

Dr. Anith K. Narayanan

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Summary

My research interest in the biological control of plant diseases with beneficial bacteria started with my Ph.D. program wherein I worked on a project entitled “Molecular basis of antifungal activity of a fluorescent Pseudomonad” at the Division of Microbiology, Indian Agricultural Research Institute, New Delhi, one of the premier institutes of agricultural education. I have been working on the broad area of “Plant-microbe interaction” with special emphasis on the biological control of plant diseases since then. In the last two and a half decades of my research career, I have worked on different pathosystems with several crops and am convinced that biological control could do wonders if it is practiced meticulously. I am proud to state that a bacterial strain (*Pseudomonas fluorescens* PN026) which I had isolated during my early career stage is being distributed by the Kerala Agricultural University, to the farmers on a commercial scale as a biocontrol agent against plant diseases. My current research interest is in the use of endospore-forming beneficial bacteria for plant health management.

Research Highlights

- Isolated, characterized and developed the *Pseudomonas fluorescens* strain PN026, currently being commercially distributed by KAU
 - For the first time developed a fungal-bacterial co-culture system in a single fermentation vessel, involving the beneficial endophytic fungus, *Piriformospora indica* and PGPR strain *Bacillus pumilus* VLY17
 - Developed a rapid and effective screening procedure for selection of efficient bacterial antagonists against *Phytophthora capsici*
 - Developed a coconut water based, farmer-friendly field level multiplication method for *Pseudomonas fluorescens* PN026
 - Formulated a coconut water based liquid bioformulation for *Pseudomonas fluorescens* PN026
 - Devised for the first time in vitro screening methods for testing antagonism of one or a couple of bacterial biocontrol isolate(s) against multiple fungal phytopathogens in a single agar plate
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Experience

Joined Kerala Agricultural University as Assistant Professor (Microbiology) in the year 1997

Education

- Graduated in Agricultural Science from Kerala Agricultural University (1990)
 - Post Graduation in Microbiology from Indian Agricultural Research Institute, New Delhi (1993)
 - Ph.D in Microbiology from Indian Agricultural Research Institute, New Delhi (1997)
 - Postdoctoral training at University of Florida, USA (2003)
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Area of Specialization

Plant microbe interactions, Biological Control of Plant Diseases

Awards & Recognitions

- IARI Junior fellowship for doing M. Sc in Microbiology
 - IARI Senior fellowship for doing Ph. D in Microbiology
 - BOYSCAST (Better opportunity for Young Scientists in Chosen Areas of Science and Technology) fellowship instituted by Department of Science and Technology, Government of India for doing postdoctoral training in the field of Plant-Microbe interaction in the area of Life Science at University of Florida, USA for a period of one year.
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Research Projects

Ongoing

1. Network project on Utilization of Beneficial endophytes for plant growth promotion and management of plant diseases in important crops of Kerala. Funded by Planning Board, Government of Kerala.
2. All India Network Project on Soil Biodiversity and Biofertilizers. Funded by Indian Council of Agricultural Research.

Completed

1. Exploitation of the endosymbiotic fungus *Piriformospora indica* for biotic and abiotic stress management in black pepper (*Piper nigrum* L.). Funded by Kerala State Council for Science Technology and Environment, Government of Kerala, India
 2. Role of bacterial endophytes in plant defense mechanisms against *Phytophthora capsici* in black pepper (*Piper nigrum* L.). Funded under Department of Science and Technology, Government of India
 3. Development of bacterial endophytes for insect pest management. Funded by Kerala Biotechnology commission, Kerala State Council for Science Technology and Environment, Government of Kerala, India
 4. Exploitation of bacterial endophytes of *Piper* spp. from western Ghats for the management of *Phytophthora capsici* infecting black pepper (*Piper nigrum* L.). Funded by Western Ghat Development Program, Government of Kerala.
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Publications

Journal Articles

(Scopus indexed)

1. Yashaswini, M.S., Nysanth, N.S., Gopinath, P.P. and Anith, K.N., (2022). Endospore-forming phyllosphere bacteria from *Amaranthus* spp. suppress leaf blight (*Rhizoctonia solani* Kühn) disease of *Amaranthus tricolor* L. *Journal of Tropical Agriculture*, 60, 94-106.
2. Nysanth, N.S., Divya, S., Nair, C.B., Anju, A.B., Praveena, R. and Anith, K.N., (2022). Biological control of foot rot (*Phytophthora capsici* Leonian) disease in black pepper (*Piper nigrum* L.) with rhizospheric microorganisms. *Rhizosphere*, p.100578.
3. Nysanth, N.S., Sivapriya, S.L., Natarajan, C. and Anith, K. N.* (2022) Novel in vitro methods for simultaneous screening of two antagonistic bacteria against multiple fungal phytopathogens in a single agar plate. *3 Biotech* 12: 140. (IF 2.406). <https://doi.org/10.1007/s13205-022-03205-3>
4. Bijula, B.L., Alex, S., Soni, K.B., Anith, K. N., Joy, M., Nair, D.S., Beena, R. and Benny, A. (2022). Algicidal Effects of Green Synthesized Silver Nanoparticles using *Tinospora cordifolia* on *Chlamydomonas reinhardtii*. *Journal of Pure and Applied Microbiology* 16, 1122-1129. doi: 10.22207/JPAM.16.2.38

5. Innazent, A., Jacob, D., Bindhu, J.S., Joseph, B., Anith, K.N., Ravisankar, N., Prusty, A.K., Paramesh, V. and Panwar, A.S. (2022) Farm typology of smallholders integrated farming systems in Southern Coastal Plains of Kerala, India. *Scientific Reports* 12: 1-14. (IF 4.379). <https://doi.org/10.1038/s41598-021-04148-0>
6. Yashaswini, M.S., Nysanth, M.S., and Anith, K.N.* (2021) Endospore-forming bacterial endophytes from *Amaranthus* spp. improve plant growth and suppress leaf blight (*Rhizoctonia solani* Kühn) disease of *Amaranthus tricolor* L. *Rhizosphere* 19: 100387. (IF 3.129). <https://doi.org/10.1016/j.rhisph.2021.100387>
7. Anith, K.N. *, Nysanth, N.S., and Natarajan, C. (2021) Novel and rapid agar plate methods for in vitro assessment of bacterial biocontrol isolates' antagonism against multiple fungal phytopathogens. *Letters in Applied Microbiology* 73: 229-236. (IF 2.858). <https://doi.org/10.1111/lam.13495>
8. Rajkumari, N., Alex, S., Soni, K.B., Anith, K.N., Viji, M.M. and Kiran, A.G. (2021) Silver nanoparticles for biolistic transformation in *Nicotiana tabacum* L. *3 Biotech* 11: 1-7. (IF 2.406). <https://doi.org/10.1007/s13205-021-03043-9>
9. Vyshakhi, A.S. and Anith, K.N. (2021). Co-inoculation with the root endophytic fungus *Piriformospora indica* and endophytic bacteria improves growth of solanaceous vegetable seedlings.(Accepted for publication in *International Journal of Vegetable Science*)
10. Athira, S. and Anith, K.N. (2020). Plant growth promotion and suppression of bacterial wilt incidence in tomato by rhizobacteria, bacterial endophytes and the root endophytic fungus *Piriformospora indica*. *Indian Phytopathology*, 73(4), pp.629-642.
11. Chandran, T.T., Mini, C. and Anith, K.N. (2020). Quality evaluation of edible film coated tomato (*Solanum lycopersicum*) fruits. *Journal of Tropical Agriculture*, 58: 219-117
12. Gopi, G. K., Meenakumari, K. S., Anith, K. N., Nysanth, N. S., and Subha, P. (2020). Application of liquid formulation of a mixture of plant growth promoting rhizobacteria helps reduce the use of chemical fertilizers in *Amaranthus* (*Amaranthustricolor* L.). *Rhizosphere*, 100212.
13. Kollakkodan, N., Anith, K.N., and Nysanth, N. S. (2020) Endophytic bacteria from *Piper colubrinum* suppress *Phytophthora capsici* infection in black pepper (*Piper nigrum* L.) and improve plant growth in the nursery, *Archives of Phytopathology and Plant Protection*, DOI:10.1080/03235408.2020.1818493
14. Nagamani, G., Alex, S., Soni, K. B., Anith, K. N., Viji, M. M., and Kiran, A. G. (2019). A novel approach for increasing transformation efficiency in *E. coli* DH5 α cells using silver nanoparticles. *3 Biotech*, 9 (3), 113.
15. Jisha, S., Anith, K. N., and Sabu, K. K. (2019). The protective role of *Piriformospora indica* colonization in *Centella asiatica* (L.) in vitro under phosphate stress. *Biocatalysis and Agricultural Biotechnology*, 19, 101088
16. Jisha, S., Gouri, P. R., Anith, K. N., and Sabu, K. K. (2018). *Piriformospora indica* cell wall extract as the best elicitor for asiaticoside production in *Centella asiatica* (L.) Urban, evidenced by morphological, physiological and molecular analyses. *Plant Physiology and Biochemistry*, 125, 106-115.
17. Anith, K. N., Aswini, S., Varkey, S., Radhakrishnan, N. V., and Nair, D. S. (2018). Root colonization by the endophytic fungus *Piriformospora indica* improves growth, yield and piperine content in black pepper (*Piper nigrum* L.). *Biocatalysis and Agricultural Biotechnology*, 14, 215-220.
18. Varkey, S., Anith, K.N., Narayana, R. and Aswini, S. (2018) A consortium of rhizobacteria and fungal endophyte suppress the root-knot nematode parasite in tomato. *Rhizosphere* 5: 38-42.
19. Kumar, A. S., Meenakumari, K. S., and Anith, K. N. (2017). Screening for Zn solubilisation potential of soil bacteria from Zn deficient soils of Kerala. *Journal of Tropical Agriculture*, 54(2), 194
20. Kollakkodan, N., Anith, K.N. and Radhakrishnan, N.V. (2017) Diversity of endophytic bacteria from *Piper* spp. with antagonistic property against *Phytophthora capsici* causing foot rot disease in black pepper (*Piper nigrum* L.) *Journal of Tropical Agriculture* 55: 63-70
21. Anith, K.N., Vyshakhi, A.S., Viswanathan, A., Varkey, S. and Aswini, S. (2016) Population dynamics and efficiency of coconut water based liquid formulation of *Pseudomonas fluorescens* AMB-8. *Journal of Tropical Agriculture* 54: 184-189.
22. Lakshmi Priya, P., Nath, V. S., Veena, S. S., Anith, K. N., Sreekumar, J. and Jeeva, M.L. (2016) *Piriformospora indica*, a Cultivable Endophyte for Growth Promotion and Disease Management in Taro (*Colocasia esculenta* (L.)). *Journal of Root Crops* 42: 107-114.
23. Anith, K. N., Sreekumar, A. and Sreekumar, J. (2015) The growth of tomato seedlings inoculated with co-cultivated *Piriformospora indica* and *Bacillus pumilus*. *Symbiosis* 65: 9-16
24. Anith, K. N., Soumya, V. G., Sreekumar, A., Raj, A. R. and Radhakrishnan, N. V. (2014) A cheap and farmer friendly method for mass multiplication of *Pseudomonas fluorescens*. *Journal of Tropical Agriculture* 52: 145-148.
25. Lekshmi, R. S., Soni, K. B., Alex, S., Rajmohan, K. and Anith, K. N. (2014) Callus induction and *Agrobacterium tumefaciens* mediated transfer of hydroxyl methyl CoA reductase (HMGR) gene in *Centella asiatica* L. *Journal of Tropical Agriculture* 52: 67-73
26. Satheesan, J., Anith, K. N. and Sakunthala, M. (2012) Induction of root colonization by *Piriformospora indica* leads to enhanced asiaticoside production in *Centella asiatica*. *Mycorrhiza* 22: 195-202
27. Anith, K. N., K. M. Faseela, P. A. Archana and K. D. Prathapan (2011) Compatibility of *Piriformospora indica* and *Trichoderma harzianum* as dual inoculants in black pepper (*Piper nigrum* L.). *Symbiosis* 55: 11-17
28. Anith, K. N. and Roy Stephen (2009) Alginate entrapped bacteria for better root colonization and plant growth promotion in black pepper in the nursery. *Journal of Plantation Crops* 37: 94- 96.

29. Prathapan, K. D., Anith, K. N., Faizal, M. H., Lekha, M. and Dhanya, M. K. (2008) A report on Siphylloidea stigmata Redtenbacher (Diapheromeridae: Necrosiinae) as the first phasmid crop pest in India and its redescription. *Zootaxa* 1959: 58-64.
30. Nair, C. B., Anith, K. N. and Sreekumar, J. (2007) Mitigation of growth retardation effect of plant defense activator, acibenzolar-S-methyl in amaranthus plants by plant-growth promoting rhizobacteria. *World Journal of Microbiology and Biotechnology* 23:1183- 1187
31. Faizal, M.H., Prathapan, K. D., Anith, K. N., Mary, C. A., Lekha, M. and Rini, C. R. (2006) *Erythrina* gall wasp *Quadrastichus erythrinae*, yet another invasive pest new to India. *Current Science* 90: 1061-1062
32. Prathapan, K. D., Faizal, M.H. and Anith, K. N. (2005) A new species of *Longitarsus* (Coleoptera: Chrysomelidae) feeding on Chinese potato, *Plectranthus rotundifolius* (Lamaceae) in southern India. *Zootaxa* 966: 1-8
33. Anith, K. N., M. T. Momol, J. W. Kloepper, J.J. Marois, S. M. Olson and J. B. Jones (2004) Efficacy of plant growth promoting rhizobacteria, acibenzolar-S-methyl and soil amendment for integrated management of bacterial wilt on tomato. *Plant Disease* 88: 669-673.
34. Anith, K. N., N. V. Radhakrishnan and T. P. Manomohandas (2003) Screening of antagonistic bacteria for biological control of nursery wilt of black pepper (*Piper nigrum* L.) *Microbiological Research*. 158: 91-97
35. Anith, K. N., N. V. Radhakrishnan and T. P. Manomohandas (2002) Management of nursery wilt of black pepper (*Piper nigrum*) with antagonistic bacteria. *Current Science*. 83: 561-562.
36. Manomohandas, T. P., Anith, K. N., Gopakumar, S. and Jayarajan, M. (2001) Kudampuli- a fruit for all reasons. *Agroforestry Today*. 13: 7-9.
37. Anith, K. N. and T. P. Manomohandas (2001) Combined application of *Trichoderma* and *Alcaligenes* sp. strain AMB 8 for controlling nursery rot (*Phytophthora capsici*) of black pepper (*Piper nigrum*). *Indian Phytopathology*. 54: 335-339.
38. Manomohandas, T. P., Anith, K. N. and M. Jayarajan (2000) New weed host of *Ephelis oryzae*, the causal organism of Udbatta disease of rice from Kerala. *Indian Phytopathology*. 53: 234.
39. Anith, K. N., T. P. Manomohandas, M. Jayarajan, K. Vasanthakumar and K. C. Aipe (2000) Integration of soil solarization and biological control with a fluorescent *Pseudomonas* sp. for control of bacterial wilt (*Ralstonia solanacearum*) disease of ginger (*Zingiber officinale*). *Journal of Biological Control*. 14: 25-29.
40. Anith, K. N., K. V. B. R. Tilak and T. P. Manomohandas (1999) Analysis of mutation affecting antifungal property of a fluorescent *Pseudomonas* sp. during cotton *Rhizoctonia* interaction. *Indian Phytopathology*. 52:366-369.
41. Anith, K. N., K. V. B. R. Tilak and S. P. S. Khanuja (1999) Molecular basis of antifungal toxin production by fluorescent *Pseudomonas* sp. strain EM85 – A biological control agent. *Current Science*. 77: 671-677.
42. Anith, K. N., K. V. B. R. Tilak, S.P.S. Khanuja and A. K. Saxena (1998) Cloning of genes involved in the antifungal activity of a fluorescent *Pseudomonas* sp. *World Journal of Microbiology and Biotechnology*. 14: 939-941.

Articles not indexed in Scopus

43. Visveswaran, S., George, T., Aparna, B., Anith, K.N. and Visal, S. (2021) Dissipation kinetics and distribution of fipronil and its toxic metabolites in Banana, cv. Nendran (AAB). *International Journal of Chemical Studies* 9: 449-452.
44. Akhilraj, B.C., Nair, D.S., Sreekala, G.S., Anith, K.N. and Sajitharani, T. (2020) Effect of physical seed pretreatments on morphology and yield of *Ocimum basilicum* L. *Journal of Pharmacognosy and Phytochemistry* 9: 2631-2635.
45. Nandana, M.S. and Anith, K.N. (2020) Growth promotion in chilli (*Capsicum annum* L.) on inoculation with co-cultured *Piriformospora indica* and *Pseudomonas fluorescens*. *International Journal of Current Microbiology and Applied Sciences* 9: 2015-2027.
46. Mampallil, L.J., Faizal, M.H. and Anith, K.N. (2019) Bioefficacy and characterization of bitter gourd phylloplane bacteria against chewing pests. *Bulletin of Environment, Pharmacology and Life Science* 8: 106-112.
47. Jisha, S., Anith, K. N. and Sabu, K.K. (2019) Acid/alkaline phosphatase and super oxide dismutase activities in *Centella asiatica* on *Piriformospora indica* co-cultivation. *Trends in Biosciences* 12: 96-99.
48. Mampallil, L.J., Faizal, M.H. and Anith, K.N. (2017) Bacterial bioagents for insect pest management. *Journal of Entomology and Zoology Studies* 5: 2237-2244.
49. Raj, S.K., Syriac, E.K., Anith, K.N. and Meenakumari, K.S. (2017) Compatibility of biocontrol agents and N fixing organisms with post emergence pre-mix herbicide-bispyribac sodium+ metamifop 14% SE. *Journal of Applied and Natural Science* 9: 1510-1514.
50. Naik, M.R., Ajithkumar, K., Santhoshkumar, A.V. and Anith, K.N. (2017) Flowering and physiological traits of *Dendrobium* Cv. earsakaul as influenced by various nutrients and microclimatic conditions. *Bulletin of Environment, Pharmacology and Life Sciences* 6: 50-54.
51. Dhinesh, D., Ajithkumar, K., Naik, M.R., Sureshkumar, P., Santhoshkumar, A.V. and Anith, K.N. (2015) Influence of *Piriformospora indica* on growth and flowering of tropical orchid *Dendrobium*. *International Journal of Tropical Agriculture* 33: 487-492.

52. George, G.M., Lekshmi, P.G., Mini, C., Anith, K.N. and Manju, R.V. (2015) Evaluation of sanitization treatments for red amaranthus (*Amaranthus tricolor* L.). *International Journal of Processing and Post Harvest Technology* 6: 144-149.
53. Faizal, M.H., Anith, K.N., Prathapan, K.D., Stephen, R. and Faseela, K.M. (2006) Beetle-fungus association leads to death of gall wasp infested *Erythrina* trees. *Insect Environment* 12: 117-118.
54. Manomohandas, T.P., Anith, K.N., Gopakumar, S. and Jayaranja, M. (2001) Kodampuli—a fruit for all reasons. *Agroforestry Today* 13: 7-8.
55. Pradeepkumar, T., Vasanthkumar, A.K., Kumaran, K., Susamma, P.G., Manmohandas, T.P. and Anith, K.N. 1999. Studies on yielding behaviour of black pepper CV Panniyur-I. *Indian Journal of Arecanut, Spices and Medicinal Plants* 1: 88-90.

Popular Articles

1. Divya, S., Das, A., Anusree, A.R. and **Anith, K.N.** (2022) The root endophytic fungus *Piriformospora indica* as a bio-hardening agent for tissue cultured plantlets. *Biotica Research Today*, **4**: 69-271.
2. Nandana, M.S., Subhash, A.P., Sivapriya, S.L. and **Anith, K.N.** (2022) Impact of climate change on plant-microbe interactions. *Biotica Research Today* **4**: 275-277.
3. Sivapriya, S.L., Subhash, A.P., Nandana, M.S., Vigi, S. and **Anith, K.N.** (2021) Plant Microbiome: The unseen lifeforms helping crops cope with biotic and abiotic stress. *Biotica Research Today* **3**: 1008-1010.
4. Nysanth, N.S., Sivapriya, S.L., Yashaswini, M.S. and **Anith, K.N.** (2021) Pink Pigmented Facultative Methylophiles (PPFMs): Bioinoculants for sustainable green agriculture. *Biotica Research Today* **3**: 975-978.
5. Yashaswini, M.S., Nysanth, N.S. and **Anith, K.N.** (2021) Bacterial endophytes: Potential role in plant growth promotion. *Biotica Research Today* **3**: 733-736.
6. Subhash, A.P., Nandana, M.S., Sivapriya, S.L. and **Anith, K.N.** (2021) Microbial inoculants for mineral nutrient solubilization and mobilization. *Biotica Research Today* **3**: 957-960.

Books/Chapters in Books

1. Zargar, M.Y. and **Anith, K. N.** (2004) Biological control of plant diseases with plant growth promoting rhizobacteria (PGPR): Role of induced systemic resistance (ISR). Khan, M.A. and Zargar, M.Y (eds) *Agriculture and Environment*. APH Publishing House, New Delhi, India. pp 59-66. ISBN 10: 9788176486033
2. Girija, V. K. and **Anith, K. N.** (2006) *Bacillus* as biological control agents of plant diseases. Trivedi, P. C. (ed) *Applied Microbiology*. Agribios (India), Jodhpur. pp 97-111. ISBN 10: 8177542842

Student Guidance (Major Advisor/ Advisory Committee member)

M. Sc.

Within KAU: Completed: 16

Outside KAU: Completed : 3

Ph. D

Within KAU: Ongoing : 4

Other Institutional Responsibilities

1. Currently acting as student Advisor/faculty mentor to 20 Undergraduate students.
2. Currently Chairman of committee to monitor “Prevention of Caste-based Discrimination in Higher Education Institutions” at College of Agriculture, Vellayani campus.

Membership in Professional Associations

1. Annual membership in the American Phytopathological Society
2. Annual membership in Indian Phytopathological Society
3. Three Year full Global Outreach membership in International Symbiosis Society