**Universidade de São Paulo
Escola Superior de Agricultura “Luiz de Queiroz”**

**Simbiontes de insetos como endofíticos: a interação *Spodoptera frugiperda*
(J. E. Smith, 1797) (Lepidoptera: Noctuidae) - *Zea mays* L. (Poales: Poaceae)**

Diandra Achre

Dissertação apresentada para obtenção do título de Mestra
em Ciências. Área de concentração: Entomologia

**Piracicaba
2018**

Diandra Achre
Engenheira Agrônoma

Simbiontes de insetos como endofíticos: a interação *Spodoptera frugiperda* (J. E. Smith, 1797) (Lepidoptera: Noctuidae) - *Zea mays* L. (Poales: Poaceae)

Orientador:
Prof. Dr. **FERNANDO LUIS CÔNSOLI**

Dissertação apresentada para obtenção do título de
Mestra em Ciências. Área de concentração: Entomologia

Piracicaba
2018

RESUMO

Simbiontes de insetos como endofíticos: a interação *Spodoptera frugiperda* (J. E. Smith, 1797) (Lepidoptera: Noctuidae) - *Zea mays* L. (Poales: Poaceae)

Insetos representam a maioria dos seres vivos na Terra. O sucesso biológico desses organismos está, em parte, relacionado às associações com microrganismos que influenciam aspectos de sua bioecologia, incluindo as relações com o primeiro e terceiro níveis tróficos. Assim como os insetos, plantas também apresentam associações com microrganismos que podem interferir na sua nutrição e relação com patógenos e herbívoros. Esse trabalho buscou analisar a capacidade de simbiontes associados a insetos de atuar como endofíticos de planta e influenciar, assim, o potencial biótico da planta e a sua capacidade de defesa contra a herbivoria, utilizando o modelo milho - *Spodoptera frugiperda* (J.E. Smith, 1797) (Lepidoptera: Noctuidae). Quatro simbiontes de insetos foram selecionados. Três deles (IIL-Sfm05, IILSfc-sus01 e IIL-Sfb05) associados ao trato digestivo de *S. frugiperda* e outro (IIL-ASP45) de *Acromyrmex coronatus* (IIL-ASP45). Adicionalmente, um endofítico (IILzm-ldp03) isolado do próprio milho foi adicionado como controle positivo. Os ensaios foram conduzidos após cultivo de sementes inoculadas com os diferentes microrganismos via *bio-priming*, aplicação no solo e aplicação foliar. Dos cinco isolados testados, três (IILSfc-sus01, IIL-Sfb05 e IILzm-ldp03) induziram maior crescimento em plantas de milho; porém, a forma de disponibilização dos microrganismos influenciou a resposta da planta. O isolado IILzm-ldp03 induziu o maior crescimento da planta pela sua disponibilização via *bio-priming*; IILzm-ldp03 e IIL-Sfb05 via inoculação do solo; e o isolado IILSfc-sus01 via inoculação foliar. Testes biológicos com *S. frugiperda* em plantas de milho inoculadas ou não com os microrganismos selecionados indicaram que dois deles (isolados IIL-Sfb05 e IIL-ASP45) resultaram em relações patogênicas, chegando à induzir a completa mortalidade de insetos alimentados em tecidos foliares de plantas inoculadas com esses microrganismos. Testes de preferência alimentar demonstraram que as lagartas não foram influenciadas pela alimentação com folhas de plantas inoculadas com as bactérias via *bio-priming*. Estudos comparativos dos índices nutricionais de plantas tratadas com as diferentes bactérias, indicaram que aquelas tratadas com IIL-ASP45 resultaram no menor crescimento e desenvolvimento larval de *S. frugiperda*, corroborado pelo menor consumo e índices nutricionais alcançados nessa fonte de alimento. A alimentação em plantas tratadas com IIL-Sfb05 causou 100% de mortalidade larval, não sendo possível a avaliação dos índices nutricionais. Os resultados desse trabalho demonstram o potencial de manipulação da planta hospedeira por bactérias associadas ao herbívoro, bem como o potencial biocida de microrganismos associados a insetos.

Palavras-chave: Controle de pragas; Interação inseto-planta; Promotor de crescimento; Simbionte

ABSTRACT

Symbionts of insects as endophytes: the interaction *Spodoptera frugiperda* (J. E. Smith, 1797) (Lepidoptera: Noctuidae) - *Zea mays* L. (Poales: Poaceae)

Insects represent most of the living things on Earth. The biological success of these organisms is in part related to associations with microorganisms that influence aspects of their bioecology, including relationships with the first and third trophic levels. Like insects, plants also have associations with microorganisms that may interfere in their nutrition and interactions to pathogens and herbivores. This work sought to assess the potential of symbionts associated with insects to act as plant endophytes and thus to influence plant growth and its utilization by the herbivory using the maize - *Spodoptera frugiperda* (JE Smith, 1797) (Lepidoptera: Noctuidae) model system. Four insect symbionts were selected. Three of them (IIL-Sfm05, IILSfc-sus01 and IIL-Sfb05) associated with the digestive tract of *S. frugiperda* and another (IIL-ASP45) with the cuticle of *Acromyrmex coronatus* (IIL-ASP45). Additionally, an endophyte (IILzm-ldp03) from maize was added as a positive control. Experiments were conducted after inoculation of the different microorganisms via *bio-priming*, soil application and foliar application. Of the five isolates tested, three (IILSfc-sus01, IIL-Sfb05 and IILzm-ldp03) induced higher growth in maize plants; however, the inoculation of the seeds with the microorganisms influenced the plant response. The isolate IILzm-ldp03 induced the highest plant growth when inoculated via bio-priming; IILzm-ldp03 and IIL-Sfb05 via soil inoculation; and IILSfc-sus01 via foliar inoculation. Biological tests with *S. frugiperda* on maize plants inoculated or not with the selected microorganisms indicated that two of them (IIL-Sfb05 and IIL-ASP45 isolates) were highly pathogenic, inducing very high larval mortality. Our analysis indicated no changes in larval feeding preference. Comparative analysis of larval food consumption and utilization indicated that plants inoculated with IIL-ASP45 resulted in the lowest growth and larval development of *S. frugiperda*, corroborated by the lower consumption and nutritional indexes reached in this food source. Feeding in plants inoculated with IIL-Sfb05 caused 100% larval mortality, and it was not possible to evaluate the nutritional indexes. Our data demonstrate the potential for manipulation of the host plant by bacteria associated with the herbivore, as well as the biocidal potential of insect - associated microorganisms.

Keywords: Insect-plant interaction; Growth promoter; Pest control; Symbiont

INTRODUÇÃO

Os insetos representam a maioria da biodiversidade da Terra, tendo originado há pelo menos 400 milhões de anos (GRIMALDI; ENGEL, 2005). Uma das chaves para o sucesso biológico desse grupo de artrópodes é o estabelecimento de associações com microrganismos simbioss (KIKUCHI et al., 2009). Associações de simbiose levam a mudanças que beneficiam o seu hospedeiro, melhorando a resposta do sistema imunológico do hospedeiro contra patógenos e parasitoides, por exemplo (FELDHAAR, 2011; FLÓREZ et al. 2015). As associações de simbiose mais evidentes são aquelas relacionadas à adaptação nutricional, que contribuem para a melhor aquisição de nutrientes e processamento da dieta, fornecendo, ao inseto, nutrientes que de outra forma estariam indisponíveis (DOUGLAS, 2009).

A associação insetos – simbioss benéficos é comum àqueles insetos que utilizam recursos alimentares de composição nutricional restrita, como os sugadores de seiva, que contam com dieta pobre em aminoácidos essenciais, e os fitófagos e xilófagos, os quais fazem uso de alimentos ricos em compostos estruturais não digeríveis, tais como celulose e lignina, e/ou alimentos com alta diversidade de xenobióticos com ação anti-herbivoria (DOUGLAS, 1998; SCHOONHOVEN et al., 2005). Com isso, microrganismos associados a insetos podem ser importantes mediadores de interações diretas e indiretas de herbívoros com suas plantas hospedeiras (BARBOSA et al., 1991). Um exemplo clássico é o dos pulgões que se alimentam de floema e a bactéria obrigatória *Buchnera aphidicola*, a qual é responsável pela síntese de aminoácidos essenciais e vitaminas que complementam o valor nutricional do recurso alimentar explorado, de forma a atender as exigências nutricionais do inseto (BAUMANN et al., 1995; MORAN et al., 2005; VAN HAM et al., 2005).

Para sua sobrevivência, as plantas respondem ao ataque de insetos herbívoros e patógenos ativando suas vias de defesa (KESSLER; BALDWIN, 2002). Quando ocorrem danos no tecido vegetal, as plantas iniciam a produção de moléculas sinalizadoras que ativam suas vias de defesa, como o ácido jasmônico (JA) e o etileno (ET) (PIETERSE et al., 2009). Insetos herbívoros de sucesso conseguem desenvolver estratégias para superar estas e outras vias de defesa da planta (SUGIO et al., 2014). Recentemente, foi demonstrado que o contato de microrganismos da microbiota intestinal de *Spodoptera frugiperda* (JE Smith, 1797) (Lepidoptera: Noctuidae), eliminados junto aos *pellets* fecais das lagartas, com o tecido

danificado da planta de milho, induziu a ativação dos mecanismos de defesa da planta, tornando a mesma menos suscetível ao ataque por patógenos, demonstrando que a microbiota de insetos pode modificar as interações estabelecidas pela planta (RAY et al., 2015). Além do contato via fezes, a microbiota associada a insetos pode entrar em contato com a planta hospedeira através de secreções orais da larva e oviposição, induzindo assim alterações na resposta de defesa das plantas hospedeiras (CHUNG et al., 2013; HILKER; MEINERS, 2006; SARMENTO et al., 2011). Além de influenciar a resposta imunológica de plantas hospedeiras, a microbiota associada a insetos também pode afetar o crescimento de plantas devido à maior fixação de nitrogênio e produção de ácido indol 3-acético (IAA) e ácido salicílico (INDIRAGANDHI et al., 2008).

Com base em todos os aspectos que podem ser influenciados pela interação planta-inseto-microrganismos simbiotes, esse trabalho visa entender o papel de componentes da microbiota intestinal de *S. frugiperda* na modificação da interação herbívoro - planta e na capacidade de crescimento de plantas de milho. O melhor conhecimento dessas relações levará ao maior entendimento das interações inseto-simbionte-planta e à exploração racional de novas formas de controle dessa praga ou de promoção de crescimento de plantas.

CONCLUSÕES

- ✓ *Enterococcus* predomina na microbiota intestinal cultivável de *S. frugiperda*;
- ✓ A forma de inoculação de microrganismos influencia a interação bactéria simbiote - planta de milho;
- ✓ O isolado IILzm-ldp03 induz o maior crescimento da planta quando inoculado via *bio-priming*;
- ✓ Na inoculação via solo, os isolados IILzm-ldp03 e IIL-Sfb05 proporcionaram o melhor desenvolvimento das plantas, enquanto que o isolado IILSfc-sus01 foi o mais adequado para inoculação via foliar;
- ✓ Os isolados IIL-Sfb05 e IIL-ASP45 são altamente patogênicos a lagartas de *S. frugiperda* quando inoculados em plantas via *bio-priming*;
- ✓ Os isolados testados não influenciam a preferência alimentar de *S. frugiperda*;
- ✓ O isolado IIL-ASP45 foi o que mais afetou a utilização do alimento por lagartas de *S. frugiperda*.

REFERÊNCIAS

- ALMEIDA, L. G.; DE MORAES, L. A. B.; TRIGO, J. R.; OMOTO, C.; CÔNSOLI, F. L. The gut microbiota of insecticide-resistant insects houses insecticide-degrading bacteria: A potential source for biotechnological exploitation. **PLoS ONE**, v. 12, n. 3, p. 1–19, 2017.
- ALVAREZ, F.; CASTRO, M.; PRÍNCIPE, A.; BORIOLI, G.; FISCHER, S.; MORI, G.; JOFRÉ, E. The plant-associated *Bacillus amyloliquefaciens* strains MEP₂18 and ARP₂3 capable of producing the cyclic lipopeptides iturin or surfactin and fengycin are effective in biocontrol of sclerotinia stem rot disease. **Journal of Applied Microbiology**, v. 112, n. 1, p. 159–174, 2012.
- ARASU, M. V.; AL-DHABI, N. A.; SARITHA, V.; DURAIPANDIYAN, V.; MUTHUKUMAR, C.; KIM, S. -J. Antifeedant, larvicidal and growth inhibitory bioactivities of novel polyketide metabolite isolated from *Streptomyces* sp. AP-123 against *Helicoverpa armigera* and *Spodoptera litura*. **BMC microbiology**, v. 13, n. 105, p. 1–6, 2013.
- BARBOSA, P.; KRISCHIK, V. A.; JONES, C. G. **Microbial Mediation of Plant-Herbivore Interactions**. New York: John Wiley & Sons, p. 535, 1991.
- BARROS, E. M.; TORRES, J. B.; RUBERSON, J. R.; OLIVEIRA, M. D. Development of *Spodoptera frugiperda* on different hosts and damage to reproductive structures in cotton. **Entomologia Experimentalis et Applicata**, v. 137, n. 3, p. 237–245, 2010.
- BASHAN, Y. Inoculants of plant growth-promoting bacteria for use in agriculture. **Biotechnology Advances**, v. 16, n. 4, p. 729–770, 1998.
- BATISTA, B. D.; LACAVA, P. T.; FERRARI, A.; TEIXEIRA-SILVA, N. S.; BONATELLI, M. L.; TSUI, S.; MONDIN, M.; KITAJIMA, E. W.; PEREIRA, J. O.; AZEVEDO, J. L.; QUECINE, M. C. Screening of tropically derived, multi-trait plant growth- promoting rhizobacteria and evaluation of corn and soybean colonization ability. **Microbiological Research**, v. 206, p. 33–42, 2018.
- BATTAN, B.; SHARMA, J.; DHIMAN, S. S.; KUHAD, R. C. Enhanced production of cellulase-free thermostable xylanase by *Bacillus pumilus* ASH and its potential application in paper industry. **Enzyme and Microbial Technology**, v. 41, n. 6, p. 733–739, 2007.
- BAUMANN, P.; BAUMANN, L.; LAI, C.-Y.; ROUHBAKHSH, D. Genetics, physiology, and evolutionary relationships of the Genus *Buchnera*: Intracellular symbionts of aphids. **Annual Review of Microbiology**, v. 49, p. 55–94, 1995.
- BHATTACHARYYA, P. N.; JHA, D. K. Plant growth-promoting rhizobacteria (PGPR): Emergence in agriculture. **World Journal of Microbiology and Biotechnology**, v. 28, n. 4, p. 1327–1350, 2012.
- BERENBAUM, M. Adaptive Significance of Midgut pH in Larval Lepidoptera. **The American Naturalist**, v. 115, n. 1, p. 138–146, 1980.
- BONAVENTURE, G. Perception of insect feeding by plants. **Plant Biology**, v. 14, n. 6, p. 872–880, 2012.
- BONAVENTURE, G.; SCHUCK, S.; BALDWIN, I. T. Revealing complexity and specificity in the

activation of lipase-mediated oxylipin biosynthesis: A specific role of the *Nicotiana attenuata* GLA1 lipase in the activation of jasmonic acid biosynthesis in leaves and roots. **Plant, Cell and Environment**, v. 34, n. 9, p. 1507–1520, 2011.

BOUCHER, D. H. The Ecology of Mutualism. **Annual Review of Ecology and Systematics**, v. 13, p. 315–347, 1982.

BOUTZIS, KOSTAS; MILLER, T. A. **Insect Symbiosis**. Flórida: CRC Press, p. 347, 2003.

BOUZAR, H.; JONES, J. B. *Agrobacterium larrymoorei* sp. nov., a pathogen isolated from aerial tumours of *Ficus benjamina*. **International Journal of Systematic and Evolutionary Microbiology**, v. 51, n.3 p. 1023–1026, 2001.

BRAVO, A.; GILL, S.; SOBERON, M. Mode of action of *bacillus thuringiensis* Cry and Cyt toxin and their potential for insect control. **National Institutes Acess**, v. 49, n. 4, p. 423–435, 2008.

BRINKMANN, N.; MARTENS, R.; TEBBE, C. C. Origin and diversity of metabolically active gut bacteria from laboratory-bred larvae of *Manduca sexta* (Sphingidae, Lepidoptera, Insecta). **Applied and Environmental Microbiology**, v. 74, n. 23, p. 7189–7196, 2008.

BRODERICK, N. A.; RAFFA, K. F.; GOODMAN, R. M.; HANDELSMAN, J. Census of the bacterial community of the gypsy moth larval midgut by using culturing and culture-independent methods. **Applied and Environmental Microbiology**, v. 70, n. 1, p. 293–300, 2004.

CANO, R. J.; BORUCKI, M. K.; HIGBY-SCHWEITZER, M.; POINAR, H. N.; POINAR JUNIOR, G. O.; POLLARD, K. J. *Bacillus* DNA in fossil bees: An ancient symbiosis? **Applied and Environmental Microbiology**, v. 60, n. 6, p. 2164–2167, 1994.

CAPPELLOZZA, S.; SAVIANE, A.; TETTAMANTI, G.; SQUADRIN, M.; VENDRAMIN, E.; PAOLUCCI, P.; FRANZETTI, E.; SQUARTINI, A. Identification of *Enterococcus mundtii* as a pathogenic agent involved in the “flacherie” disease in *Bombyx mori* L. larvae reared on artificial diet. **Journal of Invertebrate Pathology**, v. 106, n. 3, p. 386–393, 2011.

CHANDLER, D.; DAVIDSON, G.; GRANT, W. P.; GREAVES, J.; TATCHELL, G. M. Microbial biopesticides for integrated crop management: an assessment of environmental and regulatory sustainability. **Trends in Food Science and Technology**, v. 19, n. 5, p. 275–283, 2008.

CHATTERTON, S.; PUNJA, Z. K. Chitinase and β -1, 3-glucanase enzyme production by the mycoparasite *Clonostachys rosea* f. *catenulata* against fungal plant pathogens. **Canadian Journal of Microbiology**, v. 55, n. 4, p. 356–367, 2009.

CHEN, B.; TEH, B. S.; SUN, C.; HU, S.; LU, X.; BOLAND, W.; SHAO, Y. Biodiversity and activity of the gut microbiota across the life history of the insect herbivore *Spodoptera littoralis*. **Scientific Reports**, v. 6, n. 29505, p. 1–14, 2016.

CHEN, D. Q.; PURCELL, A. H. Occurrence and transmission of facultative endosymbionts in aphids. **Current Microbiology**, v. 34, n. 4, p. 220–225, 1997.

CHEN, X. H.; KOUMOUTSI, A.; SCHOLZ, R.; BORRISS, R. More than anticipated - Production of antibiotics and other secondary metabolites by *Bacillus amyloliquefaciens* FZB42. **Journal of Molecular Microbiology and Biotechnology**, v. 16, n. 1–2, p. 14–24, 2008.

- CHIBEJE JUNIOR, J.; FUCHS, B. B.; SABINO, C. P.; JUNQUEIRA, J. C.; JORGE, A. O. C.; RIBEIRO, M. S.; GILMORE, M. S.; RICE, L. B.; TEGOS, G. P.; HAMBLIN, M. R.; MYLONAKIS, E. Photodynamic and antibiotic therapy impair the pathogenesis of *Enterococcus faecium* in a whole animal insect model. **PLoS ONE**, v. 8, n. 2, p. 1-10, 2013.
- CHUNG, S. H.; ROSA, C.; SCULLY, E. D.; PPEIFFER, M.; TOOKER, J. F.; HOOVER, K.; LUTHE, D. S.; FELTON, G. W. Herbivore exploits orally secreted bacteria to suppress plant defenses. **Proceedings of the National Academy of Sciences**, v. 110, n. 39, p. 15728–15733, 2013.
- CLARK, E. L.; KARLEY, A. J.; HUBBARD, S. F. Insect endosymbionts: Manipulators of insect herbivore trophic interactions? **Protoplasma**, v. 244, n. 1-4, p. 25–51, 2010.
- CLARK, T. M. Evolution and adaptive significance of larval midgut alkalization in the insect superorder Mecoptera. **Journal of Chemical Ecology**, v. 25, n. 8, p. 1945–1960, 1999.
- CORE TEAM. R: A language and environment for statistical computing. , 2016. Vienna, Austria: R Foundation for Statistical Computing.
- COX, C. R.; GILMORE, M. S. Native microbial colonization of *Drosophila melanogaster* and its use as a model of *Enterococcus faecalis* pathogenesis. **Infection and Immunity**, v. 75, n. 4, p. 1565–1576, 2007.
- CRUZ, C. D.; REGAZZI, J. A.; CARNEIRO, P. C. S. **Modelos biométricos aplicado ao melhoramento genético**. 4ª ed. Viçosa:Editora UFV, p. 668, 2014.
- DALE, C.; MORAN, N. A. Molecular interactions between bacterial symbionts and their hosts. **Cell**, v. 126, n. 3, p. 453–465, 2006.
- DICKE, M.; VAN POECKE, R. M. P. Signaling in plant-insect interactions : signal transduction in direct and indirect plant defence. **Plant Signal Transduction**, v. 3, p. 289–316, 2002.
- DILLON, R. J.; WEBSTER, G.; WEIGHTMAN, A. J.; DILLON, V. M.; BLANFORD, S.; CHARNLEY, A. K. Composition of Acridid gut bacterial communities as revealed by 16S rRNA gene analysis. **Journal of Invertebrate Pathology**, v. 97, n. 3, p. 265–272, 2008.
- DILLON, R. J.; WEBSTER, G.; WEIGHTMAN, A. J.; KEITH CHARNLEY, A. Diversity of gut microbiota increases with aging and starvation in the desert locust. **Antonie van Leeuwenhoek, International Journal of General and Molecular Microbiology**, v. 97, p. 69–77, 2010.
- DOARES, S. H.; NARVÁEZ-VÁSQUEZ, J.; CONCONI, A.; RYAN, C. A. Salicylic-acid inhibits synthesis of proteinase-inhibitors in tomato leaves induced by systemin and jasmonic acid. **Plant Physiology**, v. 108, n. 4, p. 1741–1746, 1995.
- O'DONNELL, P. J.; CALVERT, C.; ATZORN, R.; WASTERACK, C.; LEYSER, H. M. O.; BOWLES, D. J. Ethylene as a signal mediating the wound response of tomato plants. **American Association for the Advancement of Science**, v. 274, n. 5294, p. 1914–1917, 1996.
- STAHLY, D. P.; ANDREWS, R. E.; YOSTEN, A. A. The genus *Bacillus* – Insect Pathogens. In: DWORKIN, M.; FALKOW, S.; ROSENBERG, E.; SCHLEIFER, K. -H.; STACKEBRANDT, E. **The Prokaryotes: A handbook on the biology of bacteria**. New York: Springer, p. 563- 608, 2006.

- DOUGLAS, A. E. Mycetocyte symbiosis in insects. **Biological Reviews**, v. 64, n. 4, p. 409–434, 1989.
- DOUGLAS, A. E. Nutritional interactions in insect-microbial symbioses: Aphids and their symbiotic bacteria *Buchnera*. **Annual Reviews in Entomology**, v. 43, p. 17–37, 1998.
- DOUGLAS, A. E. The microbial dimension in insect nutritional ecology. **Functional Ecology**, v. 23, p. 38–47, 2009.
- DOW, J. A; HARVEY, W. R. Role of midgut electrogenic K⁺ pump potential difference in regulating lumen K⁺ and pH in larval lepidoptera. **The Journal of experimental biology**, v. 140, p. 455–63, 1988.
- EGAMBERDIYEVA, D. The effect of plant growth promoting bacteria on growth and nutrient uptake of maize in two different soils. **Applied Soil Ecology**, v. 36, n. 2-3, p. 184–189, 2007.
- ENGEL, P.; MORAN, N. A. The gut microbiota of insects - diversity in structure and function. **Federation of European Microbiological Societies- Microbiology Reviews**, v. 37, n. 5, p. 699–735, 2013.
- ERB, M.; MELDAU, S.; HOWE, G. A. Role of phytohormones in insect-specific plant reactions. **Trends in Plant Science**, v. 17, n. 5, p. 250–259, 2012.
- FELDHAAR, H. Bacterial symbionts as mediators of ecologically important traits of insect hosts. **Ecological Entomology**, v. 36, n. 5, p. 533–543, 2011.
- FIGUEIREDO, J. E. F.; GOMES, E. A.; GUIMARÃES, C. T.; LANA, U. G. P.; TEIXEIRA, M. A.; LIMA, G. V. C.; BRESSAN, W. Molecular analysis of endophytic bacteria from the genus *Bacillus* isolated from tropical maize (*Zea mays* L.). **Brazilian Journal of Microbiology**, v. 40, n. 3, p. 522–534, 2009.
- FLÓREZ, L. V.; BIEDERMANN, P. H. W.; ENGL, T.; KALTENPOTH, M. Defensive symbioses of animals with prokaryotic and eukaryotic microorganisms. **Natural Product Reports**, v. 32, n. 7, p. 904–936, 2015.
- FUKATSU, T.; NIKOH, N.; KAWAI, R.; KOGA, R. The secondary endosymbiotic bacterium of the Pea Aphid *Acyrtosiphon pisum* (Insecta : Homoptera). **Applied and Environmental Microbiology**, v. 66, n. 7, p. 2748–2758, 2000.
- GAVRILESCU, M.; CHISTI, Y. Biotechnology - A sustainable alternative for chemical industry. **Biotechnology Advances**, v. 23, n. 7–8, p. 471–499, 2005.
- GIL, R.; LATORRE, A.; MOYA, A. Bacterial endosymbionts of insects: Insights from comparative genomics. **Environmental Microbiology**, v. 6, n. 11, p. 1109–1122, 2004.
- GLICK, B. R. Plant growth-promoting bacteria : Mechanisms and applications. **Scientifica**, v. 2012, p. 15, 2012.
- GLICK, B. R.; CHENG, Z.; CZARNY, J.; DUAN, J. Promotion of plant growth by ACC deaminase-producing soil bacteria. **European Journal of Plant Pathology**, v. 119, n. 3, p. 329–339, 2007.

GOND, S. K.; BERGEN, M. S.; TORRES, M. S.; WHITE JR, J. F. Endophytic *Bacillus* spp. produce antifungal lipopeptides and induce host defence gene expression in maize. **Microbiological Research**, v. 172, p. 79-87, 2015.

GREENE, G. L.; LEPLA, N. C.; DICKERSON, W. A. Velvetbean Caterpillar: A rearing procedure and artificial medium. **Journal of Economic Entomology**, v. 69, n. 4, p. 487–488, 1976.

GRIMALDI, D.; ENGEL, M. S. **Evolution of the Insects**, New York: Cambridge University Press, p. 755, 2005.

HALOI, K.; KALITA, M.; NATH, R.; DEVI, D. Characterization and pathogenicity assessment of gut-associated microbes of muga silkworm *Antheraea assamensis* Helfer (Lepidoptera: Saturniidae). **Journal of Invertebrate Pathology**, v. 138, p. 73-85, 2016.

HANIN, A.; SAVA, I.; BAO, Y. Y.; HEBNER, J.; HARTKE, A.; AUFRAY, Y.; SAUVAGEOT, N. Screening of *in vivo* activated genes in *Enterococcus faecalis* during insect and mouse infections and growth in urine. **PLoS ONE**, v. 5, n. 7, p. 1-12, 2010.

HARDOIM, P. R.; VAN OVERBEEK, L. S.; VAN ELSAS, J. D. Properties of bacterial endophytes and their proposed role in plant growth. **Trends in Microbiology**, v. 16, n. 10, p. 463–471, 2008.

HARTLEY, H. O. The maximum *F*-Ratio as a short-cut test for heterogeneity of variance. **Oxford University Press on behalf of Biometrika Trust**, v. 37, n. 3, p. 308–312, 1950.

HAYAT, R.; ALI, S.; AMARA, U.; KHALID, R.; AHMED, I. Soil beneficial bacteria and their role in plant growth promotion : a review. **Annals of Microbiology**, v. 60, n. 4, p. 579–598, 2010.

HIGASHIGUCHI, D. T.; HUSSENER, C.; GRACE, J. K.; BERESTECKY, J. M. *Pilibacter termitis* gen. nov., sp. nov., a lactic acid bacterium from the hindgut of the Formosan subterranean termite (*Coptotermes formosanus*). **International Journal of Systematic and Evolutionary Microbiology**, v. 56, n. 1, p. 15–20, 2006.

HILKER, M.; MEINERS, T. Early herbivore alert: Insect eggs induce plant defense. **Journal of Chemical Ecology**, v. 32, n. 7, p. 1379–1397, 2006.

HÖFLICH, G. Colonization and growth promotion of non-legumes by Rhizobium bacteria. **Proceedings of the 8th International Symposium on Microbial Ecology**, p. 39–42, 1999.

HOSOKAWA, T.; KIKUCHI, Y.; NIKOH, N.; SHIMADA, M.; FUKATSU, T. Strict host-symbiont cospeciation and reductive genome evolution in insect gut bacteria. **PLoS Biology**, v. 4, n. 10, p. 1841–1851, 2006.

HOU, X.; BOYETCHKO, S. M.; BRKIC, M.; OLSON, D.; ROSS, A.; HEGEDUS, D. Characterization of the anti-fungal activity of a *Bacillus* spp. associated with sclerotia from *Sclerotinia sclerotiorum*. **Applied Microbiology and Biotechnology**, v. 72, n. 4, p. 644–653, 2006.

HOWE, G. A.; JANDER, G. Plant immunity to insect herbivores. **Annual Review of Plant Biology**, v. 59, p. 41–66, 2008.

IDRIS, E. E.; IGLESIAS, D. J.; TALON, M.; BORRIS, R. Tryptophan-dependent production of indole-3-acetic acid (iaa) affects level of plant growth promotion by *Bacillus amyloliquefaciens* FZB42. **Molecular Plant-Microbe Interactions**, v. 20, n. 6, p. 619–626, 2007.

INDIRAGANDHI, P.; ANANDHAM, R.; MADHAIYAN, M.; SA, T. M. Characterization of plant growth-promoting traits of bacteria isolated from larval guts of Diamondback moth *Plutella xylostella* (Lepidoptera: Plutellidae). **Current Microbiology**, v. 56, n. 4, p. 327–333, 2008.

ISHIKAWA, H. Insect Symbiosis: An Introduction. In: BOURTZIS, K. M.; MILLER, A. **Insect Symbiosis**. Flórida: CRC press, p. 638, 2003.

Ji, X.; LU, G.; GAI, Y.; ZHENG, C.; MU, Z. Biological control against bacterial wilt and colonization of mulberry by an endophytic *Bacillus subtilis* strain. **Federation of European Microbiological Societies Microbiology Ecology**, v. 65, n. 3, p. 565–573, 2008.

JOHNSTON, P. R.; CRICKMORE, N. Gut bacteria are not required for the insecticidal activity of *Bacillus thuringiensis* toward the tobacco hornworm, *Manduca sexta*. **Applied and Environmental Microbiology**, v. 75, n. 15, p. 5094–5099, 2009.

JOHNSTON, P. R.; ROLFF, J. Host and symbiont jointly control gut microbiota during complete metamorphosis. **PLoS Pathogens**, v. 11, n. 11, p. 1–11, 2015.

KAUR, T.; VASUDEVA, A.; SOHAL, S. K.; MANHAS, R. K. Insecticidal and growth inhibitory potential of *Streptomyces hydrogenans* DH16 on major pest of India, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae). **BMC Microbiology**, v. 14, n. 227, p. 1–9, 2014.

KESSLER, A.; BALDWIN, I. T. Plant responses to insect herbivory: The emerging molecular analysis. **Annual Review of Plant Biology**, v. 53, p. 299–328, 2002.

KIKUCHI, Y. Endosymbiotic bacteria in insects: Their diversity and culturability. **Microbes and Environments**, v. 24, n. 3, p. 195–204, 2009.

KIKUCHI, Y.; HOSOKAWA, T.; FUKATSU, T. Insect-microbe mutualism without vertical transmission: A stinkbug acquires a beneficial gut symbiont from the environment every generation. **Applied and Environmental Microbiology**, v. 73, n. 13, p. 4308–4316, 2007.

KIKUCHI, Y.; HOSOKAWA, T.; NIKOH, N.; MENG, X. -Y.; KAMAGATA, Y.; FUKATSU, T. Host-symbiont co-speciation and reductive genome evolution in gut symbiotic bacteria of acanthosomatid stinkbugs. **BMC Biology**, v. 7, n. 2, p. 1–22, 2009.

KIM, O. -S.; CHO, Y. -J.; LEE, K.; YOON, S. -H.; KIM, M.; NA, H.; PARK, S. -C.; JEON, Y. S.; LEE, J. -H.; YI, H.; WON, S.; CHUN, J. Introducing EzTaxon-e: A prokaryotic 16S rRNA gene sequence database with phylotypes that represent uncultured species. **International Journal of Systematic and Evolutionary Microbiology**, v. 62, n. 3, p. 716–721, 2012.

KLEPZIG, K. D.; ADAMS, A. S.; HANDELSMAN, J.; RAFFA, K. F. Symbioses: A key driver of insect physiological processes, ecological interactions, evolutionary diversification, and impacts on humans. **Environmental entomology**, v. 38, n. 1, p. 67–77, 2009.

- KUMAR, S.; STECHER, G.; TAMURA, K. MEGA7: Molecular evolutionary genetics analysis version 7.0 for bigger datasets. **Molecular Biology and Evolution**, v. 33, n. 7, p. 1870–1874, 2016.
- LEONG, J. Siderophores : Their role in the biocontrol of plant pathogens. **Annual Review of Phytopathology**, v. 24, p. 187–209, 1986.
- LEUNG, T. L. F; POULIN, R. Parasitism, commensalism, and mutualism: Exploring the many shades of symbioses. **Vie et Milieu- Life and Environment**, v. 58, n. 2, p. 107–115, 2008.
- LI, M.; WANG, B.; ZHANG, M.; RANTALAINEN, M.; WANG, S.; ZHOU, H.; ZHANG, Y.; SHEN, J.; PANG, X; ZHANG, M.; et al. Symbiotic gut microbes modulate human metabolic phenotypes. , v. 105, n. 6, p. 2117–2122, 2008.
- LIU, Y.; PAN, X.; LI, J. Current agricultural practices threaten future global food production. **Journal of Agricultural and Environmental Ethics**, v. 28, n. 2, p. 203–216, 2015.
- MAGUIRE, J. D. Speed of germination-aid in selection and evaluation for seedling emergence and vigor. **Crop Science**, v. 2, n. 1, p. 176–177, 1962.
- MARGULIS, L.; FESTER, R. **Symbiosis as a source of evolutionary innovation**. Cambridge: Massachusetts Institute of Technology Press, p. 459, 1991.
- MARQUES, A. P. G. C.; PIRES, C.; MOREIRA, H.; RANGEL, A. O. S. S.; CASTRO, P. M. L. Assessment of the plant growth promotion abilities of six bacterial isolates using *Zea mays* as indicator plant. **Soil Biology and Biochemistry**, v. 42, n. 8, p. 1229–1235, 2010.
- MARTIN, J. D.; MUNDT, J. O. Enterococci in insects. **Applied microbiology**, v. 24, n. 4, p. 575–580, 1972.
- MARTINEZ, A. I. F.; FERNANDEZ, M. J. V.; ROCA, J. A. C.; LOPEZ-ROMAN, J. M.; MARTINEZ, J. A. N.; PICÓ, I. B. Pure culture of strain AH2 of the *Bacillus velezensis* species and a product for the biological control of phytopathogenic fungi. **United States Patent**, v. 2, n. 12, p. 1-3, 2013.
- MASON, K. L.; STEPIEN, T. A; BLUM, J. E.; HOLT, J. F.; LABBE, N. H.; RUSH, J. S.; RAFFA, F.; HANDELSMAN, J. From commensal to pathogen: Translocation of *Enterococcus faecalis* from the midgut to the hemocoel of *Manduca sexta*. **mBio**, v. 2, n. 3, p. 1–7, 2011.
- MENG, Q.; JIANG, H.; HAO, J. J. Effects of *Bacillus velezensis* strain BAC03 in promoting plant growth. **Biological Control**, v. 98, p. 18–26, 2016.
- MITHOFER, A.; BOLAND, W. Recognition of herbivory-associated molecular patterns. **Plant Physiology**, v. 146, n. 3, p. 825–831, 2008.
- MORAN, N. A. Symbiosis. **Current Biology**, v. 16, n. 20, p. 866–871, 2006.
- MORAN, N. A.; DUNBAR, H. E.; WILCOX, J. L. Regulation in a reduced bacterial, genome: Nutrient-provisioning genes of the obligate symbiont *Buchnera aphidicola*. **Journal of bacteriology**, v. 187, n. 2, p. 4229–4237, 2005.
- MORAN, N. A.; BAUMANN, P. Bacterial endosymbionts in animals. **Current Opinion in Microbiology**, v. 3, n. 3, p. 270–275, 2000.

MÜLLER, H.; BERG, G. Impact of formulation procedures on the effect of the biocontrol agent *Serratia plymuthica* HRO-C48 on Verticillium wilt in oilseed rape. **BioControl**, v. 53, n. 6, p. 905–916, 2008.

NAVA, D. E.; PARRA, J. R. P. Development and soybean leaf consumption by *Urbanus proteus proteus* (L.). **Scientia Agricola**, v. 59, n. 4, p. 661–663, 2002.

NWIBO, D. D. ANIEL; MATSUMOTO, Y.; SEKIMIZU, K. Identification and methods for prevention of *Enterococcus mundtii* infection in silkworm larvae, *Bombyx mori*, reared on artificial diet. **Drug discoveries & therapeutics**, v. 9, n. 3, p. 184–190, 2015.

OLDROYD, G. E. D. Speak, friend, and enter: signalling systems that promote beneficial symbiotic associations in plants. **Nature Reviews Microbiology**, v. 11, n. 4, p. 252–263, 2013.

OLIVER, K. M.; RUSSELL, J. A.; MORAN, N. A.; HUNTER, M. S. Facultative bacterial symbionts in aphids confer resistance to parasitic wasps. **Proceedings of the National Academy of Sciences**, v. 100, n. 4, p. 1803–1807, 2003.

OSBORN, F.; BERLIOZ, L.; VITELLI- FLORES, J.; MONSALVE, W.; DORTA, B.; LEMOINE, V. R. Pathogenic effects of bacteria isolated from larvae of *Hylesia metabus* Crammer (Lepidoptera: Saturniidae). **Journal of Invertebrate Pathology**, v. 80, n. 1, p. 7-12, 2002.

OULHEN, N.; SCHULZ, B. J.; CARRIER, T. J. English translation of Heinrich Anton de Bary's 1878 speech, "Die Erscheinung der Symbiose" ("De la symbiose"). **Symbiosis**, v. 69, n. 3, p. 131–139, 2016.

PARMENTIER, E.; MICHEL, L. Boundary lines in symbiosis forms. **Symbiosis**, v. 60, n. 1, p. 1–5, 2013.

PARRA, J. R.; PANIZZU, A. R.; M. L. HADDAD. Índices nutricionais para medir consumo e utilização de alimentos por insetos. In: PANIZZU, A. R.; PARRA, J. R. P. **Ecologia nutricional de insetos e suas implicações no manejo de pragas**. São Paulo: Manole/CNPq, p.37–90, 2009.

PENROSE, D. M.; GLICK, B. R. Methods for isolating and characterizing ACC deaminase-containing plant growth-promoting rhizobacteria. **Physiologia Plantarum**, v. 118, n. 1, p. 10–15, 2003.

PERRIG, D.; BOIERO, M. L.; MASCIARELLI, O. A.; PENNA, C.; RUIZ, O. A.; CASSÁN, F. D.; LUNA. Plant-growth-promoting compounds produced by two agronomically important strains of *Azospirillum brasilense*, and implications for inoculant formulation. **Applied Microbiology and Biotechnology**, v. 75, n. 5, p. 1143–1150, 2007.

PIETERSE, C. M. J.; LEON-REYES, A.; VAN DER ENT, S.; VAN WEES, S. C. M. Networking by small-molecule hormones in plant immunity. **Nature Chemical Biology**, v. 5, n. 5, p. 308–316, 2009.

PIMENTEL-GOMES, F. **Curso de estatística experimental**. Piracicaba: Fundação de Estudos Agrários Luiz de Queiroz- FEALQ, p. 451, 2009.

PONTES, M. H.; DALE, C. Culture and manipulation of insect facultative symbionts. **Trends in Microbiology**, v. 14, n. 9, p. 406–412, 2006.

RAIJ, B. V. **Fertilidade do solo e adubação**. São Paulo: Ceres, p. 343, 1991.

- RAJAGOPAL, R. Beneficial interactions between insects and gut bacteria. **Indian Journal of Microbiology**, v. 49, n. 2, p. 114–119, 2009.
- RASHID, S.; CHARLES, T. C.; GLICK, B. R. Isolation and characterization of new plant growth-promoting bacterial endophytes. **Applied Soil Ecology**, v. 61, p. 217–224, 2012.
- RAY, S.; GAFFOR, I.; ACEVEDO, F. E.; et al. Maize Plants recognize herbivore-associated cues from caterpillar frass. **Journal of Chemical Ecology**, v. 41, n. 9, p. 781–792, 2015.
- RAYMOND, B.; JOHNSTON, P. R.; NIELSEN-LEROUX, C.; LERECLUS, D.; CRICKMORE, N. *Bacillus thuringiensis*: An impotent pathogen? **Trends in Microbiology**, v. 18, n. 5, p. 189–194, 2010.
- RAYMOND, B.; JOHNSTON, P. R.; WRIGHT, D. J.; ELLIS, R. J.; CRICKMORE, N.; BONSALE, M. B. A mid-gut microbiota is not required for the pathogenicity of *Bacillus thuringiensis* to diamondback moth larvae. **Environmental Microbiology**, v. 11, n. 10, p. 2556–2563, 2009.
- REN, J. –H.; LI, H.; WANG, Y. –F.; YE, J. –R.; YAN, A. –Q.; WU, X. –Q. Biocontrol potential of an endophytic *Bacillus pumilus* JK-SX001 against poplar canker. **Biological Control**, v. 67, n. 3, p. 421–430, 2013.
- ROH, J. Y.; LIU, Q.; CHOI, J. Y.; WANG, Y.; SHIM, H. J.; XU, H. G.; CHOI, G. J.; KIM, J. –C.; JE, Y. H. Construction of a recombinant *Bacillus velezensis* strain as an integrated control agent against plant diseases and insect pests. **Journal of Microbiology and Biotechnology**, v. 19, n. 10, p. 1223–1229, 2009.
- ROMEIS, J.; MEISSLE, M.; BIGLER, F. Transgenic crops expressing *Bacillus thuringiensis* toxins and biological control. **Nature Biotechnology**, v. 24, n. 1, p. 63–71, 2006.
- ROMOLI, O.; SAVIANE, A.; BOZZATO, A.; D'ANTONA, P.; TETTAMANTI, G.; SQUARTINI, A.; CAPPELLOZA, S.; SANDRELLI, F. Differential sensitivity to infections and antimicrobial peptide-mediated immune response in four silkworm strains with different geographical origin. **Scientific Reports**, v. 7, n. 1048, p. 1–16, 2017.
- SAITOU, N.; NEI, M. The neighbor-joining method: A new method for reconstructing phylogenetic trees. **Molecular Biology and Evolution**, v. 4, n. 4, p. 406–425, 1987.
- SAMBROOK, J. J.; RUSSELL, D. D. W. **Molecular cloning: a laboratory manual**. New York: Cold Spring Harbor Laboratory Press, p. 2344, 2001.
- SANTNER, A.; CALDERON-VILLALOBOS, L. I. A.; ESTELLE, M. Plant hormones are versatile chemical regulators of plant growth. **Nature Chemical Biology**, v. 5, n. 5, p. 301–307, 2009.
- SARMENTO, R. A.; LEMOS, F.; BLEEKER, P. M.; SCHUURINK, R. C.; PALLINI, A.; OLIVEIRA, M. G. A.; LIMA, E. R.; KANT, M.; SABELIS, M. W.; JANSSEN, A. A herbivore that manipulates plant defence. **Ecology Letters**, v. 14, n. 3, p. 229–236, 2011.
- SCHMELZ, E. A.; ENGELBERTH, J.; ALBORN, H. T.; TUMLINSON, J. H.; TEAL, P. E. A. Phytohormone-based activity mapping of insect herbivore-produced elicitors. **Proceedings of the National Academy of Sciences of the United States of America**, v. 106, n. 2, p. 653–657, 2009.

- SCHMID, R. B.; LEHMAN, R. M.; BRÖZEL, V. S.; LUNDGREN, J. G. An indigenous gut bacterium , *Enterococcus faecalis* (Lactobacillales : Enterococcaceae), increases seed consumption by *Harpalus pensylvanicus* (Coleoptera : Carabidae). **Florida entomologist**, v. 97, n. 2, p. 575–584, 2014.
- SCHOONHOVEN, L. M.; JERMEY, T.; VAN LOON, J. J. A. **Insect-Plant Biology**. New York: Oxford University Press, p. 421, 2005.
- SHAPIRO, S. S.; WILK, M. B. An analysis of variance test for normality (complete samples). **Oxford University Press on behalf of Biometrika Trust**, v. 52, n. 3, p. 591–611, 1965.
- SHIRLING, E. B.; GOTTLIEB, D. Methods for characterization of *Streptomyces* Species. **International Journal of Systematic Bacteriology**, v. 16, n. 3, p. 313–340, 1966.
- SOMERS, E.; VANDERLEYDEN, J.; SRINIVASAN, M. Rhizosphere bacterial signalling: A love parade beneath our feet. **Critical Reviews in Microbiology**, v. 30, n. 4, p. 205–240, 2004.
- SUGIO, A.; DUBREUIL, G.; GIRON, D.; SIMON, J. C. Plant-insect interactions under bacterial influence: Ecological implications and underlying mechanisms. **Journal of Experimental Botany**, v. 66, n. 2, p. 467–478, 2014.
- SUN, I.; LU, Z.; BIE, X.; LU, F.; YANG, S. Isolation and characterization of a co-producer of fengycins and surfactins, endophytic *Bacillus amyloliquefaciens* ES-2, from *Scutellaria baicalensis* Georgi. **World Journal of Microbiology and Biotechnology**, v. 22, n. 12, p. 1259–1266, 2006.
- SUNNUCKS, P.; HALES, D. F. Numerous transposed sequences of mitochondrial cytochrome oxidase I-II in aphids of the genus *Sitobion* (Hemiptera: Aphididae). **Molecular biology and evolution**, v. 13, n. 3, p. 510–524, 1996.
- TADDEI, A.; VALDERRAMA, M.; GIARRIZZO, J.; REY, M.; CASTELLI, C. Chemical screening: A simple approach to visualizing *Streptomyces* diversity for drug discovery and further research. **Research in Microbiology**, v. 157, n. 3, p. 291–297, 2006.
- TANG, X.; FREITAK, D.; VOGEL, H.; PING, L.; SHAO, Y.; CORDERO, E. A.; ANDERSEN, G.; WSTERMANN, M.; HECKEL, D. G.; BOLAND, W. Complexity and Variability of Gut Commensal Microbiota in Polyphagous Lepidopteran Larvae. **PLoS ONE**, v. 7, n. 7, p. 1–9, 2012.
- TAN, G. Y. A.; WARD, A. C.; GOODFELLOW, M. Exploration of *Amycolatopsis* diversity in soil using genus-specific primers and novel selective media. **Systematic and Applied Microbiology**, v. 29, n. 7, p. 557–569, 2006.
- TEALE, W. D.; PAPONOV, I. A.; PALME, K. Auxin in action: Signalling, transport and the control of plant growth and development. **Nature Reviews Molecular Cell Biology**, v. 7, n. 11, p. 847–859, 2006.
- TENDULKAR, S. R.; SAIKUMARI, Y. K.; PATEL, V.; RAGHOTAMA, S.; MUNSHI, T. K.; BALARAM, P.; CHATTOO, B. B. Isolation, purification and characterization of an antifungal molecule produced by *Bacillus licheniformis* BC98, and its effect on phytopathogen *Magnaporthe grisea*. **Journal of Applied Microbiology**, v. 103, n. 6, p. 2331–2339, 2007.

- THAKUR, A.; DHAMMI, P.; SAINI, H. S.; KAUR, S. Pathogenicity of bacteria isolated from gut of *Spodoptera litura* (Lepidoptera: Noctuidae) and fitness costs of insect associated with consumption of bacteria. **Journal of Invertebrate Pathology**, v. 127, p. 38-46, 2015.
- TURNER, S.; PRYER, K. M.; MIAO, V. P. W.; PALMER, J. D. Investigating deep phylogenetic relationships among Cyanobacteria and Plastids by small subunit rRNA sequence analysis. **The Journal of Eukaryotic Microbiology**, v. 46, n. 4, p. 327–338, 1999.
- VAN HAM, R. C. H. J.; KAMERBEEK, J.; PALACIOS, C.; RAUSELL, C.; ABASCAL, F.; BASTOLLA, U.; FERNÁNDEZ, J. M.; JIMÉNEZ, L.; POSTIGO, M.; SILVA, F. J.; TAMAMES, J.; VIGUERA, E.; LATORRE, A.; VALENCIA, A.; MORÁN, F.; MOYA, A. **Proceedings of the National Academy of Sciences of the United States of America**, v. 100, n. 2, p. 581-586, 2003.
- VARGAS, L. K.; LISBOA, B. B.; SCHLINDWEIN, G.; GRANADA, C. E.; GIONGO, A.; BENEDUZI, A.; PASSAGLIA, L. M. P. Occurrence of plant growth-promoting traits in clover-nodulating rhizobia strains isolated from different soils in Rio Grande do Sul state. **Revista Brasileira de Ciência do Solo**, v. 33, n. 5, p. 1227–1235, 2009.
- VESSEY, J. K. Plant growth promoting rhizobacteria as biofertilizers. **Plant and Soil**, v. 255, n. 2, p. 571–586, 2003.
- VISÔTTO, L. E.; OLIVEIRA, M. G. A.; RIBON, A. O. B.; MARES-GUIA, T. R.; GUEDES, R. N. C. Characterization and identification of Proteolytic bacteria from the gut of the Velvetbean Caterpillar (Lepidoptera: Noctuidae). **Environmental Entomology**, v. 38, n. 4, p. 1078–1085, 2009.
- WANG, M.; ZHAO, W. Z.; XU, H.; WANG, Z. W.; HE, S. Y. *Bacillus* in the guts of honey bees (*Apis mellifera*; Hymenoptera: Apidae) mediate changes in amylase values. **European Journal of Entomology**, v. 112, n. 4, p. 619–624, 2015.
- WEISBURG, W. G.; BARNS, S. M.; PELLETIER, D. A.; LANE, D. J. 16S ribosomal DNA amplification for phylogenetic study. **Journal of Bacteriology**, v. 173, n. 2, p. 697–703, 1991.
- WERNEGREEN, J. J. Genome evolution in bacterial endosymbionts of insects. **Nature Reviews Genetics**, v. 3, n. 11, p. 850–861, 2002.
- WIELKOPOLAN, B.; OBREPALSKA-STEPLOWSKA, A. Three-way interaction among plants, bacteria, and coleopteran insects. **Planta**, v. 244, n. 2, p. 313–332, 2016.
- WU, J.; BALDWIN, I. T. New insights into plant responses to the attack from insect herbivores. **Annual Review of Genetics**, v. 44, p. 1–24, 2010.
- XIANG, H.; WEI, G. -F.; JIA, S.; HUANG, J.; MIAO, X. -X.; ZHOU, Z.; ZHAO, L. -P.; HUANG, Y. -P. Microbial communities in the larval midgut of laboratory and field populations of cotton bollworm (*Helicoverpa armigera*). **Canadian Journal of Microbiology**, v. 52, n.11, p. 1085-1092, 2006.
- YOUNG, J. M. Renaming of *Agrobacterium larrymoorei* Bouzar and Jones 2001 as *Rhizobium larrymoorei* (Bouzar and Jones 2001) comb. nov. **International Journal of Systematic and Evolutionary Microbiology**, v. 54, n. 1, p. 149, 2004.

ZILBER-ROSENBERG, I.; ROSENBERG, E. Role of microorganisms in the evolution of animals and plants : the hologenome theory of evolution. **Federation of European Microbiological Societies- Microbiology Reviews**, v. 32, n. 5, p. 723-735, 2008.