Research and development of green microbial metabolite pesticide for sustainable agriculture

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Challenges for sustainable agriculture

- For a long time, chemical pesticides have played a huge role in control of pests and the protection of food production and safety.
- However, the abuse of chemical pesticides causes environmental pollution, human health damage, and pesticide resistance.
- This prompted us to have to develop low-toxicity, environment-friendly biological pesticides.

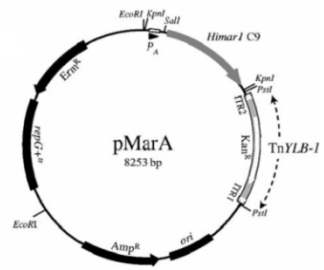
- The traditional microbial pesticides like some PGPR (Plant growth-promoting Rhizobacteria) formulations have disadvantages of low effeciency and poor stability.
- Previous studies have shown that some **metabolites from PGPR** strains, such as *Bacillus* spp., could promote plant growth, inhibit plant pathogens, and induce plant disease resistance.
- These metabolites can be developed into a new type of biological pesticides.

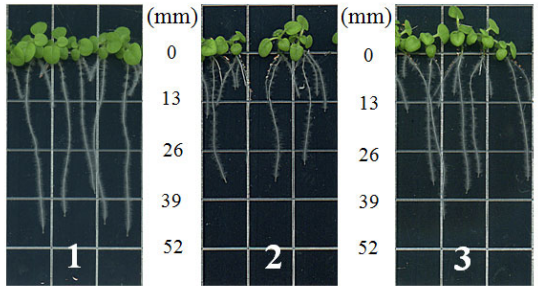
Mission and Objective

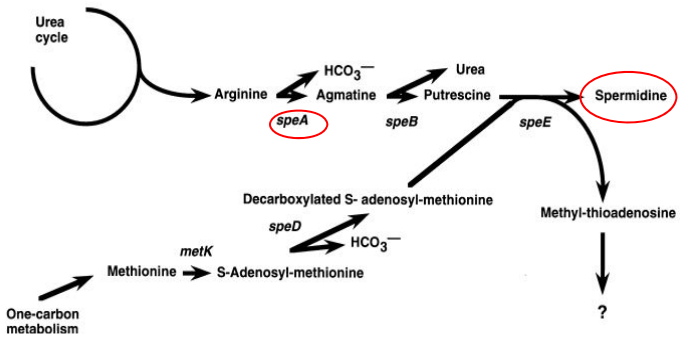
- **Research Task I:** Identification of new metabolites by the synthesis of ribosomal and nonribosomal pathways with biocontrol activity from the PGPR *Bacillus* and so on.
- **Research Task II:** Study on the regulation and synthesis mechanism of the bioactive metabolites.
- **Research Task III:** Development of metabolite biopesticide and its effect and stability evaluation.

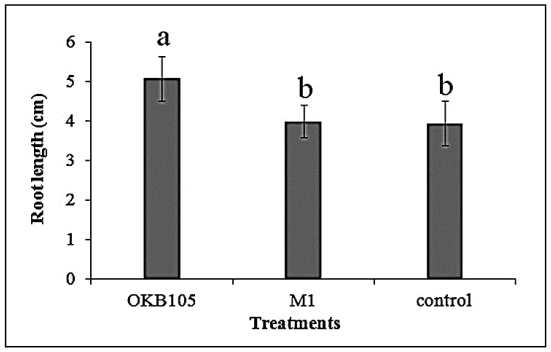
Previous work on studying metabolites produced by PGPR *Bacillus* in Prof. Gao's research group

1. Spermidine produced by *Bacillus subtilis* is a new type of plant growth promoting bioactive substance



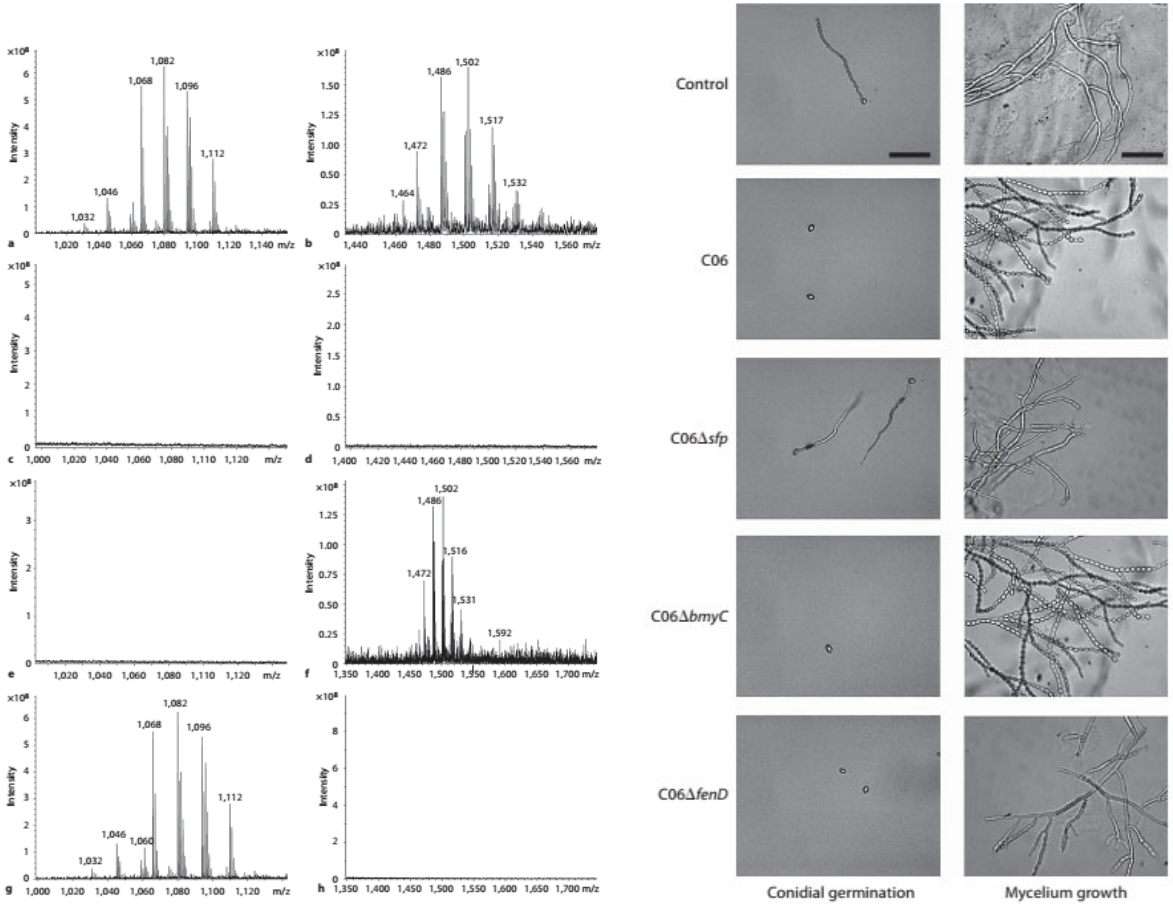






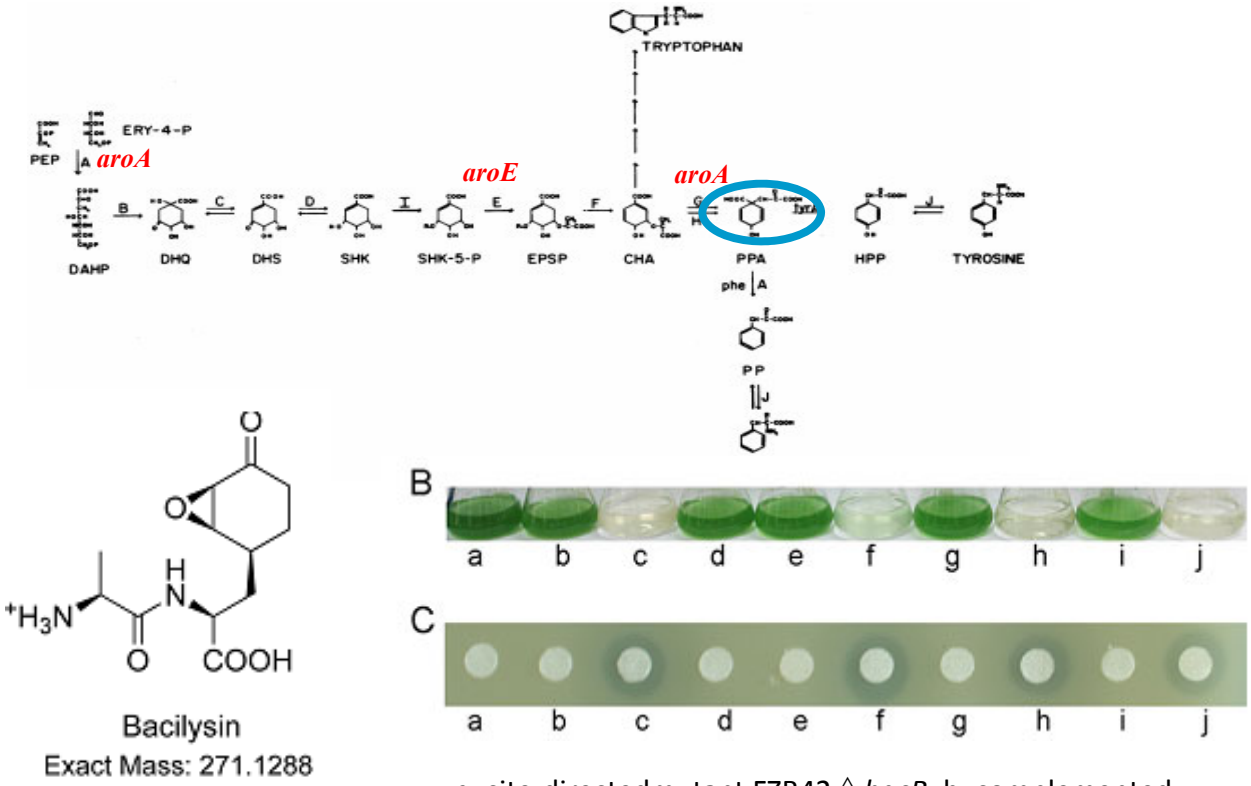
Molecular Plant-Microbe Interactions, 2014, 27(7) 655-663

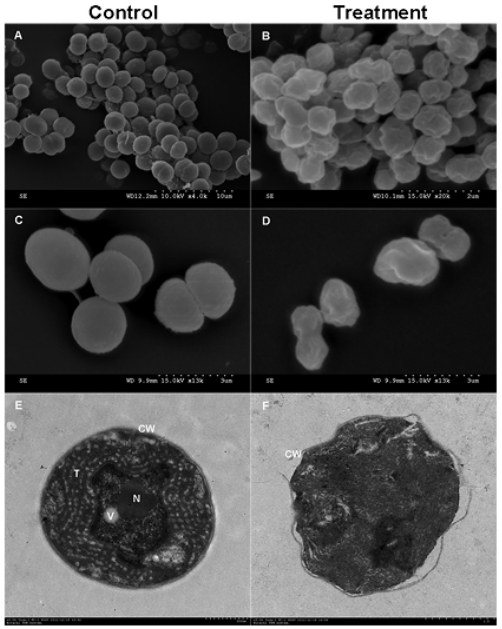
2. Lipopeptides produced by *Bacillus amyloliquefaciens* C06 significantily suppress conidial and mycelial growth of plant pathogenic fungi



Journal of Molecular Microbiology and Biotechnology, 2011;2043–52

3. Bacilysin from *Bacillus amyloliquefaciens* FZB42 has specific bactericidal activity against harmful algal bloom species

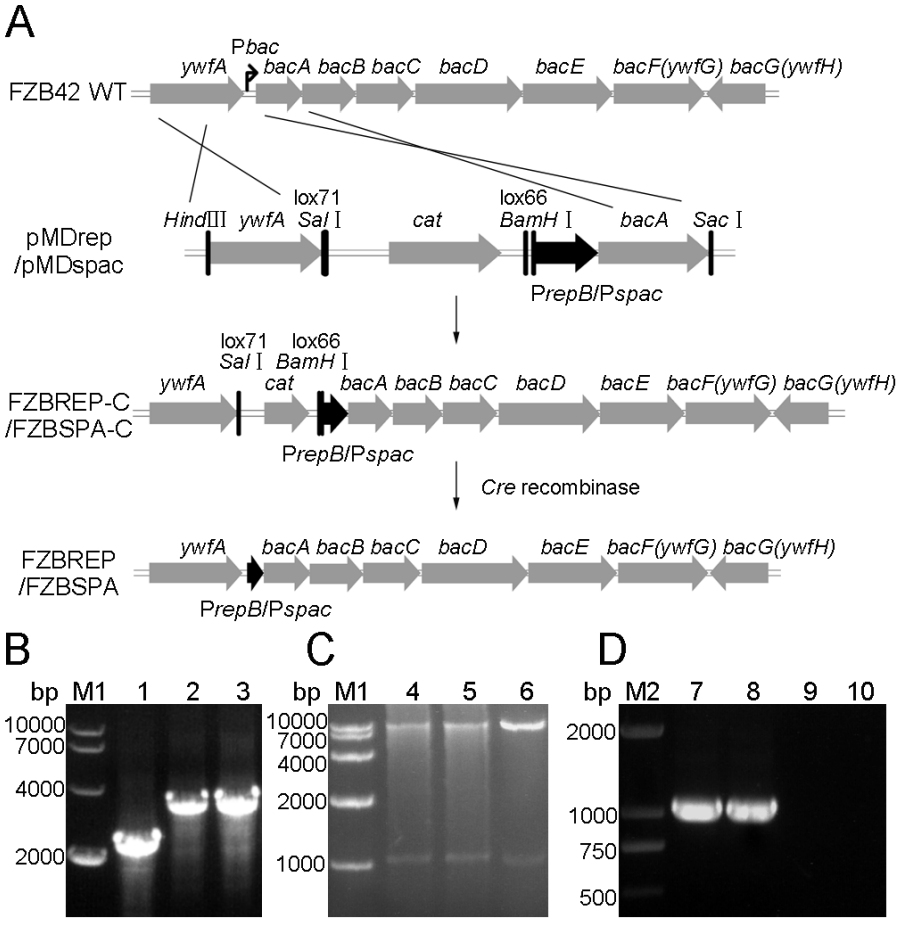


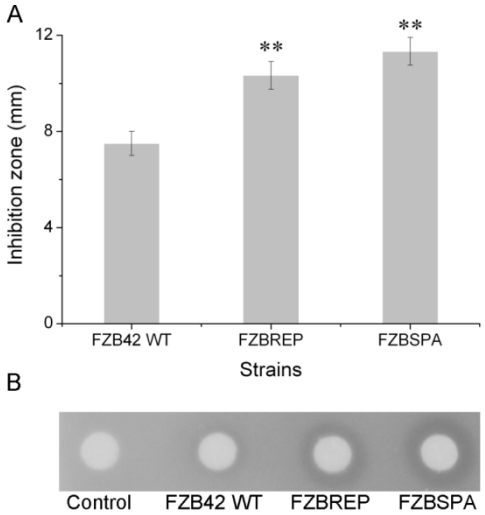


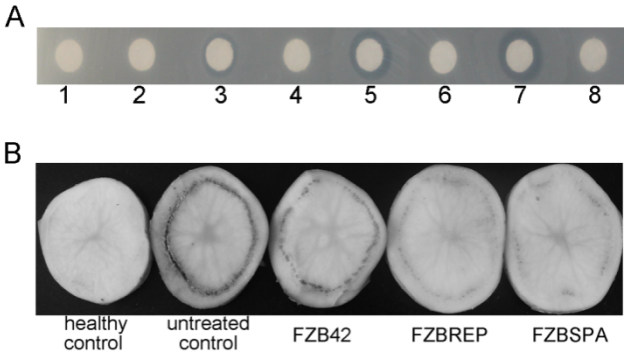
g, site-directedmutant FZB42△*bacB*; h, complemented FZB42△*bacB*△*amyE*::*bacB*; j, bacilysin.

Applied And Environmental Microbiology, 2014, 80(24):7512-7520

4. Bacilysin overproduction in *Bacillus amyloliquefaciens* FZB42 markerless derivative strains FZBREP and FZBSPA enhances antibacterial activity

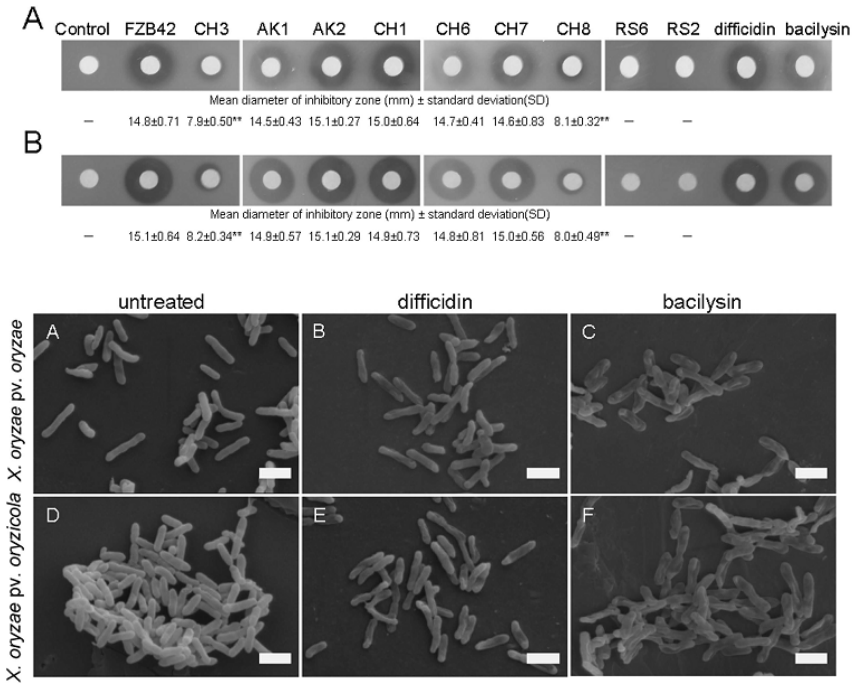


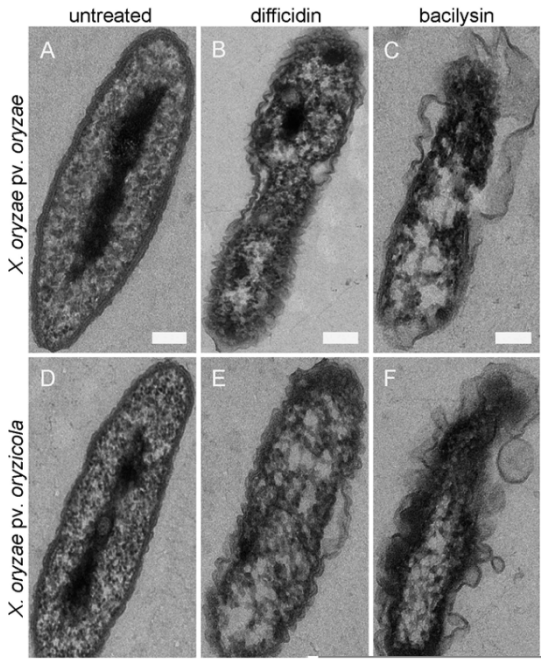




Applied Microbiology and Biotechnology, 2015, 99: 4255–4263

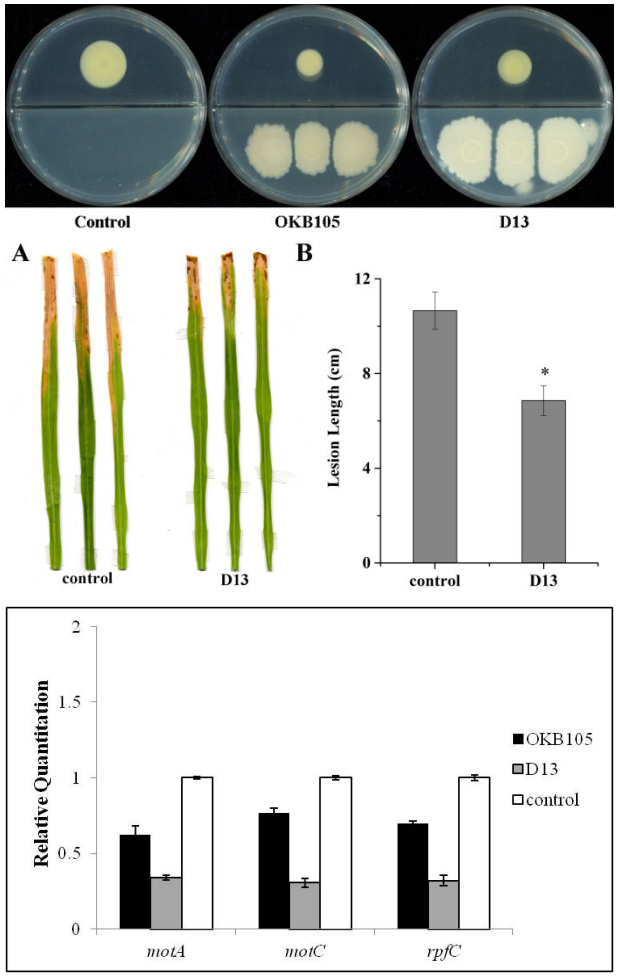
5. Difficidin and bacilysin from *Bacillus amyloliquefaciens* FZB42 have antibacterial activity against *Xanthomonas oryzae* rice pathogens

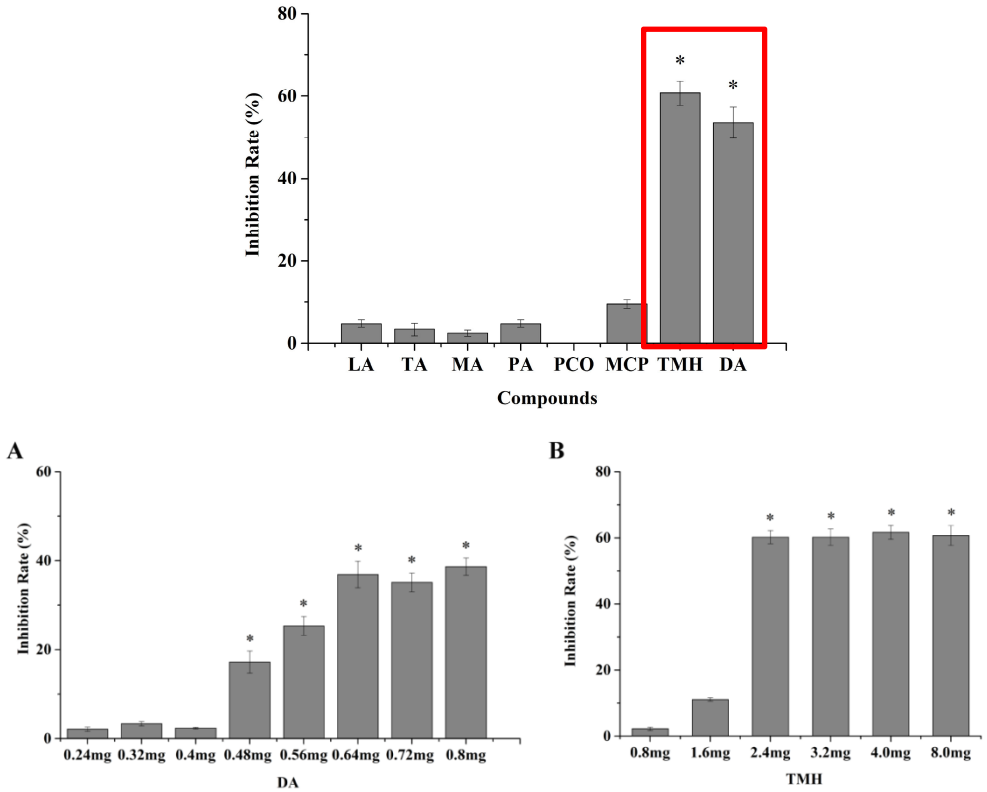




Scientific Reports, 2015, 5: 1-9, DOI: 10.1038/srep12975

6. Antibacterial activity of *Bacillus cereus* D13 volatile compounds against *Xanthomonas oryzae* pv. *oryzae*



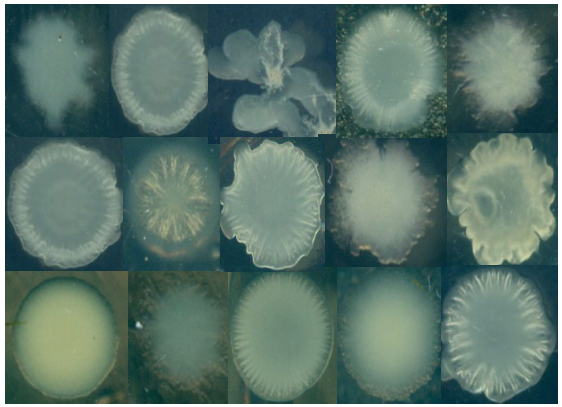


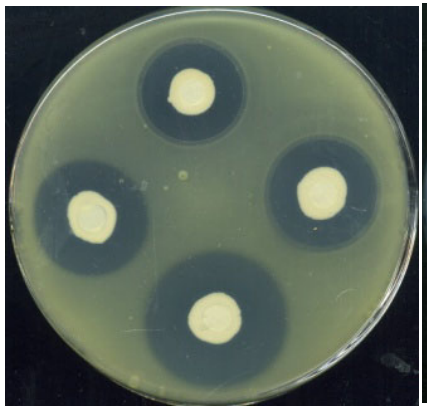
DA: decyl alcohol; TMH: 3, 5, 5-trimethylhexanol

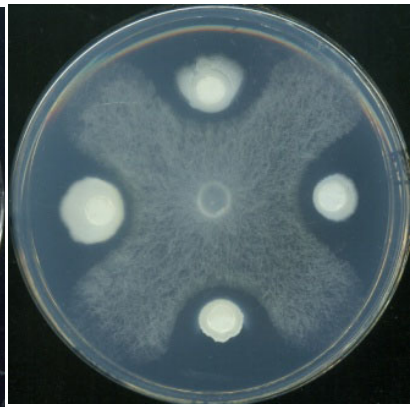
Molecular Plant Pathology, 2016, DOI: 10.1111/mpp.12494

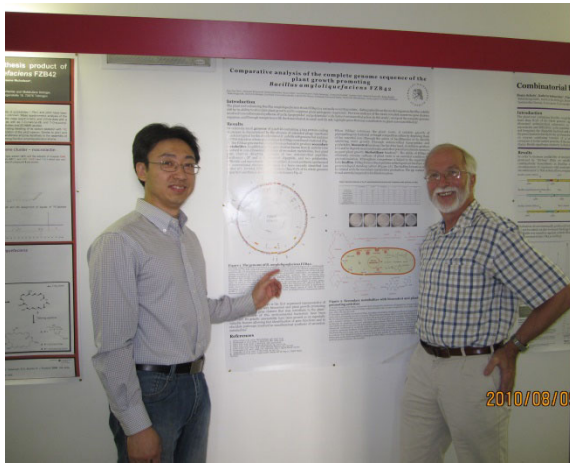
Research and development of *Bacillus* formulations

- ***Bacillus*** **resource collection from Qinghai-Tibet Plateau of China and Antarctic region**
- **Cooperation with Germany partners in R&D of** ***Bacillus*** **formulations**



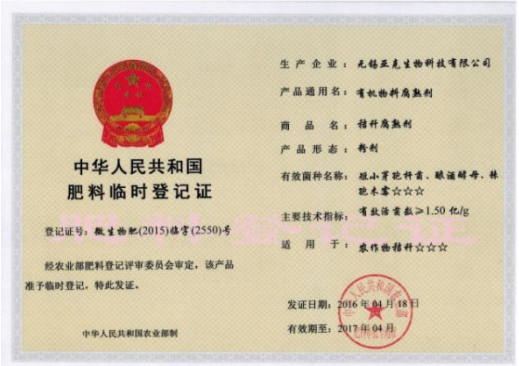






Research and development of *bacillus* formulations

- R&D of *Bacillus* biopesticide and biofertilizer.
- The *Bacillus* products become demonstration and promotion products listed by The national agricultural center (NATESC) and Liaoning Agricultural Technology Extension Station.


中华人民共和国
肥料临时登记证

生产企业：
产品通用名：
商品名：
产品形态：
有效菌种名称：
主要技术指标：
适用于：
登记证号：
经农业部肥料登记评审委员会审定，该产品准予临时登记，特此发证。
发证日期：2016年04月18日
有效期至：2017年04月
中华人民共和国农业部制

中华人民共和国
肥料正式登记证

生产企业：
产品通用名：
商品名：
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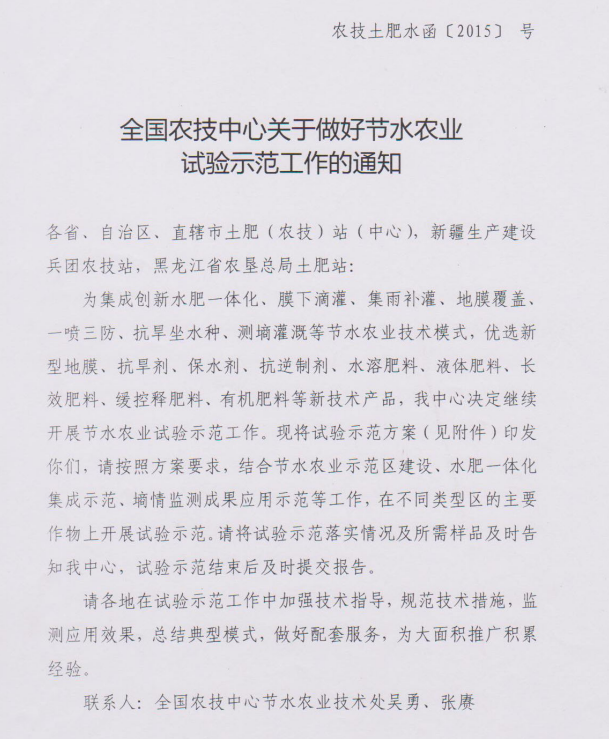
中华人民共和国农业部制


农技土肥水函〔2015〕号

全国农技中心关于做好节水农业试验示范工作的通知

各省、自治区、直辖市土肥（农技）站（中心），新疆生产建设兵团农技站，黑龙江省农垦总局土肥站：

为集成创新水肥一体化、膜下滴灌、集雨补灌、地膜覆盖、一喷三防、抗旱坐水种、测墒灌溉等节水农业技术模式，优选新型地膜、抗旱剂、保水剂、抗逆制剂、水溶肥料、液体肥料、长效肥料、缓控释肥料、有机肥料等新技术产品，我中心决定继续开展节水农业试验示范工作。现将试验示范方案（见附件）印发你们，请按照方案要求，结合节水农业示范区建设、水肥一体化集成示范、墒情监测成果应用示范等工作，在不同类型区的主要作物上开展试验示范。请将试验示范落实情况及所需样品及时告知我中心，试验示范结束后及时提交报告。

请各地在试验示范工作中加强技术指导，规范技术措施，监测应用效果，总结典型模式，做好配套服务，为大面积推广积累经验。

联系人：全国农技中心节水农业技术处吴勇、张赓

The research project sponsored by Prof. Xuewen Gao

	Title of program	financial support	Time duration	funds(×10 000 CY)
1	Study on molecular immune regulation of Harpin protein	The National High-Tech R&D program of China (863 program) (2012AA101504)	2012—2015	203
2	Identification of growth-promoting substance produced by polyamines biosynthestic pathway in *Bacillus subtilis* and its machnism of action	The National Natural Science Foundation of China (31471811)	2015—2018	80
3	Research and development of bacterial biological pesticide in sustainable agricultural production	The International Scientific and Technological Cooperation Projects（2009DFA32740）	2007－2010	90
4	Cloning and characterization of main biocontrol functional genes from *Bacillus subtilis*	The National High-Tech R&D program of China (863 program)（2006AA10Z172）	2006－2010	50
5	Cloning and functional analysis of genes of Bacillus subtilis lipopeptide biosynthetic regulatory region	The National Natural Science Foundation of China （30570041）	2006－2008	25
6	The development of a new type of promoting and immune plant pheromone	The National High-Tech R&D program of China (863 program)（2001AA246013）	2001—2005	123
7	Purification and identification of Protein Elicitor during interactions between Rice and *Xanthomonas oryzae*	The National Natural Science Foundation of China （39900096）	2000—2002	12
8	Cloning and utilization of gray leaf spot disease related genes in Soybean	Henry Fok young teachers fund（81027）	2002—2004	16

In recent 5 years, more than 30 papers was published in international journals MPMI, AEM, MPP, Biological Control and Scientific Reports, and 12 invention patents was granted in Prof. Gao's research group.

Papers published in 2015 and 2016:

1. Liming Wu, Huijun Wu, Lina Chen, Hongyue Zhang and **Xuewen Gao*.** Induction of systemic disease resistance in *Nicotiana benthamiana* by the cyclodipeptides cyclo (L-Pro-L-Pro) and cyclo (D-Pro-D-Pro). **Molecular Plant Pathology**, 2016, DOI: 10.1111/mpp.12381.
2. Shengfeng Gao, Huijun Wu, Xinfang Yu, Limin Qian**, Xuewen Gao*.** Swarming motility plays the major role in migration during tomato root colonization by *Bacillus subtilis* SWR01. **Biological Control**, 2016, 98: 11–17
3. HuijunWu, Yang Zhang, Hongyue Zhang, QinGu, **Xuewen Gao***. Identification of functional regions of the HrpZPsg protein from *Pseudomonas savastanoi* pv. *glycinea* that induce disease resistance and enhance growth in plants. **European Journal of Plant Pathology**, 2016, DOI 10.1007/s10658-016-0979-6
4. Shanshan Xie, Huijun Wu, Lina Chen, Haoyu Zang, Yongli Xie, **Xuewen Gao*.** Transcriptome profiling of Bacillus subtilis OKB105 in response to rice seedlings. **BMC Microbiology**, 2015, 15(1): 1-14.
5. Yang Yang, Huijun Wu, Ling Lin, Qingqing Zhu, Rainer Borriss, **Xuewen Gao*.** A plasmid-born Rap-Phr system regulates surfactinproduction, sporulation and genetic competence in the heterologous host *Bacillus subtilis* OKB105. **Applied Microbiology and Biotechnology**, 2015, 99(17): 7241-7252
6. Liming Wu, Huijun Wu, Lina Chen, Ling Lin, Rainer Borriss, **Xuewen Gao*.** Bacilysin overproduction in *Bacillus amyloliquefaciens* FZB42 markerless derivative strains FZBREP and FZBSPA enhances antibacterial activity. **Applied Microbiology and Biotechnology**, 2015, 99: 4255-4263
7. Liming Wu, Huijun Wu, Lina Chen, Xinfang Yu, Rainer Borriss, **Xuewen Gao*.** Difficidin and bacilysin from *Bacillus amyloliquefaciens* FZB42 have antibacterial activity against *Xanthomonas oryzae* rice pathogens. **Scientific Reports,** 2015, 5: 1-9, DOi: 10.1038/srep12975
8. Liming Wu, Huijun Wu, Junqing Qiao, **Xuewen Gao*,** Rainer Borriss*. Novel Routes for Improving Biocontrol Activity of Bacillus Based Bioinoculants. **Frontiers in Microbiology,** 2015: 6: 1-13, doi:10.3389/fmicb.2015.01395
9. Haoyu Zang, Shanshan Xie, Huijun Wu, Weiduo Wang, Xiankun Shao, Liming Wu, Faheem Uddin Rajer, **Xuewen Gao***. A novel thermostable GH5 7 β-mannanase from *Bacillus pumilus* GBSW19 and its application in manno-oligosaccharides (MOS) production. **Enzyme and Microbial Technology**, 2015, 78: 1–9
10. Yu Wang, Huijun Wu, Guifang Wei, Hongyue Zhang, Yan Zhang, **Xuewen Gao***. Transcriptome Profiling of *hrf2* Transgenic Rapeseed Revealed Genes Related to the Defense Responses and Signaling Pathways. **Crop Science,** 2015, 55:1–11, doi: 10.2135/cropsci2014.03.0174

Prof. Gao's Lab members in 2015 New Year

Thank you !