acid production by bacteria immobilized on a nitrocellulose membrane rapid in situ assay for indoleacetic acid production by bacteria immobilized on a nitrocellulose membrane. *Appl Environ Microbiol* **57**, 535–538.

Cameron, D. (1988). Tropical and subtropical pasture legumes 5.Siratro (Macroptilium atropurpureum): the most widely planted subtropical legume. *Queensl Agric J* **111**, 45–49.

Chang, Y. L., Wang, E. T., Sui, X. H., Zhang, X. X. & Chen, W. X. (2011). Molecular diversity and phylogeny of rhizobia associated with *Lablab purpureus* (Linn.) grown in Southern China. *Syst Appl Microbiol* **34**, 276–284.

Chang, Y. L., Wang, J. Y., Wang, E. T., Liu, H.C., Sui, X. H., & Chen, W. X. (2011). *Bradyrhizobium lablabi* sp. nov., isolated from effective nodules of *Lablab purpureus* and *Arachis hypogaea*. *Int J Syst Evol Microbiol* **61**, 2496–2502.

Chen, C. R., Condron, L. M., Davis, M. R. & Sherlock, R. R. (2003a). Seasonal changes in soil phosphorus and associated microbial properties under adjacent grassland and forest in New Zealand. *For Ecol Manage* **117**, 539–557.

Chen, L. S., Figueredo, A., Pedrosa, F. O. & Hungria, M. (2000). Genetic characterization of soybean rhizobia in Paraguay. *Appl Environ Microbiol* **66**, 5099–5103.

Chen, W. M., Laevens, S., Lee, T. M., Coenye, T., De Vos, P., Mergeay, M. & Vandamme, P. (2001). *Ralstonia taiwanensis* sp. nov., isolated from root nodules of Mimosa species and sputum of a cystic fibrosis patient. *Int J Syst Evol Microbiol* **51**, 1729–1735.

Chen, W. M., Moulin, L., Bontemps, C., Vandamme, P., Bena, G. & Boivin-Masson, C. (2003b). Legume symbiotic nitrogen fixation by beta-proteobacteria is widespread in nature. *J Bacteriol* **185**, 7266–7272.

Chen, W., Faria, S. M. De, Straliotto, R., Pitard, R. M., Simões-araùjo, J. L., Chou, J., Chou, Y., Barrios, E., Prescott, A. R. & other authors. **(2005).** Proof that *Burkholderia* strains form effective symbioses with legumes : a study of novel mimosa -nodulating strains from South America. *Appl Environ Microbiol* **71**, 7461–7571.

Chen, W. M., James, E. K., Coenye, T., Chou, J.-H., Barrios, E., de Faria, S. M., Elliott, G. N., Sheu, S.-Y., Sprent, J. I. & Vandamme, P. (2006).*Burkholderia mimosarum* sp. nov., isolated from root nodules of *Mimosa* spp. from Taiwan and South America. *Int J Syst Evol Microbiol* **56**, 1847–1851.

Chen, W. M., de Faria, S. M., Chou, J. H., James, E. K., Elliott, G. N., Sprent, J. I., Bontemps, C., Young, J. P. W. & Vandamme, P. (2008).*Burkholderia sabiae* sp. nov., isolated from root nodules of *Mimosa caesalpiniifolia*. *Int J Syst Evol Microbiol* **58**, 2174–2179.

Chen, W. X., Yan, G. H., Li, J. L. (1988). Numerical taxonomic study of fast-growing soybean rhizobia and a proposal that *Rhizobium fredii* be assigned to *Sinorhizobium* gen. nov. *Int JSyst Bacteriol* **38**, 392-397.

Choudhury, B., Azad, P. & Kalita, M. C. (2010). Variability in symbiotic effectiveness of native Rhizobia in acid stress. *Curr Microbiol* **61**, 85–91.

Cigdem, K., Merih, K. & Engin, K. (2006). Characterization of *Rhizobium* sp. isolated from bean. *Turkish J Biol* **30**, 127–132.

Cooper, J. E.(2007). Early interactions between legumes and rhizobia: disclosing complexity in a molecular dialogue. *J Appl Microbiol* **103**, 1355–1365.

Costa, F. M., Schiavo, J. A., Brasil, M. S., Leite, J., Xavier, G. R. & Fernandes, P. I. J. (2014). Phenotypic and molecular fingerprinting of fast growing rhizobia of field-grown pigeonpea from the eastern edge of the Brazilian Pantanal. *Genet Mol Res* **13**, 469–482.

Csonka, L. N. & Hanson, A. D. (1991). Prokaryotic osmoregulation: genetics and physiology. *Annu Rev Microbiol* **45**, 569–606.

Datta, C. & Basu, P. S. (2000). Indole acetic acid production by a *Rhizobium* species from root nodules of a leguminous shrub, *Cajanus cajan*. *Microbiol Res* **155**, 123–127.

de Lajudie, P., Laurent-Fulele, E., Willerns, A., Torck, U., Coopman, R., Collins, M. D., Kersters, K., Dreyfus, B. & Gillis, M. (1998).*Allorhizobium undicola* gen. nov., sp. nov., nitrogen-fixing bacteria that efficiently nodulate *Neptunia natans* in Senegal. *Int J Syst Bacteriol* **48**, 1277-1290.

Dean, D. R. & Jacobson M. R. (1992). Biochemical genetics of nitrogenase in Biological Nitrogen Fixation. Edited by G. Stacey, R. H. Burris and H. J. Evans. Chapman & Hall, New 371, 763-834.

Deb. K., Deb., B & Pandey, P. (2015). Screening the *Rhizobium* from *Cajanus cajan* for plant growth promoting factors. *The International Journal Of Science & Technoledge* **2** (8), 134-138.

Deka, A. K. & Azad, P.(2006). Isolation of rhizobium strains: cultural and biochemical characteristics. *Legum Res* **29**, 209–212.

Deka, R. K. & Sarkar, C. R. (1990). Nutrient composition and antinutritional factors of *Dolichos lablab* L. seeds. *Food Chem* **38**, 239–246.

Delgado, M. J., Ligero, F. & Lluch, C. (1994). Effects of salt stress on growth and nitrogen fixation by pea, faba-bean, common bean and soybean plants. *Soil Biol Biochem* **26**, 371–376.

Deshwal, V. & Chaubey, A. (2014). Isolation and Characterization of Rhizobium leguminosarum from root nodule of *Pisum sativum* L. *J Acad Ind Res* **2**, 464–467.

Dhabhai, K. & Batra, A. (2012). Physiological and phylogenetic analysis of rhizobia isolated from *Acacia nilotica* L. *African J Biotechnol* **11**, 1386-139

Dilworth, M. J. & Parker, C. A. (1969). Development of the nitrogen-fixing system in legumes. *J Theor Biol* **25**, 208–218.

Dreyfus, B., Garcia, J. L. &Gillis, M. (1988). Characterization of *Azorhizobium caulinodans*gen sp.nov., a stem-nodulating nitrogen-fixing bacterium isolated from *Sesbania rostrata*. *Int J Syst Bacteriol* **38**, 89-98.

Dubey, R. C., Maheshwari, D. K., Kumar, H. & Choure, K. (2010). Assessment of diversity and plant growth promoting attributes of rhizobia isolated from *Cajanus cajan* L. *African J Biotechnol* **9**, 8619–8629.

Dudeja, S. S., Giri, R., Saini, R., Suneja-Madan, P. & Kothe, E. (2012). Interaction of endophytic microbes with legumes. *J Basic Microbiol* **52**, 248–260.

Eardly, B. D., Eardly, B. D., Nour, S. M., Nour, S. M., Selander, R. K. & Selander, R. K. (2005). Rhizobial 16S rRNA and dnaK Genes: mosaicism and the uncertain phylogenetic placement of *Rhizobium galegae.Appl Environ Microbiol***71**,

1328–1335.

Edulamudi, P., Masilamani, A., Divi, V., Zakkula, V. & Konada, V. (2015). Genetic characterization of rhizobia associated with horse gram [*Macrotyloma uniflorum* (Lam.) Verdc.] based on RAPD and RFLP. *Br Microbiol Res J* **5**, 339–350.

Elanchezhian, R., Rajalakshmi, S. &Jayakumar, V. (2009). Salt tolerance characteristics of rhizobium species associated with *Vigna marina*. *Indian J Agr Sci* **79 (12)**, 980–85.

Fernandes Júnior, P. I., da Silva Almeida, J. P., Passos, S. R., de Oliveira, P. J., Rumjanek, N. G. & Xavier, G. R. (2010). Production and rheological behavior of exopolysaccharide synthesized by pigeonpea rhizobia isolates. *Pesqui Agropecu Bras* **45**, 1465–1471.

Fernandes Júnior, P. I., Lima, A. A. de, Passos, S. R., Gava, C. A. T., Oliveira, P. J. De, Rumjanek, N. G. & Xavier, G. R. (2012). Phenotypic diversity and amylolytic activity of fast growing rhizobia from pigeonpea [*Cajanus cajan* (L.) MILLSP.]. *Brazilian J Microbiol* **43**, 1604–1612.

Figueiredo, M., Seldin, L., Araujo, F. & Mariano, R. (2011). *Plant growth promoting rhizobacteria:fundamentals and applications, D.K. Maheshwari (Ed.), Plant Growth and Health Promoting Bacteria*. Berlin, Heidelberg: Springer-Verlag.

Frank, B. (1889). Über die Pilzsymbiose der Leguminosen. *Berichte der Dtsch Bot Gesellschaft* **7**, 332–346.

Fred, E., Baldwin, I. & McCoy, E. (1932). Root nodule bacteria and leguminous plants. Madison, WI: University of Wisconsin Press.

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

Gao, J. L., Sun, J. G., Li, Y., Wang, E. T. & Chen, W. X. (1994). Numerical taxonomy and DNA relatedness of tropical rhizobia isolated from Hainan Province, China. *Int J Syst Bacteriol* **44**, 151 –158.

Gauri, Singh, A. K., Bhatt, R. P., Pant, S., Bedi, M. K., & Naglot, A. (2011). Characterization of *Rhizobium* isolated from root nodules of *Trifolium alexandrinum*. *Journal of Agricultural Technology* **7(6)**, 1705-1723

George, T., Buresh, R., Ladha, J. & Punzalan, G. (1988). Recycling (in situ) of legume fixed and soil nitrogen in tropical lowland rice. *Agron J* **90**, 429–437.

Gillis, M., Van, T., Bardin, R., Goor, M., Hebbar, P., Willems, A., Segers, P., Kersters, K., Heulin, T. & Fernandez, M. P. (1995). Polyphasic taxonomy in the genus *Burkholderia* leading to an emended description of the genus and proposition of *Burkholderia vietnamiensis* sp. nov. for N2-fixing isolates from rice in Vietnam. *Int J Syst Bacteriol* **45**, 274–289.

Glenn, A. R. & Dilworth, M. J. (1994). The life of root nodule bacteria in the acidic underground. *FEMS Microbiol Lett* **123**, 1–9.

Glick, B. R. & Glick, B. R. (2012). Plant growth-promoting bacteria: mechanisms and applications. *Scientifica* 2012, 1–15.

Gordon, S. A. & Weber, R. P. (1951). Colorimetric estimation of indole acetic acid. *Plant Physiol* **26**, 192–195.

Graham, P. H., Draeger, K. J., Ferrey, M. L., Conroy, M. J., Hammer, B. E., Martinez, E., Aarons, S. R. & Quinto, C. (1994). Acid pH tolerance in strains of *Rhizobium* and *Bradyrhizobium*, and initial studies on the basis for acid tolerance of *Rhizobium tropici* Umr1899. *Can J Microbiol* **40**, 198–207.

Gupta, A., Saxena, A. K., Gopal, M. & Tilak, K. V. B. R. (1998). Effect of plant growth promoting rhizobacteria on competitive ability of introduced *Bradyrhizobium* sp. (Vigna) for nodulation. *Microbiol Res* **153**, 113–117.

Gyaneshwar, P., Hirsch, A. M., Moulin, L., Chen, W.-M., Elliott, G. N., Bontemps, C., Estrada-de los Santos, P., Gross, E., dos Reis, F. B. & other authors. **(2011).** Legume-nodulating betaproteobacteria: diversity, host range, and future prospects. *Mol Plant-Microbe Interact* **24**, 1276–1288.

Hall, T.(1999). BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symp Ser*.

Hallmann, J., Quadt-Hallmann, A., Mahaffee, W. F. & Kloepper, J. W. (1997). Bacterial endophytes in agricultural crops. *Can J Microbiol* **43**, 895–914.

Hashem, F. M., Swelim, D. M., Kuykendall, L. D., Mohamed, A. I., Abdel-Wahab, S. M. & Hegazi, N. I. (1998). Identification and characterization of salt- and thermo-tolerant Leucaena-nodulating Rhizobium strains. *Biol Fertil Soils* **27**, 335–341.

Haukka, K., Lindström, K. & Young, J. (1998). Three phylogenetic groups of *nodA* and *nifH* genes in *Sinorhizobium* and *Mesorhizobium* isolates from leguminous trees growing in Africa and Latin America. *Appl Environ Microbiol* **64**, 419–426.

Holt, J., Krieg, N., Sneath, P., Staley, J. & Williams, S. (1994). *In: Bergey's*

manual of Determinative Bacteriology. Baltimore, U.S.A: Williams and Wilkins Press.

Horvath, B., Kondorosi, E., John, M., Schmidt, J., Török, I., Györgypal, Z., Barabas,I., Wieneke, U., Schell, J., Kondorosi, A. (1986). Organization, structure and symbiotic function of *Rhizobium meliloti* nodulation genes determining host specificity for alfalfa. *Cell* **46 (3)**, 335-43.

Hungria, M. & Vargas, M. A. T. (2000). Environmental factors affecting N2 fixation in grain legumes in the tropics, with an emphasis on Brazil. *F Crop Res* **65**, 151–164.

Hunter, W. J., Kuykendall, L. D. & Manter, D. K. (2007). *Rhizobium selenireducens* sp. nov.: a selenite-reducing alpha-Proteobacteria isolated from a bioreactor. *Curr Microbiol* **55**, 455–460.

Hurek, T., Egener, T. & Reinhold-Hurek, B. (1997). Divergence in nitrogenases of *Azoarcus* spp., Proteobacteria of the beta subclass. *J Bacteriol* **179**, 4172–4178.

Hussain, N., Mujeeb, F., Tahir, M., Khan, G., Hassan, N. & A, B. (2002). Effectiveness of Rhizobium under salinity streess.pdf. *Asian J Pant Sci* **1**, 12–14.

Jarvis, B. D. W., Van Berkum, P., Chen, W. X., Nour, S. M., Fernandez, M. P., Cleyet-Marel, J. C. & Gillis, M. (1997). Transfer of *Rhizobium loti, Rhizobium huakuii, Rhizobium ciceri, Rhizobium mediterraneum*, and *Rhizobium tianshanense* to *Mesorhizobium* gen. nov. *Int J Syst Bacteriol* **47**, 895–898.

Jensen, M. A., Webster, J. A. & Straus, N. (1993). Rapid identification of bacteria on the basis of polymerase chain reaction-amplified ribosomal DNA spacer polymorphisms. *Appl Environ Microbiol* **59**, 945–952.

Ji, S. H., Gururani, M. A. & Chun, S.-C. (2014). Isolation and characterization of plant growth promoting endophytic diazotrophic bacteria from Korean rice cultivars. *Microbiol Res* **169**, 83–98.

Jones, K. M., Kobayashi, H., Davies, B. W., Taga, M. E. & Graham, C. (2007). How rhizobial symbionts invade plants: the *Sinorhizobium-Medicago* model. *Nat Rev Microbiol* **5**, 619–633.

Jordan, D. C. (1982). Transfer of Rhizobium japonicum Buchananm 1980 to *Bradyrhizobium japonicum* gen. Nov., a genus of slow growing root nodule bacteria. *Int J Syst Bacteriol* 378–380.

Jordan, D. (1984). Family III. *Rhizobiaceae.* In: Bergey's Manual of Systematic Bacteriology. Baltimore:The Williams and Wilkins.

Jordan, D. & Allen, O. (1974). Genus II. Rhizobium. In *Bergey's Man Determ Bacteriol 8th ed*, pp. 262–264. Baltimore: The Williams and Wilkins Co.

Kamble, P. M., Singh, A. & Kashyap, L. R. (2006). Characterization of intrinsic variability of *Mesorhizobium ciceri* isolates of cultivated fields. *Indian J Exp Biol* **44(8)**, 671-674

Kaneko, T., Nakamura, Y., Sato, S., Asamizu, E., Kato, T., Sasamoto, S., Watanabe, A., Idesawa, K., Ishikawa, A. & other authors. **(2000).** Complete genome structure of the nitrogen-fixing symbiotic bacterium *Mesorhizobium loti*. *DNA Res***7**, 331–338.

Kang, J. W., Song, J., Doty, S. L. & Lee, D. K. (2013). Diversity of rhizobia associated with leguminous trees growing in South Korea. *J Basic Microbiol* **53**, 291–298.

Kennedy, I. R., Choudhury, A. T. M. . & Kecskés, M. L. (2004). Non-symbiotic bacterial diazotrophs in crop-farming systems: can their potential for plant growth promotion be better exploited? *Soil Biol Biochem* **36**, 1229–1244.

Kesari, V., Ramesh, A. M.& Rangan, L. (2013). *Rhizobium pongamiae* sp. nov. from Root Nodules of *Pongamia pinnata*. *BioMed Res Int* doi: 10.1155/2013/165198

Khalifa, A. Y. Z. & Almalki, M. A. (2014). Isolation and characterization of an endophytic bacterium, *Bacillus megaterium* BMN1, associated with root-nodules of *Medicago sativa* L. growing in Al-Ahsaa region, Saudi Arabia. *Ann Microbiol* **65**, 1017–1026.

Khan, M. S., Zaidi, A., Ahemad, M., Oves, M. & Wani, P. A. (2010). Plant growth promotion by phosphate solubilizing fungi – current perspective. *Arch Agron Soil Sci* **56**, 73–98.

Khbaya, B., Khbaya, B., Neyra, M., Neyra, M., Normand, P., Normand, P., Zerhari, K., Zerhari, K., Filali-maltouf, A. & Filali-maltouf, A. (1998). Genetic diversity and phylogeny of rhizobia that nodulate *Acacia* spp. in Morocco assessed by analysis of rRNA genes. *Appl Environ Microbiol* **64**, 4912–4917.

Kim, J. & Rees, D. C. (1994). Nitrogenase and biological nitrogen fixation. *Biochemistry* **33**, 389–397.

Kiss, E., Mergaert, P., Olah, B., Kereszt, A., Staehelin, C., Davies, A. E., Downie, J. A., Kondorosi, A. & Kondorosi, E. (1998). Conservation of nolR in the *Sinorhizobium* and *Rhizobium* genera of the *Rhizobiaceae* family. *Mol Plant-Microbe Interact* **11**, 1186–1195.

Klonowska, A., Chaintreuil, C., Tisseyre, P., Miche, L., Melkonian, R., Ducousso,

M., Laguerre, G., Brunel, B. & Moulin, L. (2012). Biodiversity of *Mimosa pudica* rhizobial symbionts (*Cupriavidus taiwanensis, Rhizobium mesoamericanum*) in New Caledonia and their adaptation to heavy metal-rich soils. *FEMS Microbiol Ecol* **81**, 618–635.

Kovacs, N. (1956). Identification of *Pseudomonas pyocyanea* by the oxidase reaction. *Nature* **178**, 703.

Kucuk, C., Kivanc, M. & Kinaci, E.(2006). Characterization of *Rhizobium* sp. isolated from bean. *Turk J Biol* **30**, 127–132.

Kuykendall, L.B., Saxena, B., Devine, T.E., Udell & S.E. (1992). Genetic diversity in *Bradyrhizobium japonicum* Jordan 1982 and a proposal for *Bradyrhizobium elkanii* sp. nov. *Can J Microbiol* **38**, 501–505.

Kumar, A., Devi, S., Patil, S., Payal, C. & Negi, S. (2012).) Isolation, screening and characterization of bacteria from rhizospheric soils for different plant growth promotion (PGP) activities: An in vitro study. *Recent Res Sci Technol* **4**, 1–5.

Kumar, B., Kumar, S. K., Annapurna, K. & Maheshwari, D. K. (2006). Genetic diversity of plant growth- promoting rhizobia isolated from a medicinal legume, *Mucuna pruriens*. *Curr Sci* **91**, 1–6.

Kumar, V., Vir Pathak, D., Singh Dudeja, S., Saini, R., Giri, R., Narula, S. & Chander Anand, R. (2013). Legume nodule endophytes more diverse than endophytes from roots of legumes or non legumes in soils of Haryana, India. *J Microbiol Biotechnol Res* **3**, 83–92.

Kumari, B., Ram, M. & Mallaiah, K.(2010). Studies on nodulation, biochemical analysis and protein profiles of Rhizobium isolated from Indigofera species. *Malays J*

*Microbiol***6**, 133–139.

Kundu, S. & Dudeja, S. S. (2008). Molecular diversity, effectiveness and competitiveness of indigenous rhizobial population infecting mungbean *Vigna radiata* (L. Wilczek) under semi-arid conditions. *Indian J Microbiol* **48**, 445–452.

Laguerre, G., Allard, M.-R., Revoy, F. & Amarger, N. (1994). Rapid identification of rhizobia by restriction fragment length polymorphism analysis of PCR-amplified 16s RNA genes. *Appl Environ Microbiol* **60**, 56–63.

Laranjo, M., Alexandre, A. & Oliveira, S. (2014). Legume growth-promoting rhizobia: An overview on the *Mesorhizobium* genus. *Microbiol Res* **169**, 2–17.

Lee, J. Y. & Song, S.-H. (2007). Evaluation of groundwater quality in coastal areas: implications for sustainable agriculture. *Environ Geol* **52**, 1231–1242.

Lei, X., Wang, E. T., Chen, W. F., Sui, X. H. & Chen, W. X. (2008). Diverse bacteria isolated from root nodules of wild Vicia species grown in temperate region of China. *Arch Microbiol* **190**, 657–671.

Li, J. H., Wang, E. T., Chen, W. F. & Chen, W. X. (2008). Genetic diversity and potential for promotion of plant growth detected in nodule endophytic bacteria of soybean grown in Heilongjiang province of China. *Soil Biol Biochem* **40**, 238–246.

Lin, D.X., Wang, E.T., Tang, H., Han, T.X., He, Y.R., Guan, S.H. & Chen, W.X. (2008). *Shinella kummerowiae* sp. nov., a symbiotic bacterium isolated from root nodules of the herbal legume *Kummerowia stipulacea*. *Int J Syst Evol Microbiol* **58**, 1409-1413.

Liu, X. Y., Wang, E. T., Li, Y. & Chen, W. X. (2007). Diverse bacteria isolated

from root nodules of Trifolium, Crotalaria and Mimosa grown in the subtropical regions of China. *Arch Microbiol* **188**, 1–14.

Liu, X. Y., Wu, W., Wang, E. T., Zhang, B., Macdermott, J. & Chen, W. X. (2011). Phylogenetic relationships and diversity of rhizobia associated with Mimosa species grown in Sishuangbanna, China. *Int J Syst Evol Microbiol* **61**, 334–342.

Liu, X., Wei, S., Wang, F., James, E. K., Guo, X., Zagar, C., Xia, L. G., Dong, X. & Wang, Y. P. (2012).*Burkholderia* and *Cupriavidus* spp. are the preferred symbionts of *Mimosa* spp. in southern China. *FEMS Microbiol Ecol* **80**, 417–426. England.

Lopez-Bucio, J., Campos-Cuevas, J. C., Hernandez-Calderon, E., Velasquez-Becerra, C., Farias-Rodriguez, R., Macias-Rodriguez, L. I. & Valencia-Cantero, E. (2007). *Bacillus megaterium* rhizobacteria promote growth and alter root-system architecture through an auxin- and ethylene-independent signaling mechanism in *Arabidopsis thaliana*. *Mol Plant Microbe Interact* **20**, 207–217.

Lorite, M. J., Muñoz, S., Olivares, J., Soto, M. J. & Sanjuán, J. (2010). Characterization of strains unlike *Mesorhizobium loti* that nodulate *Lotus* spp. in saline soils of Granada, Spain. *Appl Environ Microbiol* **76**, 4019–4026.

Lu, J. K., He, X. H., Huang, L. B., Kang, L. H. & Xu, D. P. (2012). Two Burkholderia strains from nodules of *Dalbergia odorifera* T. Chen in Hainan Island, southern China. *New For* **43**, 397–409.

Lynch, J. M. (1990). Beneficial interactions between micro-organisms and roots. *Biotechnol Adv* **8**, 335–346.

Madrzak, C. J., Golinska, B., Kroliczak, J., Pudelko, K., Lazewska, D., Lampka,

B. & Sadowsky, M. J. (1995). Diversity among field populations of *Bradyrhizobium japonicum* in Poland. *Appl Environ Microbiol* **61**, 1194–1200.

Magingo, F. (1992).*CrotaIaria ochroleuca* a promising biofertiliser for the small-scale African farmer. *InABN Symp Biotechnol Rapid Dev Africa*, 17–21. Nairobi.

Mahenthiralingam, E., Bischof, J., Byrne, S. K., Radomski, C., Davies, J. E., Av-Gay, Y. & Vandamme, P. (2000). DNA-Based diagnostic approaches for identification of *Burkholderia cepacia* complex, *Burkholderia vietnamiensis,Burkholderia multivorans*, *Burkholderia stabilis*, and *Burkholderia cepacia* genomovars I and III. *J Clin Microbiol* **38**, 3165–3173.

Maier, R. J. & Triplett, E. W. (1996). Towards more productive, efficient, and competitive nitrogen-fixing symbiotic bacteria. *CRC Crit Rev Plant Sci* **15**, 191–234.

Martens, M., Dawyndt, P., Coopman, R., Gillis, M., De Vos, P. & Willems, A. (2008). Advantages of multilocus sequence analysis for taxonomic studies: a case study using 10 housekeeping genes in the genus Ensifer (including former *Sinorhizobium*). *Int J Syst Evol Microbiol* **58**, 200–214.

Martinez-Hidalgo, P., Ramirez-Bahena, M.H., Flores-Felix, J. D., Rivas, R. Mateos, P. F., Martinez-Molina, E., Leon-Barrios, M., Peix, A. & Velazquez, E. (2015). Revision of the taxonomic status of type strains of *Mesorhizobium loti* and reclassification of strain USDA 3471T as the type strain of *Mesorhizobium erdmanii* sp. nov. and ATCC 33669T as the type strain of *Mesorhizobium jarvisii* sp. nov. *Int J Syst Evol Microbiol* **65**, 1703-1708.

Martinez-Romero, E. & Caballero-Mellado, J. (1996).*Rhizobium phylogenies* and bacterial genetic diversity. *CRC Crit Rev Plant Sci* **15**, 113–140.

Marufu, L., Karanja, N. & Ryder, M. (1995). Legume inoculant production and use in East and Southern Africa. *Soil Biol Biochem* **27**, 735–738.

Merrick, M. J. & Edwards, R. A. (1995). Nitrogen control in bacteria. *Microbiol Rev* **59**, 604–622.

Mhamdi, R., Mrabet, M., Laguerre, G., Tiwari, R. & Aouani, M. E. (2005). Colonization of *Phaseolus vulgaris* nodules by Agrobacterium-like strains. *Can J Microbiol* **51**, 105–111.

Miller, S. C. M., LiPuma, J. J. & Parke, J. L. (2002). Culture-based and non-growth-dependent detection of the *Burkholderia cepacia* complex in soil environments. *Appl Environ Microbiol* **68**, 3750–3758.

Mishra, R. P. N., Tisseyre, P., Melkonian, R., Chaintreuil, C., Miche, L., Klonowska, A., Gonzalez, S., Bena, G., Laguerre, G. & Moulin, L. (2012). Genetic diversity of *Mimosa pudica* rhizobial symbionts in soils of French Guiana: investigating the origin and diversity of *Burkholderia phymatum* and other beta-rhizobia. *FEMS Microbiol Ecol* **79**, 487–503.

Moulin, L., Munive, A., Dreyfus, B. & Boivin-Masson, C. (2001). Nodulation of legumes by members of the beta-subclass of Proteobacteria. *Nature* **411**, 948–950.

Moulin, L., Bena, G., Boivin-Masson, C. & Stepkowski, T. (2004). Phylogenetic analyses of symbiotic nodulation genes support vertical and lateral gene co-transfer within the Bradyrhizobium genus. *Mol Phylogenet Evol* **30**, 720–732.

Nadeem, S. M., Zahir, Z. A., Naveed, M. & Arshad, M. (2007). Preliminary investigations on inducing salt tolerance in maize through inoculation with rhizobacteria containing ACC deaminase activity. *Can J Microbiol* **53**, 1141–1149.

Olivares, J., Bedmar, E. J. & Sanjuán, J. (2013). Biological nitrogen fixation in the context of global change. *Mol Plant Microbe Interact* **26**, 486–94.

Ollivier, J., Töwe, S., Bannert, A., Hai, B., Kastl, E. M., Meyer, A., Su, M. X., Kleineidam, K. & Schloter, M. (2011). Nitrogen turnover in soil and global change. *FEMS Microbiol Ecol* **78**, 3–16.

Pandey, P., Sahgal, M., Maheswari, D. K. & Johri, B. N. (2004). Genetic diversity of rhizobia isolated from medicinal legumes growing in the sub-Himalayan region of Uttaranchal. *Curr Sci* **86**, 202–207.

Pandey, P., Kang, S. C. & Maheshwari, D. K. (2005). Isolation of endophytic plant growth promoting *Burkholderia* sp. MSSP from root nodules of *Mimosa pudica*. *Curr Sci* **89**, 177–180.

Patil, S. M., Patil, D. B., Patil, M. S. & Gaikwad, P. V. **(2014).** Isolation , characterization and salt tolerance activity of Rhizobium sp. from root nodules of some legumes. *Int J Curr Micobiology Appl Sci* **3**, 1005–1008.

Patten, C. L. & Glick, B. R. (1996). Bacterial biosynthesis of indole-3-acetic acid. *Can J Microbiol* **42**, 207–220.

Peoples, M. B. & Craswell, E.T. (1992). Biological nitrogen fixation: Investments, expectations and actual contributions to agriculture. *Plant Soil* **141**, 13–39.

Perret, X., Staehelin, C. & Broughton, W. J. (2000). Molecular basis of symbiotic promiscuity. *Microbiol Mol Biol Rev* **64**, 180–201.

Pikovskaya, R. (1948). Mobilization of phosphorous in soil in connection with vital activity of some microbial species. *Mikrobiologiya* **17**, 362–370.

Pueppke, S. G. & Broughton, W. J. (1999). *Rhizobium* sp. strain NGR234 and *R. fredii* USDA257 share exceptionally broad, nested host ranges. *Mol Plant Microbe Interact* **12**, 293–318.

Rai, R., Dash, P. K., Mohapatra, T. & Singh, A. (2012). Phenotypic and molecular characterization of indigenous rhizobia nodulating chickpea in India. *Indian J Exp Biol* **50**, 340–350.

Ramírez-Bahena, M.H., Peix, A., Rivas, R., Camacho, M., Rodríguez-Navarro, D.N., Mateos, P.F., Martínez-Molina, E., Willems, A., Velázquez, E. (2009). *Bradyrhizobium pachyrhizi* sp. nov. and *Bradyrhizobium jicamae* sp. nov., isolated from effective nodules of *Pachyrhizus erosus*. *Int J Syst Evol Microbiol* **59**, 1929–34.

Ramsubhag, A., Umaharan, P. & Donawa, A. (2002). Partial 16S rRNA gene sequence diversity and numerical taxonomy of slow growing pigeonpea (*Cajanus cajan* L Millsp) nodulating rhizobia. *FEMS Microbiol Lett* **216**, 139–144.

Rashid, S., Charles, T. C. & Glick, B. R. (2012). Isolation and characterization of new plant growth-promoting bacterial endophytes. *Appl Soil Ecol* **61**, 217–224.

Rasolomampianina, R., Bailly, X., Fetiarison, R., Rabevohitra, R., Bena, G., Ramaroson, L., Raherimandimby, M., Moulin, L., De Lajudie, P. & other authors. **(2005).** Nitrogen-fixing nodules from rosewood legume trees (*Dalbergia* spp.) endemic to Madagascar host seven different genera belonging to alpha- and beta-Proteobacteria. *Mol Ecol* **14**, 4135–4146. England.

Rasul, A., Amalraj, E. L. D., Praveen Kumar, G., Grover, M. & Venkateswarlu, B. (2012). Characterization of rhizobial isolates nodulating *Millettia pinnata* in India. *FEMS Microbiol Lett* **336**, 148–158.

Rincon-Rosales, R., Villalobos-Escobedo, J. M., Rogel, M. A., Martinez, J., Ormeno-Orrillo, E. & Martinez-Romero, E. (2013). *Rhizobium calliandrae* sp. nov., *Rhizobium mayense* sp. nov. and *Rhizobium jaguaris* sp. nov., rhizobial species nodulating the medicinal legume *Calliandra grandiflora*. *Int J Syst Evol Microbiol* **63**, 3423–3429.

Rivas, R., Velázquez, E., Willems, A., Vizcaíno, N., Subba-Rao, N.S., Mateos, P.F., Gillis, M., Dazzo, F.B. & Martínez-Molina, E. (2002). A new species of *Devosia* that forms a unique nitrogenfixing root-nodule symbiosis with the aquatic legume *Neptunia natans* (L.f.) Druce. *Appl Environ Microbiol* **68**, 5217-5222.

Rohlf, F. (1998). Numerical taxonomy and multivariate analysis system version 2.02f. Exeter Software. New York, USA.

Romdhane, S. Ben, Nasr, H., Samba-Mbaye, R., Neyra, M., Ghorbal, M. H. & De Lajudie, P. (2006). Genetic diversity of *Acacia tortilisssp.raddiana* rhizobia in Tunisia assessed by 16S and 16S-23S rDNA genes analysis. *J Appl Microbiol* **100**, 436–445.

Ruvkun, G. B. & Ausubel, F. M. (1980). Interspecies homology of nitrogenase genes. *Proc Natl Acad Sci U S A***77**, 191–195.

Sadowsky, M. J., Keyser, H. H. & Bohlool, B. B. (1983). Biochemical characterization of fast- and slow-growing rhizobia that nodulate soybeans. *Int J Syst Bacteriol* **33**, 716–722.

Saha, A. K. & Haque, F. (2005). Effect of inoculation with rhizobium on nodulation and growth of bean, *Dolichos lablab.J Life Earth Sci* **1**, 71–74.

Saini, R., Dudeja, S.S., Giri, R. & Kumar, V. (2015). Isolation, characterization, and evaluation of bacterial root and nodule endophytes from chickpea cultivated in Northern India. *J Basic Microbiol* **55**, 74–81.

Samba, R. T., De Lajudie, P., Gillis, M., Neyra, M., Barreto, M. M. S. & Dreyfus, B. (1999). Diversity of rhizobia nodulating *Crotalaria* spp. from Senegal. *Symbiosis* **27**, 259–268.

Sambrook, J., Fritsch, E. & Maniatis, T. (1989). *Molecular cloning: a laboratory manual*. New York: Cold Spring Harbor.

Saxena, A. K., Shende, R. & Grover, M. (2006). Interactions Among Beneficial Microorganisms. In *Microb Act Rhizoshere*, pp. 121–137. Edited by K. G. Mukerji, C. Manoharachary & J. Singh. Berlin, Heidelberg: Springer Berlin Heidelberg.

Sharma, M. P., Srivastava, K. & Sharma, S. K. (2010). Biochemical characterization and metabolic diversity of soybean rhizobia isolated from Malwa region of central India. *Plant Soil Environ* **56**, 375–383.

Sharma, S. B., Sayyed, R. Z., Trivedi, M. H. & Gobi, T. A. (2013). Phosphate solubilizing microbes: sustainable approach for managing phosphorus deficiency in agricultural soils. *Springerplus* **2**, 587.

Shende, R. C. & Patil, M. B. (2011). Growth behaviour and indole acetic acid (IAA) production by a Rhizobium sp. Isolated from *Cajanus cajan* plant. *Int J Pharma Bio Sci* **2**, 621–628.

Singh, B., Kaur, R. & Singh, K. (2008). Characterization of *Rhizobium* strain isolated from the roots of *Trigonella foenumgraecum* (fenugreek). *African J Biotechnol* **7**, 3671–3676.

Singh, R. K., Mishra, R. P. N., Jaiswal, H. K., Kumar, V., Pandey, S. P., Rao, S. B. & Annapurna, K. (2006). Isolation and identification of natural endophytic rhizobia from rice (*Oryza sativa* L.) through rDNA PCR-RFLP and sequence analysis. *Curr Microbiol* **52**, 345–349.

Smith, B. E. (1999). Structure, function, and biosynthesis of the metallosulfur clusters in nitrogenases. *Adv Inorg Chem* **47**, 159–218.

Somasegaran, P. & Hoben, H. (1994). *Handbook for rhizobia*. New York, USA: Springer-Verlag.

Sprent, J. I. (1995). Legume trees and shrubs in the tropics: N2 fixation in perspective. *Soil Biol Biochem* **27**, 401–407.

Sprent, J. (2001). Nodulation in Legumes. Kew, UK: Royal Botanic Gardens.

Sprent, J. & Sprent, P. (1990). *Nitrogen Fixing Organisms. Pure and Applied Aspects*. London, United Kingdom: Chapmen and Hall.

Sridevi, M., Mallaiah, K. V & Yadav, N. C. S. (2007). Phosphate solubilization by Rhizobium isolates from Crotalaria species. *J Plant Sci* **2**, 635–639.

Stackebrandt, E. & Goebel, B. M. (1994). Taxonomic Note: A place for DNA-DNA reassociation and 16S rRNA sequence analysis in the present species definition in bacteriology. *Int J Syst Bacteriol* **44**, 846–849.

Surin, B. P., Downie, J. A. (1989). *Rhizobium leguminosarum* genes required for expression and transfer of host specific nodulation. *Plant Mol Biol* **12(1)**, 19-29

Sy, A., Giraud, E., Jourand, P., Garcia, N., Willems, A., De Lajudie, P., Prin, Y., Neyra, M., Gillis, M., Boivin-Masson, C. & Dreyfus, B. (2001). Methylotrophic

Methylobacterium bacteria nodulate and fix nitrogen in symbiosis with legumes. *J Bacteriol* **183**, 214-220.

Tamura, K., Dudley, J., Nei, M. & Kumar, S. (2007). MEGA4: Molecular Evolutionary Genetics Analysis (MEGA) software version 4.0. *Mol Biol Evol* **24**, 1596–1599.

Thompson, J. D., Higgins, D. G. & Gibson, T. J. (1994). CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. *Nucleic Acids Res* **22**, 4673–4680.

Trinick, M. (1980). Relationships amongst thefast-growing rhizobia of *Lablab purpureus*, *Leucaena leucocephala*, *Mimosa* spp., *Acacia farnesiana* and *Sesbania grandiflora* and their affinities with other rhizobial groups. *J Appl Microbiol* **49**, 39–53.

Trujillo, M. E., Willems, A., Abril, A., Planchuelo, A. M., Rivas, R., Ludena, D., Mateos, P. F., Martinez-Molina E. & Velazquez, E. (2005). Nodulation of *Lupinus albus* by strains of *Ochrobactrum lupini* sp. nov. *Appl Environ Microb* **71**, 1318-1327.

Valverde, A., Velazquez, E., Fernandez-Santos, F., Vizcaino, N., Rivas, R., Mateos, P. F., Martinez- Molina, E., Igual, J. M. & Willems, A. (2005). *Phyllobacterium trifolii* sp. nov., nodulating *Trifolium* and *Lupinus* in Spanish soils. *Int J Syst Evol Microbiol* **55**, 1985–1989.

van Rhijn, P. & Vanderleyden, J. (1995). The Rhizobium-plant symbiosis. *Microbiol Rev* **59**, 124–42.

Vandamme, P., Goris, J., Chen, W.-M., de Vos, P. & Willems, A. (2002).

Burkholderia tuberum sp. nov. and *Burkholderia phymatum* sp. nov., nodulate the roots of tropical legumes. *Syst Appl Microbiol* **25**, 507–512.

Verma, S. C., Chowdhury, S. P. & Tripathi, A. K. (2004). Phylogeny based on 16S *rDNA* and *nifH* sequences of *Ralstonia taiwanensis* strains isolated from nitrogen-fixing nodules of *Mimosa pudica*, in India. *Can J Microbiol* **50**, 313–322.

Versalovic, J., Koeuth, T. & Lupski, J. R. (1991). Distribution of repetitive DNA sequences in eubacteria and application to fingerprinting of bacterial genomes. *Nucleic Acids Res* **19**, 6823–6831.

Vincent, J. (1970). *A Manual for the Practical Study of the Root Nodule Bacteria*. Edinburgh, UK: Oxford, Blackwell Scientific.

Vinuesa, P., Silva, C., Lorite, M. J., Izaguirre-Mayoral, M. L., Bedmar, E. J. & Martinez-Romero, E. (2005). Molecular systematics of rhizobia based on maximum likelihood and Bayesian phylogenies inferred from *rrs*, *atpD*, *recA* and *nifH* sequences, and their use in the classification of Sesbania microsymbionts from Venezuelan wetlands. *Syst Appl Microbiol* **28**, 702–716.

Wang, E. T., van Berkum, P., Sui, X. H., Beyene, D., Chen, W. X. & Martinez-Romero, E. (1999). Diversity of rhizobia associated with *Amorpha fruticosa* isolated from Chinese soils and description of *Mesorhizobium amorphae* sp. nov. *Int J Syst Bacteriol* **49**, 51–65.

Weisburg, W. G., Barns, S. M., Pelletier, D. A. & Lane, D. J. (1991). 16S ribosomal DNA amplification for phylogenetic study. *J Bacteriol* **173**, 697–703.

Willems, A., Munive, A., de Lajudie, P. & Gillis, M. (2003). In most *Bradyrhizobium* groups sequence comparison of 16S-23S rDNA internal transcribed

spacer regions corroborates DNA-DNA hybridizations. *Syst Appl Microbiol* **26**, 203–210.

Williams, J. G., Kubelik, A. R., Livak, K. J., Rafalski, J. A. & Tingey, S. V. (1990). DNA polymorphisms amplified by arbitrary primers are useful as genetic markers. *Nucleic Acids Res* **18**, 6531–6535.

Woese, C. R., Kandler, O. & Wheelis, M. L. (1990). Towards a natural system of organisms: proposal for the domains Archaea, Bacteria, and Eucarya. *Proc Natl Acad Sci U S A* **87**, 4576–4579.

Yabuuchi, E., Kosako, Y., Oyaizu, H., Yano, I., Hotta, H., Hashimoto, Y., Ezaki T &Arakawa, M. (1992). Proposal of *Burkholderia* gen. nov. and transfer of seven species of the genus *Pseudomonas* homology group II to the new genus, with the type species *Burkholderia cepacia* (Palleroni and Holmes 1981) comb. nov.*Microbiol Immunol* **36(12)**, 1251-75.

Yadav, A, Singh, A. L., Rai, G. K. & Singh, M. (2013). Assessment of molecular diversity in chickpea (*Cicer arietinum* L.) rhizobia and structural analysis of 16S rDNA sequences from *Mesorhizobium ciceri*. *Pol J Microbiol* **62 (3)**, 253-262

Young, J. M., Pennycook, S. R. & Watson, D. R. W. (2006). Proposal that *Agrobacterium radiobacter* has priority over *Agrobacterium tumefaciens*. Request for an opinion. *Int J Syst Evol Microbiol* **56**, 491–493. England.

Young, J. P. W. & Haukka, K. E. (1996). Diversity and phylogeny of rhizobia. *New Phytol* **133**, 87–94.

Zahran, H. H. (1999). Rhizobium-legume symbiosis and nitrogen fixation under severe conditions and in an arid climate. *Microbiol Mol Biol Rev* **63**, 968–89.

Zahran, H. H. (2001). Rhizobia from wild legumes: diversity, taxonomy, ecology, nitrogen fixation and biotechnology. *J Biotechnol* **91**, 143–153.

Zehr, J. P. & McReynolds, L. A. (1989). Use of degenerate oligonucleotides for amplification of the nifH gene from the marine cyanobacterium *Trichodesmium thiebautii. Appl Environ Microbiol* **55**, 2522–2526.