BIO-DATA

1. **Name** : **Dr Prabir Kumar Paul**

2. **Designation (Present)** : Professor
Department of Biotechnology
IMS Engineering College
NH24 , Adhyatmik Nagar
Near Dasna , Ghaziabad
Uttar Pradesh , India .

3. **Date of Birth** : 1st January 1965

4. **Languages Known** : English, Hindi , Bengali

5. **Academic Details (Qualifications and research / teaching experience)**

Degree / Assignment	**University**	**Subject Studied & % marks obtained / area of research / subjects taught**	**Year**	**Experience**	
				Research	**Teaching**
B.Sc.(H) Botany	Delhi	Botany**(69.33 %)**	1983-86		
M.Sc. Botany	Delhi	Botany (with specialization in molecular cell physiology and molecular plant pathology)**(67.7%)**	1986-88		
Ph.D.	Delhi	Thesis title : Microbial Ecology on the Phyllo-plane of Tobacco.	1988-92 Submitted in June,1992. Viva held on 23January,1993.		
Undergraduate Teaching (Lecturer- Ad-hoc)	Dayal Singh College , Delhi University	Cell biology, Genetics and physiology	11 November 1993 - 23 December 1993 .		01month and 13 days
Undergraduate Teaching (Lecturer- Ad-hoc)	Dayal Singh College , Delhi University	Cell biology, Genetics and physiology	11 January 1994 – 25 January 1994		15 days
Post Doctoral CSIR Research Associate	Delhi	Molecular aspects of induction of defence responses in Barley	01February 1994 – 31 January 1999	05years	

Post Doctoral CSIR Senior Research Associate (Pool officer)	Delhi	Molecular aspects of induction of defence responses in Barley	03May, 1999 – 30 September, 1999.	04months and 28 days.	04 months and 28 days.
Lecturer (Ad-hoc)	Department of Botany , University of Delhi	Mycology , Plant Pathology , Microbiology , Principles of plant pathology	01October 1999 - 30 April 2003	03 years 06months	03 years and 06 months
Professor (Biotechnology)	Centre for Biotechnology , Former Rai University, Delhi	Post graduate courses – Molecular biology, Recombinant DNA Technology, Cell Biology	06July 2003- 12 September 2005	02years , 02 months and 07 days	02years , 02 months and 07 days
Assistant Professor , (Biotechnology)	Amity Institute of Biotechnology, Amity University Uttar Pradesh , Noida	Post Graduate courses - Cell Biology, Molecular Biology , Recombinant DNA Technology , Plant – microbe interactions	13 September , 2005 – 18 September , 2009	04 years and 05days	04years and 05days
Professor , (Biotechnology)	Amity Institute of Biotechnology, Amity University Uttar Pradesh , Noida	Post Graduate courses - Cell Biology, Molecular Biology , Recombinant DNA Technology, Molecular Plant – microbe interactions	19 September , 2009 – 31 January, 2020	10years , 04months and 12 days	10years , 04 months and 12 days
Professor (Biotechnology)	Department of Biotechnology, IMS Engineering College Ghaziabad,Uttar Pradesh Affliated to Dr A.P.J Abdul Kalam Technical University ,Uttar Pradesh,Lucknow	Plant Biotechnology , Enzyme Engineering , Food Biotechnology	08 March,2021-continuing	03 month	29 days

Total teaching experience : 21 Years 00 Months and 05 Days
Total research experience : 26 Years 00 Months and 09 Days

6. NET Qualified : Yes (UGC-CSIR NET , 1988)

7. Administrative experience

Designation	Organisation	Tenure	Experience
Associate Dean	Centre for Biotechnology , Former Rai University, Delhi	10 January , 2004 – 31 August , 2005	01 year , 07 months ,21 days
Programme coordinator (Biotechnology)	Amity Institute of Biotechnology, Amity University Uttar Pradesh , Noida campus	12 July , 2006 – 10 July , 2009.	03 years
Deputy Director (Biotechnology)	Amity Institute of Biotechnology, Amity University Uttar Pradesh , Noida campus	18 September , 2009 – 31 January , 2016	06 year , 04 months and 12 days
Dean (Biotechnology and Biological sciences)	Amity University Uttar Pradesh , Noida Campus	02 January , 2014 – 28 July , 2017	03 years and 06 months
Head (Biotechnology)	Amity Institute of Biotechnology, Amity University Uttar Pradesh , Noida campus	02January , 2013 – 06 October , 2014	01 year , 09 months and 05 days
Head (Biotechnology)	Amity Institute of Biotechnology, Amity University Uttar Pradesh , Greater Noida Campus	03 July , 2015 – 20 July , 2018	03 years and 20 days

8. Field of Specialisation :

(a) **Teaching :** Molecular plant pathology, Mycology ; Microbiology, Cell biology, Molecular Biology, Plant science , Recombinant DNA Technology

(b) **Present research interests :** signal transduction in plant defence responses, molecular events during interaction of a pathogen with a host and non-host ; protein – protein and DNA-protein interaction ; gene expression during plant – phylloplane microbe interaction ; influence of phylloplane microbes on physiology and gene expression in chloroplast and mitochondria , proteomics of cell wall during phylloplane microbe – plant interaction; development of phylloplane microflora based biocides ; molecular mechanisms in colonization of phylloplane by human enteric pathogens , quorum sensing in human enteric pathogens .

9. Awards/Distinctions received/achieved:

(i) All India Post-Graduate scholarship for pursuing M.Sc. in Botany (1986-88).

(ii) Awarded Junior Research Fellowship (1988-90) and subsequently Senior Research Fellowship (1990-93) after qualifying NET conducted by CSIR, New Delhi.

(iii) Selected as Research Associate (1994-99) by CSIR, New Delhi for Post-doctoral Research at Department of Botany, University of Delhi.

(iv) Selected Senior Research Associate (Pool Officer) by CSIR, New Delhi, for Post-doctoral Research at Department of Botany, Delhi University (1999).

(v) Fellow and life member , International Society for Conservation of Natural Resources .

(vi) International Travel Grant to present research findings in International conferences :
DST , New Delhi - 01
CSIR , New Delhi - 03

10. Membership of Academic/Professional Societies:

Member of the:

(i) Life member of International Society for Conservation of Natural Resources.

(ii) National Institute of Ecology.

(iii) Member of American Society of Microbiology

11 . a. Publications

Research articles - 46
Review article - 04
Book chapter - 01

b. Complete Patents **: Filed : Six**
Granted : one (Patent no. : 325819)

c. Microbial Genome Sequences accession no. granted : Seven

i. *Stenotrophomonas maltophilia* D457 (HE 798556.1)
ii. *Chryseobacterium jejuense* M 17306 (JF 710962.1)
iii. *Klebsiella pneumoniae* NGB-FR-80 (CP 008797.1)
iv. *Serratia fonticola* M 17 (JN 596121.1)
v. *Enterobacter ludwigii* (KF 724149.1)
vi *Aspergillus niger* (MK 590413)
vii *Fusarium oxysporum* (MK590412

Nucleotide sequence accession no. granted : 01
KY 640323

12. a. Conferences attended

International - 12

Bandol **France**	**- 01**
California, **USA**	**- 01**
Oregon**, USA**	**- 01**
Oxford, **U.K.**	**- 01**
Delhi, India	**- 02**
Varanasi, India	**- 02**
Lucknow, India	**- 01**
New South Wales, **Australia**	**- 01**
Auckland, **New Zealand**	**- 01**
Chiang Mai, **Thailand**	**- 01**

National - 18

b. Conference organized : Organising secretary for international conference, **"Perspectives in Phyllosphere Biology",15th -17th February, 2012**.Amity University Uttar Pradesh Noida, India. (Supported by DST, New Delhi, India)

13. Research Supervision:

Ph.D. in progress	1
Ph.D. Awarded	8
Women Scientist (DST)	1 (October, 2012- September ,2014)

14.. Address for communication : **Dr. Prabir Kumar Paul**
A - 403, Gitanjali Apartments,
Karkardooma,
Delhi 110092.
India

15. e mail : prabir_kp@rediffmail.com

16. Contact telephone number : 9818789144 ,
011- 22379821

17. Family details :

Father : Late(Retd.) Prof. Pijush Kanti Paul , Department of Zoology , University of Delhi . .
Mother: Mrs Chanchala Paul , House wife
Wife : Mrs Kanika Paul ,Engineer , Formerly employed with HCL Infosystems , Noida .
Elder son : Bhashkar Paul , 3rd Year, B.Sc(Hons.) Biomedical Science , Delhi University.
Younger Son : Pradeepto Paul , Class X , Amity International School , Mayur Vihar , Delhi

18. References :

Prof K.C Upadhyaya
Former Vice Chancellor ,
M.S University , Baroda
INSA Fellow
Professor of Life Sciences (Retd)
JNU , New Delhi
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Prof. C.R Babu
Professor Emeritus , Delhi University
Honorary Director , Delhi School of Climate Change and Sustainability, Delhi University
Former Pro Vice Chancellor ,Delhi University
Prof. of Botany (Retd.) University of Delhi
Present address :
Prof. C.R Babu
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crb26@hotmail.com

July 04 , 2021 **Dr. PRABIR KUMAR PAUL**

Delhi , India

Publications

Total Cites : 324 h-index : 7 i10- index : 5

2020

1. Susmita Goswami, Prabir Kumar Paul, Navodit Goel and Rita Singh (Majumdar) . Impact of phylloplane microbe on the cell wall and cytoplasmic protein of tomato leaves . Plant Archives . 21 (1) 709-714 (Impact factor : 0.7).

2. Navodit Goel and P.K Paul .*Drechslera graminea* downregulates RuBisCo expression in Barley. Archives of Phytopathology and Plant Protection . (Doi.org/10.1080/03235408.2020.1762964) (Impact factor : 0.56)

2019

3. Shilpi , Neha Bhadauria , P.D Sharma and P.K Paul . Biofilm formation and survival of *Serratia fonticola , Klebsiella pneumonia* and *Chryseobacterium jejuense* on tomato phylloplane . Journal of Tropical Agricultural Science . 42 (3) 1097-1110 (Impact factor : 0.50).

4. Susmita Goswami , P.D Sharma and P.K Paul . *Aspergillus niger* a dominant phylloplanr coloniser influences activity of defence enzymes in *Solanum lycoperscicum*.Journal of Plant Protection Research . DOI: 10.24425/jppr.2019.131265 . 59 (4) (Impact factor: 0.89)

5. Joyeeta Mitra , P.D Sharma and P.K Paul . Do Phylloplane microfungi influence activity of Rubisco and Carbonic anhydrase. South African Journal of Botany.124 , 118-126.(Impact factor : 1.594).

6. Neha Bhadauria , Shilpi , P.D Sharma and P.K Paul . Interaction between *Serratia fonticola* and *Chryseobacterium jejuense* on tomato phylloplane influences the cellular protein profile . Research Journal of Biotechnology . 14 (5) 36-43 . (Impact factor : 0.2)

7. Neha Bhadauria , Shilpi , P.D Sharma and Prabir K Paul . Colonization of *Serratia fonticola* on phylloplane of tomato and its impact on leaf cytoplasmic protein profile . Journal of Environmental Biology . 40 , 607-612 .(Impact factor : 0.73)

8. Shilpi , Neha Bhadauria , P.D Sharma and P.K Paul . Comparaitive study of colonization of different human enteric pathogens on phylloplane of *Solanum lycopersicum* . Plant Archives . 19 , 941 – 945 . (Impact factor : 0.2)

2018

9. Navodit Goel, Gaurav Jaiswal , Abhinav Kr Srivastava, P.K Paul and Anukrati Goel . Effect of *Dreschlera gaminea* on total soluble proteins and defense enzymes of barley. Journal of Plant Protection Research. 58 (3) 220-226 (Impact factor – 0.89).

10. Navodit Goel , Anukrati Goel and Prabir Kumar Paul. A strategy to control human enteric pathogens on farm fresh tomatoes. Research Journal of Pharmacy and Technology. 11 (6), 2408-2417.

2017

11. Indu Gaur, P.D Sharma and P.K Paul. Effect of *Klebsiella pneumoniae* on speck disease development in *Solanum lycopersicum*. Indian Journal of Agricultural Research .51(5)431-436.

12. Navodit Goel and P.K Paul. Biocontrol of bacterial speck of tomato by aqueous extracts of *Tagetes erecta*. Journal of Plant Protection Research. 57(4),361-369 (Impact factor – 0.89)

2016

13. Joyeeta Mitra, Priyanka Narad , Abhishek Sengupta , P.D Sharma and P.K. Paul. In silico identification of ergesterol as a novel fungal metabolite enhancing RuBisCo activity in *Lycoperscicum esculentum*. Interdisciplinary Sciences: Computational Life Sciences.8(3):229–240 (Impact factor 0.66)

14. Joyeeta Mitra and P.K Paul. A potent biocide formulation inducing SAR in plants. Journal of Plant Diseases and Protection. 124 (2) 163-175. (Impact factor 0.622)

15. Indu Gaur , P.D Sharma and P.K Paul. Human pathogenic bacteria associated with field grown Tomato and Radish. Asian Journal of Microbiology, Biotechnology and Environmental Sciences. 18 (3), 755 – 763.

16. Beenish Saleem and P. K. Paul, Microbial colonization of tomato phylloplane is influenced by leaf age. Journal of Functional and Environmental Botany. 6 (1), 1-8 .

17. Joyeeta Mitra, P . Narad and P.K. Paul. Insilico, Invivo and Invitro approach in understanding the functional relationship between ergosterol and RuBisCo. Photosynthetica . 54 (4), 517–523. Doi : 10.1007/s11099-016-0211-0 (Impact factor 1.55)

18. Navodit Goel, Kumari Anukrati and P.K Paul . Anti – phytopathogenic and SAR inducing properties of Neem: a review. Journal of Chemical and Pharmaceutical Sciences. 9 (4) , 2547 – 2555.

2015

19. V. Bhuvaneshwari, R. Amsaveni , M.Kalaiselvi , V. Rajeshwari and P.K. Paul. Induced resistance by neem extracts in plants . International Journal of Biosciences and Nanosciences. 2 (12) 221-224. (Review)

20. Beenish Saleem and P.K Paul . Antifungal activity of bacteria on phylloplane of tomato. Journal of functional and environmental botany. 5 (2). 116-127.

21. Beenish Saleem and P.K Paul. Phytohormones from Phylloplane microbes – a review. Trends in Biosciences. 8 (17). 4450-4458.

22. Navodit Goel, Kumari Anukrati, Ankita Singh and Prabir Kumar Paul. *Tagetes erecta* leaf extract induces defence enzymes in *Solanum lycopersicum* . Journal of Chemical and Pharmaceutical Research . 7 (7) 466 – 475. (Impact factor 0.75)

23. Archana Yadav, T. Theivasanthi , P.K. Paul and K.C Upadhyaya . Extracellular biosynthesis of silver nanoparticles from plant growth promoting rhizobacteria *Pseudomonas sp.* International Journal of Current Microbiology and Applied Sciences. 4 (8) (Impact factor 2.015)

24. Onkar Grover, Indu Gaur, Joyeeta Mitra and P.K Paul . Effect of salicylic acid on germination of *Phaseolus vulgaris* and *Cicer arietenum* under salt stress. Trends in Bioscience.8(16) 4142-4147.

25. Archana Yadav , Indu Gaur, Navodit Goel, Joyeeta Mitra , Beenish Saleem, Susmita Goswami, P.K, Paul and K.C. Upadhyaya. Rhizospheric microbes are excellent growth promoters. Indian Journal of Natural Sciences. 30 (5). 6584 – 6595. (Review)

26. Joyeeta Mitra and P.K. Paul . Phylloplane microfungal metabolites as crop protectants. Plant Cell Biotechnology and Molecular Biology. 16 (1)84-92

27. Navodit Goel and P.K. Paul . Polyphenol oxidase and lysozyme mediate induction of systemic resistance in tomato when a bioelicitor is used. Journal of Plant Protection Research. 55 (4) 343 – 350. (Impact factor 0.55).

28. V. Bhuvaneshwari, Navodit Goel and P.K Paul. Protein - protein and DNA - protein interactions mediate induction of defense genes by fruit extract of *Azadirachta indica* A Juss. in *Solanum lycopersicum*. Plant Cell Reports. 34 (10) .1735 -1745 (Impact factor :3.49)

29. Navodit Goel and P.K Paul. Induction and expression of peroxidase is age depended. Archieves of Phytopathology and Plant Protection. 48 (7) 555 – 568. (Impact factor : 0.78).

30. Navodit Goel and P.K Paul . Plant age influences elicitation of Polyphenol Oxidase activity by Neem extract in *Solanum lycoperscicum* against *Pseudomonas syringae* pv. *tomato*. Israel Journal of Plant Sciences. 62 (4) 283-293. (Impact Factor 0.419).

31. V.Bhuvaneshwari , Navodit Goel and Prabir Kumar Paul. Bioelicitors induce association of defence enzymes with cell walls of *Lycopersicum esculentum*. Journal of Phytopathology.163 (11-12) 886-897. (Impact factor : 1.097).

2014

32. Navodit Goel and Prabir Kumar Paul. Neem fruit extract induces peroxidase and lipoxygenase in tomato. Asian Journal of Biological and Life Sciences. 3 (3): 189-194.

33. Navodit Goel and Prabir Kumar Paul. Induction of systemic resistance in tomato by fruit extracts of *Azadirachta indica*. Reviews of Literature. 2 (2) :12-27.

34. Reetika Kapoor, Bikash Mandal, Prabir Kumar Paul, Phaneendra Chigurupati and Rakesh Kumar Jain . Production of cocktail of polyclonal antibodies using bacterial expressed recombinant protein for multiple virus detection. Journal of Virological Methods. 196 : 7-14 (Impact factor : 1.642)

35. Reetika Kapoor, Bikash Mandal, Prabir Kumar Paul &Rakesh Kumar Jain. Simultaneous detection of potato viruses Yand X by DAC-ELISA using polyclonal antibodies raised against fused coat proteins expressed in *Escherichia coli.* Journal of Plant Biochemistry and Biotechnology. DOI 10.1007/s13562-013-0251-5 (Impact factor : 1.09).

2013

36. Navodit Goel, A.N. Sahi and P.K. Paul. Stage specific induction of systemic acquired resistance by fruit extracts of *Azadirachta indica*. Archieves of Phytopathology and Plant Protection . 47 (4) : 477 – 489. (Impact factor : 0.78)

37. Joyeeta Mitra, A.N. Sahi and P.K. Paul. Phylloplane microfungal metabolite influences activity of RuBisCO. Archieves of Phytopathology and Plant Protection. 47 (5) 584 - 590. (Impact factor 0.78).

38. Joyeeta Mitra, V. Bhuvaneshwari and P.K. Paul. Broad Spectrum Management of Plant Diseases by Phylloplane Microfungal Metabolites. Archieves of Phytopathology and Plant Protection. 46 (16) : 1993 – 2001. (Impact factor : 0.78)

39. Navodit Goel, A.N Sahi and P.K. Paul. Age as a factor in induction of Systemic acquired resistance in Tomato against bacterial speck by aqueous fruit extracts of *Azadirachta indica.* Archieves of Phytopathology and Plant Protection. 46 (14) : 1696-1706. (Impact factor : 0.78)

2012

40. V. Bhuvaneswari and P.K.Paul. Transcriptional and translational regulation of defence enzymes induced by neem fruit extract in tomato. Archieves of Phytopathology and Plant Protection . 45 (12) : 1374-1385. (Impact factor : 0.78)

41. V. Bhuvaneswari . A.K Srivastava and P.K Paul Aqueous fruit extracts of *Azadirachta indica* induces systemic acquired resistance in barley against *Drechslera graminea*. Archieves of Phytopathology and Plant Protection . 45 (8) :898-908. (Impact factor : 0.78)

2011

42. V. Bhuvaneswari and P.K. Paul .Involvement of protein kinases in induction of acidic isopolyphenol oxidases in cell walls of tomato by fruit extracts of *Azadirachta indica* Juss . Asian Journal of Biosciences 6(2): 232-237.

2002

43. P.K. Paul, and P.D. Sharma. *Azadirachta indica* leaf extract induces resistance in barley against leaf stripe disease. Physiological and molecular plant pathology, 61, 3-13. (Impact factor : 1.94)

2001

44. P.K .Paul, Devayani Muley and P.D. Sharma. Effect of the insecticide monocrotophos on hydrolytic enzymes of leaf litter fungi of tobacco.Indian journal of plant physiology, 6 (4), 342-347.

1998

45. P.D. Sharma and P.K. Paul. Recent tactics of biological control. In New trends in Mircobioal ecology, eds Bharat Rai and M.S. DKhar. Pp : 272-286.

1997

46. Devyani Muley, P.K. Paul and P.D. Sharma. Uredinial state of *Melampsora geniculatae* Ramachar and Bhagyanarayana. Journal of the Indian Botanical society, 76, 297-298.

1996

47. P.K.Paul and P.D.Sharma. Biocontrol of leaf stripe disease of barley conserving fungal biodiversity. Vasundhara 1, 19-24.

1995

48. Richi Garg, P.K. Paul and P.D. Sharma. Phylloplane mycoflora of mulberry in relation to leaf senescence. International journal of ecology and environmental sciences, 21, 97-102.

49. P.K. Paul, Vibaha varshney and P.D. Sharma. Monocrotophos induced changes in amino acid and monosaccharide contents of tobacco leaves. Indian journal of experimental biology, 33, 449-455. (Impact factor 0.75)

1993

50. P.K. Paul, Ritu Kapoor and P.D. Sharma. Effect of Monocil on phylloplane mycoflora of tobacco. International journal of ecology and environmental sciences, 19, 63-72.

1990

51. P.K. Paul, N.K. Saxena and P.D. Sharma. Mycoflora of tobacco leaves and tobacco products. International journal of ecology and environmental sciences, 16, 179-185.

List of Ph.D degree awarded / research under progress

1. Mrs. V.Bhuvaneshwari, 'Molecular events during induction of Systemic Acquired Resistance in *Lycopersicum esculentum* by plant extracts against *Pseudomonas syringae* pv. *tomato'*. **(Awarded 2012).**
2. Mr. Navodit Goel, 'Study of expression of genes involved in induction of systemic acquired resistancein *Lycoperscicum esculentum* by fruit extracts of *Azadirachta indica* against *Pseudomonas syringae* pv. *tomato'.* **(Awarded, 2014)**
3. Ms. Joyeeta Mitra, 'Studies on the effect of phylloplane microflora on chloroplast and mitochondria of *Hordeum vulgare* and *Lycopersicum esculentum*'. **(Awarded 2014)**
4. Ms. Reetika Kapoor, 'Production of broad spectrum immunodiagnostic reagents against plant viruses and development of lateral flow assay for their detection'. **(Awarded , 2014)**
5. Ms. Indu Gaur, 'A Molecular insight into the occurrence, colonization and interaction of Human enteric pathogens with *Lycopersicum esculentum*'. (**Awarded , 2018**)
6. Ms. Beenish, 'Leaf age correlation to phylloplane microbe-microbe and plant-microbe interactions on *Lycopersicum esculentum'.* (**Awarded, 2017**).

7. Ms Manjita Mishra, "Characterisation of fungal root endophytes isolated from extreme salt stress condition and their beneficial impact on *Pennisetum glaucum*" Co – Supervisor. (Supervisor – Prof. Ajit Varma). **(Awarded 2015).**

8. Ms Shilpi, "Molecular insight into cross-talk between phylloplane microflora and human enteric pathogens on leaf surface. **(Awarded 2020).**

9. Ms Sushmita Goswami. "Phylloplane microbes induced protein - protein and DNA - protein interactions influencing functioning of chloroplast. **(Ongoing).**

Conferences attended

2017

1. Shilpi and P.K. Paul . Interaction of human enteric pathogen with phylloplane of tomato and its molecular implication. (Poster). 58th International Conference of the Association of Microbiologists of India (AMI 2017), November 16 – 19, 2017. Lucknow, India.

2. Neha Bhaduria and P.K. Paul . Influence of Human Enteric Pathogens on Protein – Protein interactions in *Solanum lycoperscicum*. (Poster). 58th International Conference of the Association of Microbiologists of India (AMI 2017), November 16 – 19, 2017. Lucknow, India.

3. National seminar on identifying and avoiding publishing in predatory journals : A lesson for researchers. March, 18, 2017. Department of Botany, University of Delhi, Delhi -110007. India. Member, panel discussion.

2014

4. P.K Paul and V. Bhuvaneshwari . Molecular interactions in bio-elicitor induced SAR in tomato. 5th Asian Conference on Plant Pathology (ACPP 2014), November 3-6, 2014 . Chiang Mai, Thailand. Invited oral presentation.

5. Navodit Goel and P.K. Paul . Elicitor mediated defense response in tomato is age dependent . 5th Asian Conference on Plant Pathology (ACPP 2014), November 3 -6, 2014. Chiang Mai, Thailand. Poster presentation.

6. Indu Gaur and P.K Paul. Bacterial interactions in development of speck disease in tomato. 5th Asian Conference on Plant Pathology (ACPP 2014), November 3 -6, 2014. Chiang Mai, Thailand. Poster presentation .

7. S. Beenish and P.K Paul . Role of leaf age in phylloplane colonization by pathogens on *Lycopersicum esculentum*. 5th Asian Conference on Plant Pathology (ACPP 2014), November 3 -6, 2014. Chiang Mai, Thailand. Poster presentation.

2013

8. P.K Paul and Joyeeta Mitra . Phyllosphere microbes influence succinate dehydrogenase activity in mitochondria of tomato. APPS - 2013 (Australasian Plant Pathology Conference) 25-29, November 2013. Auckland, New Zealand. (Oral presentation). Complete financial support by DST, New Delhi.

9. Joyeeta Mitra and P.K Paul . Phyllosphere microbial influence on RuBisCO activity in *Hordeum vulgare*. APPS - 2013 (Australasian Plant Pathology Conference). 25-28, November 2013. Auckland, New Zealand. (Poster presentation).

10. Navodit Goel and P.K. Paul. Age – a factor in induction of defence responses in tomato. APPS – 2013 (Australasian Plant Pathology Conference) 25-28, November 2013. Auckland, New Zealand. (Poster presentation) .

2012

11. Bhuvaneshwari V, Paul PK Protein kinases are involved in inducing systemic acquired resistance by fruit extracts of *Azadirachta indica* A. Juss in *Lycopersicum esculentum*. International conference on "Perspectives in Phyllosphere biology" at Amity University Uttar Pradesh, (15-17February, 2012), Oral Presentation.

12. Nazia Khan, Bhuvaneshwari V, Paul PK Impact of epiphytic micro-fungal metabolites on DNA-protein interaction in mitochondria of *Lycopersicum esculentum*. International conference on "Perspectives in Phyllosphere biology" at Amity University Uttar Pradesh, (15-17February, 2012), Oral presentation.

13. Navodit Goel, Paul PK Application Of Aqueous Fruit Extracts Of *Azadirachta indica* On Phylloplane of *Lycopersicum esculentum* Induces Systemic Acquired Resistance Against *Pseudomonas syringae pv.* tomato. International conference on "Perspectives in Phyllosphere biology" at Amity University Uttar Pradesh, (15-17February, 2012), Poster presentation

14. Ritika Rampal, Bhuvaneshwari V, Paul PK Effect of metabolites of phylloplane microfungi on protein-protein interaction in cell membranes of *Glycine max.* International conference on "Perspectives in Phyllosphere biology" at Amity University, Uttar Pradesh (15-17 February, 2012), Poster presentation

15. Sania Bajaj, Bhuvaneshwari V, Paul PK Impact of epiphytic bacterial metabolites on DNA- protein interaction in mitochondrial genome of *Lycopersicum esculentum.* International conference on "Perspectives in Phyllosphere biology" at Amity University, Uttar Pradesh (15-17 February, 2012), Poster presentation

16. Sweta Sanguri, Bhuvaneshwari V, Paul PK Impact of metabolites of phyllosphere microfungi on DNA-protein interaction in chloroplast of tomato plant. International conference on "Perspectives in Phyllosphere biology" at Amity University, Uttar Pradesh (15-17 February, 2012), Poster presentation

17. Swati Singhal, Bhuvaneshwari V, Paul PK Effect of phylloplane bacterial metabolites on cell wall bound defense enzymes in relation with age of *Lycopersicum esculentum.* International conference on "Perspectives in Phyllosphere biology" at Amity University, Uttar Pradesh (15-17 February, 2012), Poster presentation

18. Joyeeta Mitra, Paul PK. Effect of the Phylloplane Microfungal Metabolites on RuBisCO of Chloroplasts of Barley and Tomato. International conference on "Perspectives in Phyllosphere biology" at Amity University, Uttar Pradesh (15-17 February, 2012), Poster presentation

2010

19. Bulbul Khare, Joyeeta Mitra, V. Bhuvaneswari and P.K. Paul. Phylloplane microfungal metabolites induce systemic acquired resistance in *Hordeum vulgare* var. *jagriti* against *Dreschlera graminea* . 9th International Symposium on microbial ecology of aerial plant surfaces. August 15-18, 2010, Oregon State University, Corvallis, Oregon, USA. (Oral Presentation).

20. Shweta Bhandwaj, Soundarya D., Summi Jeevan, V. Bhuvaneswari and P.K. Paul. Influence of phylloplane microflora metabolites on gene expression in chloroplasts of barley. 9th International Symposium on microbial ecology of aerial plant surfaces. August 15-18, 2010, Oregon State University, Corvallis, Oregon, USA. (Poster Presentation)

2009

21. V. Bhuvaneswari, Parul Tyagi, Sandeep Soni, Satyakam Pugla and P.K. Paul. Fruit extracts of *Azadirachta indica* induces systemic acquired resistance in tomato against P*seudomonas syringae* pv. tomato. APPS – 2009 – Plant Health management : an integrated approach. September 29-October Ist, 2009, New Castle, New South Wales, Australia (Oral presentation).

2008

22. P.K. Paul and V. Bhuvaneswari - Interaction of cell wall receptors of *Hordeum Vulgare* with leaf extracts of *Azadirachta indica* in control of *Dreschlera graminea.* International congress of plant pathology. August 24-29, 2008, Torino, Italy (Poster Presentation)

2005

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July 04 , 2021 **Dr. Prabir Kumar Paul**

Delhi , India .

Pertanika J. Trop. Agric. Sc. 42 (3): 1097 - 1110 (2019)

PERTANIKA

TROPICAL AGRICULTURAL SCIENCE

Journal homepage: http://www.pertanika.upm.edu.my/

Biofilm Formation and Survival of *Serratia fonticola*, *Klebsiella pneumoniae* and *Chryseobacterium jejuense* on Tomato Phylloplane

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ABSTRACT

Various human enteric pathogens have been isolated from surface of spinach, lettuce, sprouts, tomato, radish, berries etc. These microbes are not endemic to plant surface but they adapt and survive by mechanism(s) which are still unknown. This study was aimed to understand the colonization pattern of *Serratia fonticola*, *Klebsiella pneumoniae* and *Chryseobacterium jejuense* by leaf impression method on tomato plants raised under aseptic conditions. The biofilm forming ability of these bacteria were also studied. The study revealed that the population of these enteric pathogens were significantly high (89 CFU/cm^2) on phylloplane of tomato after 96 hours of incubation. Each of these microbes had a distinct colonization pattern and could successfully form biofilm. The study throws light on the ability of human enteric pathogens to colonize phylloplane possibly aided by their biofilm forming capability on leaf surface. The study is significant since it shall enhance understanding of association of human enteric pathogens with plants to design strategies for their survival.

Keywords: Biofilm, *Chryseobacterium jejuense*, colonization, cross talk, human enteric pathogen, *Klebsiella pneumoniae*, *Serratia fonticola*

ARTICLE INFO

Article history:
Received: 07 December 2018
Accepted: 11 July 2019
Published: 19 August 2019

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ISSN: 1511-3701
e-ISSN: 2231-8542

INTRODUCTION

Increasing number of food borne gastrointestinal outbreaks is a global concern. Consumption of fresh produce as a part of organic and healthy diet has been reported to be associated with gastrointestinal disorders (Brandl & Mandrell, 2002; Martínez-Vaz et al., 2014). Important sources of human

Journal of Plant Protection Research ISSN 1427-4345

ORIGINAL ARTICLE

Aspergillus niger, a dominant phylloplane coloniser, influences the activity of defense enzymes in *Solanum lycopersicum*

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DOI: 10.24425/jppr.2019.131265

Received: January 23, 2019
Accepted: June 18, 2019

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Abstract

Phylloplane microbes have been studied as strategic tools in management against plant pathogens. Non-pathogenic bacteria and fungi have been applied as crop protectants against various plant diseases. The present study aimed at evaluating the potentiality of *Aspergillus niger* spores in altering the activity of four key enzymes related to defense in tomato. The experiment was designed such that two groups of 50 tomato plants were considered: group 1 – sprayed with autoclaved distilled water (control) and group 2 – sprayed with *A. niger* spores. Spraying was carried out under aseptic conditions. The experimental parameters included analysis of the activity of peroxidase (POX), polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL) and tyrosine ammonia lyase (TAL) as well as expression of POX and PPO isoforms. The results demonstrated an inductive effect of *A. niger* on the activity of POX, PPO, PAL and TAL. Enhanced expression of POX and PPO isoforms was also observed. The results indicated that *A. niger* can be considered probiotic for the management of tomato against its phytopathogens.

Keywords: *Aspergillus niger*, phylloplane, peroxidase, phenylalanine ammonia lyase, polyphenol oxidase, *Solanum lycopersicum*, tyrosine ammonia lyase

Introduction

An array of microbes colonize plant surfaces. These have been reported to play an important role in plant growth and development, crop productivity, uptake and use of nutrients and resistance to abiotic stress (Windham *et al.* 1986). Phylloplane microorganisms are also known to play vital roles with respect to host plants as pathogens, natural antagonists to various detrimental organisms and as stimulating sources of plant growth (Blakeman 1991; Andrews 1992; Braga *et al.* 2009). A better wheat variety was seen to harbor better plant growth promoting phylloplane bacteria, thus playing a role in the superior yield of the host (Batool *et al.* 2016). Fungal endophytes and bacteria are important in facilitating foliar water uptake through stomata by decreasing leaf surface tension (Fernandez *et al.* 2017). A number of phylloplane microbes have been shown to profoundly impact the physiology of host plants. *Trichoderma* spp. have been found to induce the tolerance of plants against abiotic stress such as soil salinity, drought or flooding in plants (Zaidi *et al.* 2014). Epiphytic fungi have been reported to control foliar, root and fruit pathogens along with invertebrates like nematodes (Shoresh *et al.* 2010). The influence of phylloplane microbes on host plants defense has been very widely studied. Studies have revealed that phylloplane colonisers play significant roles in host defense thus inducing systemic acquired resistance. *Trichoderma harzianum* OTPB3 was found to be antagonistic against *Alternaria solani* and *Phytophthora infestans in vitro* and induced systemic resistance in tomato seedlings against early and late blight (Chowdappa *et al.* 2013). *Trichoderma viride* and *Pseudomonas fluorescens* could protect rose plants against *Diplocarpon rosae* due to enhanced activity of phenylalanine ammonia lyase,

South African Journal of Botany 124 (2019) 118–126

Contents lists available at ScienceDirect

South African Journal of Botany

journal homepage: www.elsevier.com/locate/sajb

Do phylloplane microfungi influence activity of Rubisco and Carbonic anhydrase

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ARTICLE INFO

Article history:
Received 7 July 2018
Received in revised form 8 April 2019
Accepted 27 April 2019
Available online xxxx

Edited by J Van Staden

Keywords:
Carbonic anhydrase
Chloroplasts
Phylloplane microfungi
Rubisco

ABSTRACT

Ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco; EC 4.1.1.39) and Carbonic anhydrase (EC 4.2.1.1) are key enzymes of photosynthesis in plants. Microfungi colonizing leaf surface are known to affect photosynthesis but their influence on chloroplast physiology is not well understood. The present study aimed at possible effect of phylloplane microbes on activity of two key enzymes in chloroplast. The activity of Rubisco and Carbonic anhydrase was estimated in aseptically raised tomato and barley plants treated with metabolites of *Fusarium oxysporum* and *Aspergillus niger* which were dominant phylloplane microfungi. The activity of Carbonic anhydrase and Rubisco was significantly enhanced on application of fungal metabolites, either singly or in combination. Both the metabolites could significantly increase the activity of Rubisco and Carbonic anhydrase within 72 h of treatment in both tomato and barley. The effect was more pronounced when the fungal metabolites were sprayed in combination, thereby indicating their cumulative positive effect on the plants. However, the metabolite effect was reduced if the plants were pre-infected with their respective pathogens. The study highlights the critical relationship of phylloplane microflora with functioning of these two chloroplast enzymes in higher plants. The application of these metabolites, either singly or in combination in the host plants demonstrated a positive correlation between rubisco and carbonic anhydrase.

1. Introduction

Ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) plays a crucial role in net photosynthetic carbamylation by the addition of a CO_2 molecule to an amino group of a lysine located in its active site (Lorimer et al., 1976; Cleland et al., 1998). Carbonic anhydrase catalyzes the interconversion of CO_2 and HCO_3^- in plants and is involved in hydration of CO_2 to bicarbonate (Hatch and Burnell, 1990; Hewett-Emmett and Tashian, 1996). Respiration and photorespiration produce dissolved inorganic carbon in the form of CO_2, whereas many β-carboxylases like phosphoenolpyruvate carboxylase and pyruvate carboxylase require HCO_3^-. Thus, if the uncatalyzed rate of CO_2 conversion to HCO_3^- is not sufficiently high, enzymatic hydration of CO_2 to HCO_3^- is catalyzed by Carbonic anhydrase (Giordano et al., 2003). Makino et al. (1992) observed that there was an increase in activity of Carbonic anhydrase and Rubisco in rice, pea, spinach, and bean plants with increase of leaf nitrogen.

Phylloplane microflora has been reported to play crucial role in plant productivity, ecosystem functioning and protection. Plant-associated microbiome has been reported to increase resource uptake and provide novel nutritional and defense pathways to the host plant (Berg et al., 2004). Phylloplane fungal species have been shown to aid in plant growth and development, crop productivity, resistance to abiotic stresses and the uptake and use of nutrients (Windham et al., 1986). Earlier studies by Mitra et al. (2014, 2016) demonstrated that phylloplane microbial metabolites could induce Rubisco activity in tomato plants.

The phylloplane microbes occupying the leaf surface exhibit a close functional relationship with the host plant. Therefore, it is pertinent to study the influence of metabolites from phylloplane microbes on functioning of chloroplasts since any alteration in CO_2 fixation may affect carbohydrate metabolism. Two different plant species were selected for the study, one representative each from monocotyledons and dicotyledons. Tomato and barley were considered since they cover maximum area under cultivation in vegetables and cereals respectively (Stewart and Shepherd, 2003; Vasanthan and Hoover, 2009). Phylloplane fungi common to phylloplane of barley and tomato were selected for the study. The experimental age of the plant having optimal microbial colonization and plant–microbe interaction was determined from previous studies in the laboratory on the same variety of tomato and

Abbreviations: L/D, Light/Dark; OD, optical density; SA, Salicylic acid; YME, Yeast Malt Extract.

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https://doi.org/10.1016/j.sajb.2019.04.033
0254-6299/

P.K Paul
21/7/19

Interdiscip Sci Comput Life Sci
DOI 10.1007/s12539-015-0105-z

ORIGINAL RESEARCH ARTICLE

In silico Identification of Ergosterol as a Novel Fungal Metabolite Enhancing RuBisCO Activity in *Lycopersicum esculentum*

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Received: 24 November 2014 / Revised: 2 July 2015 / Accepted: 7 July 2015

Abstract RuBisCO (EC 4.1.1.39), a key enzyme found in stroma of chloroplast, is important for fixing atmospheric CO_2 in plants. Alterations in the activity of RuBisCO could influence photosynthetic yield. Therefore, to understand the activity of the protein, knowledge about its structure is pertinent. Though the structure of *Nicotiana* RuBisCO has been modeled, the structure of tomato RuBisCO is still unknown. RuBisCO extracted from chloroplasts of tomato leaves was subjected to MALDI-TOF–TOF followed by Mascot Search. The protein sequence based on gene identification numbers was subjected to in silico model construction, characterization and docking studies. The primary structure analysis revealed that protein was stable, neutral, hydrophilic and has an acidic pI. The result though indicates a 90 % homology with other members of Solanaceae but differs from the structure of *Arabidopsis* RuBisCO. Different ligands were docked to assess the activity of RuBisCO against these metabolite components. Out of the number of modulators tested, ergosterol had the maximum affinity ($E = -248.08$) with RuBisCO. Ergosterol is a major cell wall component of fungi and has not been reported to be naturally found in plants. It is a known immune elicitor in plants. The current study throws light on its role in affecting RuBisCO activity in plants, thereby bringing changes in the photosynthetic rate.

Keywords Docking · Ergosterol · MALDI-TOF–TOF · Modeling · RuBisCO · Tomato

1 Introduction

Chloroplasts aid in capturing and converting light energy to chemical energy through photosynthesis to form carbohydrates essential for plant survival. Ribulose-1,5-bisphosphate (RuBP) carboxylase/oxygenase (RuBisCO; EC 4.1.1.39), a primary carboxylating enzyme found in stromal fractions of chloroplasts, catalyzes the first step in net photosynthetic CO_2 assimilation. RuBisCO holoenzyme consists of eight large subunits (LSUs) and eight small subunits (SSUs) [1]. The SSU is imported from the cytosol, and both subunits undergo several posttranslational modifications before assembly into functional holoenzyme [2].

The carboxylase activity of RuBisCO (EC 4.1.1.39) generates carbohydrate moieties essential for sugar synthesis through Calvin cycle [3, 4]. The properties of effectiveness and specificity of RuBisCO determine the photosynthetic efficiency and the productivity of plants [5]. Biochemists have worked extensively on the catalytic mechanism and regulation of the protein [6], which is influenced by age of the plant. Imai et al. [7] studied changes in the RuBisCO content at different leaf ages and observed high RuBisCO levels in young leaves than in mature leaves.

RuBisCO has been the focus for a number of studies, but the structure of RuBisCO in tomato is still an enigma. The bioinformatics tools provide an excellent method to characterize the physicochemical properties of the protein. In silico approach was aimed at understanding the complexities of the structure of the large and small subunits (LSU and SSU, respectively) of tomato RuBisCO. The absence of an experimental structural data advocates the necessity of 3D

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Published online: 08 August 2015

DOI: 10.1007/s11099-016-0211-0 PHOTOSYNTHETICA 54 (4): 517-523, 2016

In silico, *in vitro* and *in vivo* approach in understanding the functional relationship between ergosterol and Rubisco

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Abstract

Ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco; EC 4.1.1.39) is one of the key enzymes involved in assimilation of CO_2 in chloroplasts. Phylloplane microfungi and their metabolites have been reported to affect the physiology of host plants, particularly, their photosynthesis. However, information is lacking on the effect of these microflora on the physiology of chloroplasts. The current study emphasized the impact of two dominant phylloplane fungi, *Aspergillus niger* and *Fusarium oxysporum*, on activity of Rubisco in tomato chloroplasts. Ergosterol, which is a component of only fungal cell membranes and is not synthesized by plants, have been demonstrated to elicit activity of Rubisco. In the present study, it was demonstrated through *in silico*, *in vitro*, and *in vivo* approaches. Results demonstrated that the fungal metabolites, which contained ergosterol, could double Rubisco activity. Maximum carboxylation rate of Rubisco increased also in ergosterol-treated plants. Michaelis-Menten constant of Rubisco was also slightly affected. Ergosterol was found also to influence and enhance the binding of CO_2 and ribulose-1,5-bisphosphate to Rubisco. Therefore we can postulate that the physiology of the chloroplast is probably influenced by phylloplane microfungi.

Additional key words: enzyme activity; ergosterol; phylloplane; Rubisco; tomato.

Introduction

Chloroplasts harbour an important protein, ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco) which catalyzes the first step in photosynthetic assimilation of CO_2. Light modulation in plants is dependent on redox regulation of the larger isoform of Rubisco (Zhang *et al.* 2002). The carboxylase activity of Rubisco (EC 4.1.1.39) generates carbohydrate moieties essential for sugar synthesis through the Calvin cycle (Portis Jr. 1992, Meenakshi and Srisudha 2012).

Phylloplane microbes have been reported to support plant growth and development (Compant *et al.* 2005). Ergosterol, a key component of fungal cell membranes, is often found to be one of the common entities of the metabolite composition. Ergosterol is of fungal origin (Weete *et al.* 2010) and has not been reported till date to be produced by plants. Ergosterol has been reported to act as plant defense elicitors (Boller 1995, Felix *et al.* 1999). Kauss and Jeblick (1996) demonstrated that plant cells could perceive ergosterol which could elicit H_2O_2 production in the host plant. However, no data is available on the effect of ergosterol on chloroplast functioning. How these microbes or their metabolites influence plant physiology, particularly that of chloroplasts, is still an enigma. The present investigation could help understand the effect of phylloplane microfungal metabolite and ergosterol on the activity of Rubisco, which can be crucial in overall photosynthetic yield.

Materials and methods

Plant: *Solanum lycopersicum* plants were raised in plastic trays (25 cm × 24 cm × 6 cm) in sterile artificial soil under aseptic conditions at 25 ± 1°C, relative humidity of 70%, and 12 h (light/dark) photoperiod. Ten-week-old tomato plants were used for the study.

Received 20 July 2015, *accepted* 8 February 2016, *published as online-first* 1 March 2016.
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Abbreviations: K_m – Michaelis-Menten constant; LSU – large subunit; OD – optical density; RuBP – ribulose-1,5-bisphosphate; SSU – small subunit; YME – yeast malt extract; V_{max} – maximum carboxylation rate.
Acknowledgements: The authors express their sincere thanks to Amity Institute of Biotechnology, Amity University Uttar Pradesh, NOIDA, India for providing the necessary infrastructural facilities and DST-INSPIRE, India for providing Senior Research Fellowship to the first author.

P.K Paul 21/7/19