

BACTERIAS SOLUBILIZADORAS DE FOSFATO: EFECTOS SOBRE CULTIVOS DE IMPORTANCIA ECONOMICA.

María Claudia Narváez Gutiérrez¹; Nelson Antonio de Ávila Ucros¹; Liliana Pérez-Lavalle², Elwi Guillermo Machado Sierra^{3*}.

¹ Estudiante programa de Microbiología, Facultad Ciencias Básicas y Biomédicas, Universidad Simón Bolívar.

² Docente investigador programa de Microbiología, Facultad Ciencias Básicas y Biomédicas Grupo de investigación Bio-organizaciones, Universidad Simón Bolívar.

*Correspondencia: lperez70@unisimonbolivar.edu.co

³ Docente investigador programa de Microbiología, Facultad Ciencias Básicas y Biomédicas Grupo de investigación Bio-organizaciones, Universidad Simón Bolívar.

*Correo electrónico: elwi.machado@unisimonbolivar.edu.co

Resumen.

La utilización de microorganismos para mejorar los rendimientos de los cultivos y minimizar el uso de fertilizantes químicos es una estrategia promisoría. En este sentido, las bacterias solubilizadoras de fosfato se posicionan como una buena alternativa para disminuir el uso de estos fertilizantes y promover a su vez el crecimiento vegetal. El objetivo de este trabajo fue ofrecer una perspectiva actualizada del efecto de inóculos bacterianos con capacidad solubilizar en diferentes cultivos. Para esto se llevó a cabo una revisión en diferentes bases de datos; la mayoría de los estudios se direccionaron a cultivos como el maíz y el trigo; asimismo, los resultados arrojaron que los géneros *Pseudomonas*, *Burkholderia* y *Bacillus* se destacan como potenciales promotores de crecimiento vegetal que pueden ser incluidos en la formulación de biofertilizantes obteniendo un producto agrícola de calidad y sin generar consecuencias al ambiente.

Palabras Claves: Bacterias solubilizadoras de fosfato (BSF), biofertilizante.

Referencias Bibliográficas.

1. Fernández M. Fósforo: amigo o enemigo. ICIDA Sobre los Deriv la Caña Azúcar. 2007;41(2):51-7.
2. Pérez L, Bolívar H, Díaz A. Biofertilizantes en Colombia. Productos de confitería nutracéutica. Una opción empresarial para cultivadores de frutas y hortalizas. Barranquilla: Universidad Simón Bolívar; 2018. P 179-222
3. Beltrán Pineda ME. La solubilización de fosfatos como estrategia microbiana para promover el crecimiento vegetal. Corpoica Cienc Tecnol Agropecu. 2014;15(1):101-13.
4. Sharma S, Kumar V, Tripathi RB. Isolation of Phosphate Solubilizing Microorganism (PSMs) From Soil. J Microbiol Biotechnol Res Sch Res Libr J Microbiol Biotech Res



- [Internet]. 2011;1(2):90-5. Available from:
<http://scholarsresearchlibrary.com/archive.html>
5. Restrepo-Franco GM, Marulanda-Moreno S, de la Fe-Pérez Y, Díaz-de la Osa A, Lucia-Baldani V, Hernández-Rodríguez A. Bacterias solubilizadoras de fosfato y sus potencialidades de uso en la promoción del crecimiento de cultivos de importancia económica. Rev CENIC Ciencias Biol [Internet]. 2015;46(1):63-76. Available from:
<http://proxy.timbo.org.uy:443/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=108658147&lang=es&site=eds-live>
 6. Díaz Vargas P, Ferrera-Castro R, Almaraz-Suárez JJ, Alcántar González G. Inoculación de bacterias promotoras de crecimiento vegetal en lechuga. Terra Latinoam [Internet]. 2001;19(4):327-35. Available from:
<http://www.chapingo.mx/terra/contenido/19/4/art327-335.pdf>
 7. Corrales-Ramírez L, Arévalo-Galvez Z, Moreno-Burbano V. Solubilización de fosfatos: una función microbiana importante en el desarrollo vegetal. Nova. 2014;12(21):67-79.
 8. Suñer LG. Formas de fósforo edáfico como indicadores del efecto de las prácticas de manejo en la región Pampeana Argentina. 2015;
 9. Fact A, Series S. Phosphorus Basics - The Phosphorus Cycle Agronomy Fact Sheet Series.
 10. Lizasoain A, Tort LF, Garcí'a M, Gomez MM, Leite JP, Miagostovich MP, et al. INORGANIC PHOSPHORUS FRACTIONATION IN SOME SELECTED SOILS FROM THE EASTERN REGION OF GHANA. J Appl Microbiol. 2015;119(3):859-867.
 11. Emilia L, Rincón C, Ancizar F, Gutiérrez A. Dinámica del ciclo del nitrógeno y fósforo en suelos Dinámica del ciclo del nitrógeno y fósforo en suelos Nitrogen and phosphorus cycles dynamics in soils. Rev Colomb Biotecnol [Internet]. 2012;(1):285-95. Available from:
<http://www.redalyc.org/pdf/776/77624081026.pdf>
 12. Filippelli GM. Encyclopedia of Paleoclimatology and Ancient Environments. 2009;(January 2009):3-7. Available from: <http://link.springer.com/10.1007/978-1-4020-4411-3>
 13. Sandra Patricia Jaramillo Padilla 1 ; Jhon Mauricio Silva Benjumea 2 y NelsonWalter Osorio Vega 3. POTENCIAL SIMBIOTICO Y EFECTIVIDAD DE HONGOS MICORRIZO ARBUSCULARES DE TRES SUELOS SOMETIDOS A DIFERENTES USOS. 2004;57(1):2203-14.
 14. Tahiri A. Universidad Austral De Chile Facultad De Ciencias Agrarias Escuela De Agronomia. CybertesisUachCl [Internet]. 2006;311(5769):1886. Available from:
<http://dx.doi.org/10.1126/science.1124635>
<http://cybertesis.uach.cl/tesis/uach/2009/fag203p/doc/fag203p.pdf>
 15. Verlag C, Jentzsch-cuvillier IA. Kyi Myint (Autor) Short- and long-term P dynamics of various P fractions in the field and in the rhizosphere. 49(0):0-6.
 16. Ri Q, Wkdw W, Eh FDQ, Grpdlq XE. 3Urfhvv &Rqiljxudwlrq 6Xssruw. 2010;3.



17. Tarafdar JC, Claassen N. Organic phosphorus compounds as a phosphorus source for higher plants through the activity of phosphatases produced by plant roots and microorganisms. *Biol Fertil Soils*. 1988;5(4):308-12.
18. Barham K. Return on customer [Review of the book Return on customer: Creating maximum value for your scarcest resource by D. Peppers & M. Rogers]. *Virtual Ashridge book reviews*. 2013;Year(Month Day):48-58. Available from: <https://virtual.ashridge.org.uk/en-GB/materials/bookreviews/pr/Pages/BRReturnoncustomer.aspx>
19. Khan AA, Jilani G, Akhtar MS, Naqvi SMS, Rasheed M. Phosphorus Solubilizing Bacteria: occurrence, mechanisms and their role in crop production. *J Agric Biol Sci* [Internet]. 2009;1(1):48-58. Available from: <http://www.phytojournal.com/archives/2017/vol6issue2/PartF/6-2-70-493.pdf>
20. Suman M, Meghawal DR, Sahu OP, Mahaveer C, Senior S, Fellow R, et al. Phosphate solubilizing bacteria and their role in plant growth promotion.1. Suman M, Meghawal DR, Sahu OP, Mahaveer C, Senior S, Fellow R, et al. Phosphate solubilizing bacteria and their role in plant growth promotion. *J Pharmacogn Phytochem* [Internet]. . *J Pharmacogn Phytochem* [Internet]. 2017;331(62):331-7. Available from: <http://www.phytojournal.com/archives/2017/vol6issue2/PartF/6-2-70-493.pdf>
21. Sculte and Kelling. *Soil and Phosphorus Applied*. Underst Plant Nutr. 1994;
22. Alori ET, Glick BR, Babalola OO. Microbial phosphorus solubilization and its potential for use in sustainable agriculture. *Front Microbiol*. 2017;8(JUN):1-8.
23. Rodríguez H, Fraga R. Phosphate solubilizing bacteria and their role in plant growth promotion. *Biotechnol Adv*. 1999;17(4-5):319-39.
24. Bolívar-Anillo HJ, Contreras-Zentella ML, Teherán-Sierra LG. *Burkholderia tropica* UNA BACTERIA CON GRAN POTENCIAL PARA SU USO EN LA AGRICULTURA. *TIP*. 2016;
25. RANI GUPTA,* REKHA SINGAL, APARNA SHANKAR, RAMESH CHANDER KUHAD ARKS. A modified plate assay for screening PSM. *JGenApplMicrobiol*. 1994;260:255-60.
26. Beever RE, Burns DJW. Phosphorus Uptake, Storage and Utilization by Fungi. *Adv Bot Res*. 1981;8(C):127-219.
27. Madhaiyan M, Sa T. Isolation and Identification of Phosphate Solubilizing Bacteria from Chinese Cabbage and Their Effect on Growth and Phosphorus Utilization of Plants. 2008;18:773-7.
28. Sharan A, Shikha, Darmwal NS, Gaur R. *Xanthomonas campestris*, a novel stress tolerant, phosphate-solubilizing bacterial strain from saline-alkali soils. *World J Microbiol Biotechnol*. 2008;24(6):753-9.
29. Valetti L, Iriarte L, Ecology AF-AS, 2018 undefined. Growth promotion of rapeseed (*Brassica napus*) associated with the inoculation of phosphate solubilizing bacteria. *Elsevier* [Internet]. [cited 2018 Nov 10]; Available from: <https://www.sciencedirect.com/science/article/pii/S0929139318300489>
30. Biswas J, Banerjee A, Rai M, Naidu R, *Geoderma* BB-, 2018 undefined. Potential



application of selected metal resistant phosphate solubilizing bacteria isolated from the gut of earthworm (*Metaphire posthuma*) in plant growth promotion. Elsevier [Internet]. [cited 2018 Nov 10]; Available from:
<https://www.sciencedirect.com/science/article/pii/S0016706117322371>

31. Mishra BK, Meena KK, Dubey PN, Aishwath OP, Kant K, Sorty AM, et al. Influence on yield and quality of fennel (*Foeniculum vulgare* Mill.) grown under semi-arid saline soil, due to application of native phosphate solubilizing rhizobacterial isolates. *Ecol Eng* [Internet]. 2016 Dec 1 [cited 2018 Nov 10];97:327-33. Available from:
<https://www.sciencedirect.com/science/article/abs/pii/S0925857416305626>
32. Yu X, Liu X, Zhu T-H, Liu G-H, Mao C. Co-inoculation with phosphate-solubilizing and nitrogen-fixing bacteria on solubilization of rock phosphate and their effect on growth promotion and nutrient uptake by walnut. *Eur J Soil Biol* [Internet]. 2012 May 1 [cited 2018 Nov 10];50:112-7. Available from:
<https://www.sciencedirect.com/science/article/abs/pii/S1164556312000052>
33. Marzban A, Ebrahimipour G, Karkhane M, Teymouri M. Metal resistant and phosphate solubilizing bacterium improves maize (*Zea mays*) growth and mitigates metal accumulation in plant. *Biocatal Agric Biotechnol* [Internet]. 2016 Oct 1 [cited 2018 Nov 10];8:13-7. Available from:
<https://www.sciencedirect.com/science/article/pii/S1878818116302237>
34. Batool S, Iqbal A. Phosphate solubilizing rhizobacteria as alternative of chemical fertilizer for growth and yield of *Triticum aestivum* (Var. Galaxy 2013). *Saudi Journal of Biological Sciences* [Internet]. 2018 May 24 [cited 2018 Nov 10]; Available from:
<https://www.sciencedirect.com/science/article/pii/S1319562X18301359>
35. Kaur G, Reddy MS. Effects of phosphate-solubilizing bacteria, rock phosphate and chemical fertilizers on maize-wheat cropping cycle and economics. *Pedosphere* [Internet]. 2015 [cited 2018 Nov 10];25(3):428-37. Available from:
https://www.researchgate.net/profile/Mohamed_Ouzine2/post/Can_the_biofertilizer_replace_the_mineral_fertilizer_in_crop_productivity/attachment/5a1c52364cde267c3e6f0fb4/AS:565367374348294@1511805494491/download/kaur2015.pdf
36. Anzuay MS, Ciancio MGR, Ludueña LM, Angelini JG, Barros G, Pastor N, et al. Growth promotion of peanut (*Arachis hypogaea* L.) and maize (*Zea mays* L.) plants by single and mixed cultures of efficient phosphate solubilizing bacteria that are tolerant to abiotic stress and pesticides. *Microbiol Res* [Internet]. 2017 Jun 1 [cited 2018 Nov 10];199:98-109. Available from:
<https://www.sciencedirect.com/science/article/pii/S0944501317300241>
37. Mamta, Rahi P, Pathania V, Gulati A, Singh B, Bhanwra RK, et al. Stimulatory effect of phosphate-solubilizing bacteria on plant growth, stevioside and rebaudioside-A contents of *Stevia rebaudiana* Bertoni. *Appl Soil Ecol* [Internet]. 2010 Oct 1 [cited 2018 Nov 10];46(2):222-9. Available from:
<https://www.sciencedirect.com/science/article/pii/S0929139310001344>
38. Bakhshandeh E, Pirdashti H, Lendeh KS. Phosphate and potassium-solubilizing bacteria effect on the growth of rice. *Ecol Eng* [Internet]. 2017 Jun 1 [cited 2018



- Nov 10];103:164-9. Available from:
<https://www.sciencedirect.com/science/article/abs/pii/S0925857417301507>
39. Martins da Costa E, de Lima W, Oliveira-Longatti SM, de Souza FM. Phosphate-solubilising bacteria enhance *Oryza sativa* growth and nutrient accumulation in an oxisol fertilized with rock phosphate. *Ecol Eng* [Internet]. 2015 Oct 1 [cited 2018 Nov 10];83:380-5. Available from:
<https://www.sciencedirect.com/science/article/abs/pii/S0925857415300987>
 40. Babana AH, Kassogué A, Dicko AH, Maïga K, Samaké F, Traoré D, et al. Development of a Biological Phosphate Fertilizer to Improve Wheat (*Triticum Aestivum* L.) Production in Mali. *Procedia Eng* [Internet]. 2016 Jan 1 [cited 2018 Nov 10];138:319-24. Available from:
<https://www.sciencedirect.com/science/article/pii/S1877705816004550>
 41. Pereira SIA, Castro PML. Phosphate-solubilizing rhizobacteria enhance *Zea mays* growth in agricultural P-deficient soils. *Ecol Eng* [Internet]. 2014 Dec 1 [cited 2018 Nov 10];73:526-35. Available from:
<https://www.sciencedirect.com/science/article/abs/pii/S0925857414004716>
 42. Chauhan A, Guleria S, Balgir PP, Walia A, Mahajan R, Mehta P, et al. Tricalcium phosphate solubilization and nitrogen fixation by newly isolated *Aneurinibacillus aneurinilyticus* CKMV1 from rhizosphere of *Valeriana jatamansi* and its growth promotional effect. *Brazilian J Microbiol* [Internet]. 2017 Apr [cited 2018 Nov 10];48(2):294-304. Available from:
<https://linkinghub.elsevier.com/retrieve/pii/S1517838216313004>
 43. Zhao K, Penttinen P, Zhang X, Ao X, Liu M, Yu X, et al. Maize rhizosphere in Sichuan, China, hosts plant growth promoting *Burkholderia cepacia* with phosphate solubilizing and antifungal abilities. *Microbiol Res* [Internet]. 2014 Jan 20 [cited 2018 Nov 10];169(1):76-82. Available from:
<https://www.sciencedirect.com/science/article/pii/S0944501313001122>
 44. Pande A, Pandey P, Mehra S, Singh M, Kaushik S. Phenotypic and genotypic characterization of phosphate solubilizing bacteria and their efficiency on the growth of maize. *J Genet Eng Biotechnol* [Internet]. 2017 Dec 1 [cited 2018 Nov 17];15(2):379-91. Available from:
<https://www.sciencedirect.com/science/article/pii/S1687157X17300331>
 45. Mahanta D, Rai RK, Dhar S, Varghese E, Raja A, Purakayastha TJ. Modification of root properties with phosphate solubilizing bacteria and arbuscular mycorrhiza to reduce rock phosphate application in soybean-wheat cropping system. *Ecol Eng* [Internet]. 2018 Feb 1 [cited 2018 Nov 17];111:31-43. Available from:
<https://www.sciencedirect.com/science/article/abs/pii/S0925857417305918>
 46. Iyer B, Rajput MS, Rajkumar S. Effect of succinate on phosphate solubilization in nitrogen fixing bacteria harbouring chick pea and their effect on plant growth. *Microbiol Res* [Internet]. 2017 Sep 1 [cited 2018 Nov 17];202:43-50. Available from: <https://www.sciencedirect.com/science/article/pii/S0944501317302112>
 47. Ghosh P, Rathinasabapathi B, Ma LQ. Phosphorus solubilization and plant growth enhancement by arsenic-resistant bacteria. *Chemosphere* [Internet]. 2015 Sep 1



[cited 2018 Nov 17];134:1-6. Available from:

<https://www.sciencedirect.com/science/article/pii/S0045653515002696>

48. Jeong S, Moon HS, Nam K, Kim JY, Kim TS. Application of phosphate-solubilizing bacteria for enhancing bioavailability and phytoextraction of cadmium (Cd) from polluted soil. *Chemosphere* [Internet]. 2012 Jun 1 [cited 2018 Nov 17];88(2):204-10. Available from:
<https://www.sciencedirect.com/science/article/pii/S004565351200327X>
49. Ghosh R, Barman S, Mukherjee R, Mandal NC. Role of phosphate solubilizing Burkholderia spp. for successful colonization and growth promotion of *Lycopodium cernuum* L. (Lycopodiaceae) in lateritic belt of Birbhum district of West Bengal, India. *Microbiol Res* [Internet]. 2016 Feb 1 [cited 2018 Nov 17];183:80-91. Available from:
<https://www.sciencedirect.com/science/article/pii/S0944501315300331>
50. Istina IN, Widiastuti H, Joy B, Antralina M. Phosphate-solubilizing Microbe from Saprist Peat Soil and their Potency to Enhance Oil Palm Growth and P Uptake. *Procedia Food Sci* [Internet]. 2015 Jan 1 [cited 2018 Nov 17];3:426-35. Available from: <https://www.sciencedirect.com/science/article/pii/S2211601X15000486>
51. Suelo MDEL. XII Congreso Ecuatoriano de la Ciencia del Suelo TECNICAS APLICADAS AL ESTUDIO DE LA DIVERSIDAD XII Congreso Ecuatoriano de la Ciencia del Suelo. 2010;(m):17-9.
52. Salamone IEG. Use of Soil Microorganisms to Improve Plant Growth and Ecosystem Sustainability. *Mol Basis Plant Genet Divers*. 2012;233-58.
53. Salamone IG De, Baca BE, Azcón R. Microorganismos que mejoran el crecimiento de las plantas y la calidad de los suelos. *Revisión*. 2010;11:155-64.