Tulasi Satyanarayana
Sunil K. Deshmukh
B. N. Johri *Editors*

Developments in Fungal Biology and Applied Mycology

Springer

Developments in Fungal Biology and Applied Mycology

Tulasi Satyanarayana
Sunil K. Deshmukh · B. N. Johri
Editors

Developments in Fungal Biology and Applied Mycology

Springer

Editors
Tulasi Satyanarayana
Biological Sciences and Engineering
Netaji Subhas Institute of Technology
(University of Delhi)
New Delhi
India

B. N. Johri
Department of Biotechnology
Barkatullah University
Bhopal, Madhya Pradesh
India

Sunil K. Deshmukh
TERI-Deakin Nano-Biotechnology Centre
The Energy and Resources Institute (TERI)
New Delhi
India

ISBN 978-981-10-4767-1 ISBN 978-981-10-4768-8 (eBook)
https://doi.org/10.1007/978-981-10-4768-8

Library of Congress Control Number: 2017958608

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

To late Prof. S. B. Saxena, whose birth centenary has been celebrated during 2016–2017

Preface

Fungal biology deals with the study of fungi, including their growth and development, their genetic and biochemical characteristics, their taxonomy and genomics, and their use to humans. The current research focuses on mushrooms which may have hypoglycemic activity, anticancer activity, anti-pathogenic activity, and immune system-enhancing activity. A recent research has found that the oyster mushroom naturally contains the cholesterol-lowering drug, lovastatin, that mushrooms produce large amounts of vitamin D when exposed to UV light, and that certain fungi may be a future source of taxol. To date, penicillin, lovastatin, cyclosporine, griseofulvin, cephalosporin, ergometrine, and statins are the most famous pharmaceuticals which have been isolated from fungi.

Fungi are fundamental for life on earth in their roles as symbionts (e.g., in the form of mycorrhizae, insect symbionts, and lichens). Many fungi are able to break down complex organic biomolecules such as lignin, and pollutants such as xenobiotics, petroleum, and polycyclic aromatic hydrocarbons. By decomposing these molecules, fungi play a critical role in the global carbon cycle.

The kingdom fungi encompasses an enormous diversity of taxa with varied ecologies, life cycle strategies, and morphologies ranging from unicellular aquatic chytrids to large mushrooms. Little is, however, known about their true biodiversity, which has been estimated at 1.5 to 5 million species, with about 5% of these having been formally classified. Advances in molecular genetics have opened the way for DNA analysis to be incorporated into taxonomy, which has sometimes challenged the historical groupings based on morphology and other traits. Phylogenetic studies published in the last decade have helped reshape the classification within kingdom fungi, which is divided into one subkingdom, seven phyla, and ten subphyla.

The human use of fungi for food preparation or preservation and other purposes is extensive and has a long history. Mushroom farming and mushroom gathering are large industries in many countries. The study of the historical uses and sociological impact of fungi is known as ethnomycology. Because of the capacity of this group to produce an enormous range of natural products with antimicrobial or other biological activities, many species have long been used or are being developed for industrial production of antibiotics, vitamins, and anticancer and cholesterol-lowering drugs. More recently, methods have been developed for

genetic engineering of fungi, enabling metabolic engineering of fungal species. For example, genetic modification of yeast species, which are easy to grow at fast rates in large fermentation vessels, has opened the way for pharmaceutical production that are potentially more efficient than production by the original source organisms.

Several pivotal discoveries in biology have been made by researchers using fungi as model organisms, which grow and sexually reproduce rapidly in the laboratory. For example, the one gene–one enzyme hypothesis was formulated by scientists using the bread mold *Neurospora crassa* to test their biochemical theories. Other important model fungi are *Aspergillus nidulans* and the yeasts *Saccharomyces cerevisiae* and *Schizosaccharomyces pombe*, each with a long history of use to investigate issues in eukaryotic cell biology and genetics, such as cell cycle regulation, chromatin structure, and gene regulation. Other fungal models have more recently emerged that address specific biological questions relevant to medicine, plant pathology, and industrial uses; examples include *Candida albicans*, a dimorphic, opportunistic human pathogen; *Magnaporthe grisea*, a plant pathogen; and *Pichia pastoris*, a yeast widely used for eukaryotic protein production. Fungi are used extensively to produce industrial chemicals such as citric, gluconic, lactic, and malic acids, and industrial enzymes such as lipases used in biological detergents, cellulases used for making cellulosic ethanol and stonewashed jeans, and amylases, invertases, proteases, and xylanases. Several fungi such as *Psilocybe* mushrooms (colloquially known as magic mushrooms) are ingested for their psychedelic properties, both recreationally and religiously.

We are grateful to Prof. G. P. Mishra, Prof. R. S. Mehrotra, and Dr. Shashi Rai for their constant encouragement in bringing out this book on the occasion of the birth centenary of late Prof. S. B. Saksena.

The book is an attempt in collating recent developments in fungi from various environments: their diversity and potential applications. We greatly appreciate the efforts of experts in contributing on various aspects of fungi. The opinions expressed by the authors are their own. We wish to thank all the contributors for readily accepting our invitation and Springer for publishing the book.

New Delhi, India — Tulasi Satyanarayana
New Delhi, India — Sunil K. Deshmukh
Bhopal, India — B. N. Johri

Contents

Editors and Contributors

About the Editors

Prof. Tulasi Satyanarayana became a faculty fellow at the Division of Biological Sciences and Engineering, Netaji Subhas Institute of Technology (affiliated to the University of Delhi), New Delhi, after retiring from Department of Microbiology, University of Delhi South Campus, New Delhi, in 2016. He has over 270 scientific papers and reviews, six edited books, and three patent to his credit. He is a fellow of the National Academy of Agricultural Sciences (NAAS), the Association of Microbiologists of India (AMI), the Biotech Research Society (I), and the Mycological Society of India (MSI). He has 40 years of research and teaching experience and was the president of the AMI and MSI. His research has focused on understanding the diversity and applications of yeasts, thermophilic fungi, and bacteria and their enzymes as well as carbon sequestration using extremophilic bacterial carbonic anhydrases.

Dr. Sunil K. Deshmukh is a fellow and area convenor at the Nano-Biotechnology Research Centre, The Energy and Resources Institute (TERI), New Delhi. He was an assistant director (natural products) at Piramal Enterprises Ltd., Mumbai. He has broad industrial experience in the field of applied microbiology. He is now the president of the Mycological Society of India. He has 100 publications and eight patent to his credit. He has also edited seven books.

Dr. B. N. Johri is a professor and NASI senior scientist at the Department of Biotechnology, Barkatullah University, India. He has been the recipient of many academic awards, including the Indian National Science Academy's Young Scientist Medal, Rafi Ahmad Kidwai Memorial Award, and Acharya PC Ray Fellowship (MPCST). He is a fellow of the National Academy of Sciences (I), National Academy of Agricultural Sciences, and National Institute of Ecology. He has extensive teaching and research experience and has 148 research publications and three edited books to his credit.

Contributors

Alok Adholeya Biotechnology & Bioresources Division, Centre for Mycorrhizal Research, The Energy & Resources Institute (TERI), New Delhi, India

Ashok Aggarwal Department of Botany, Kurukshetra University, Kurukshetra, India

A. Aneja University Health Center, Kurukshetra University, Kurukshetra, Haryana, India

K. R. Aneja Formerly at Department of Microbiology, Kurukshetra University, Kurukshetra, Haryana, India

N. S. Atri Department of Botany, Punjabi University, Patiala, Punjab, India

Sunil K. Deshmukh TERI-Deakin Nano Biotechnology Centre, The Energy and Resources Institute (TERI), New Delhi, India

M. V. Deshpande Biochemical Sciences Division, CSIR-National Chemical Laboratory, Pashan, Pune, India

Sunny Dhiman University Institute of Biotechnology, Chandigarh University, Mohali, Punjab, India

Satyendra Kumar Garg Department of Microbiology, Centre of Excellence, Dr. Ram Manohar Lohia Avadh University, Faizabad, India

Pooja Ghosh Centre for Rural Development and Technology, Indian Institute of Technology, New Delhi, India

Bhoopander Giri Department of Botany, Swami Shraddhanand College, University of Delhi, Delhi, India

Surendra K. Gond Botany Section, MMV, Banaras Hindu University, Varanasi, India

Ashwini Jadhav School of Life Sciences, S.R.T.M. University, Nanded, MH, India

Vaneet Jishtu Himalayan Forest Research Institute Conifer Campus, Panthaghati, Shimla, H.P, India

B. N. Johri Department of Biotechnology, Barkatullah University, Bhopal, Madhya Pradesh, India

Swati Joshi School of Life Sciences, Central University of Gujarat, Gandhinagar, India

D. N. Kamra ICAR National Professorial Chair, Animal Nutrition Division, Indian Veterinary Research Institute, Izatnagar, India

Naveen Kango Department of Microbiology, Dr. Harisingh Gour Vishwavidyalaya, Sagar, MP, India

Sankunny Mohan Karuppayil School of Life Sciences, S.R.T.M. University, Nanded, MH, India

Gurdeep Kaur Department of Agricultural Sciences, Chandigarh University, Gharuan, Mohali, Punjab, India

Munruchi Kaur Department of Botany, Punjabi University, Patiala, Punjab, India

S. A. Khan Department of Biotechnology and Microbiology, Bhagwati College of Management and Technology, Meerut, India

Ravindra N. Kharwar Department of Botany, Banaras Hindu University, Varanasi, India

Ankit Kumar Biotechnology & Bioresources Division, Centre for Mycorrhizal Research, The Energy & Resources Institute (TERI), New Delhi, India

Anu Kumar University Institute of Biotechnology, Chandigarh University, Mohali, Punjab, India

Anuj Kumar Departments of Botany, Buddha PG College, Kushinagar, India

Jitendra Kumar Centre of Advanced Study in Botany, Banaras Hindu University, Varanasi, India

Sunil Kumar Department of Biosciences, Himachal Pradesh University, Shimla, H.P, India

R. K. S. Kushwaha Department of Botany, Shri Shakti College, Ghatampur, Kanpur, India

T. N. Lakhanpal Department of Biosciences, Himachal Pradesh University, Shimla, H.P, India

C. Manoharachary Department of Botany, Osmania University, Hyderabad, Telangana, India

Annapurna Maurya Department of Microbiology, Centre of Excellence, Dr. Ram Manohar Lohia Avadh University, Faizabad, India

R. S. Mehrotra Kurukshetra University, Kurukshetra, India

Ashish Mishra Centre of Advanced Study in Botany, Banaras Hindu University, Varanasi, India

Tulika Mishra Department of Biotechnology, Chandigarh University, Mohali, Punjab, India

Gunjan Mukherjee University Institute of Biotechnology, Chandigarh University, Mohali, Punjab, India

Papiya Mukherjee Department of Botany, Panjab University, Chandigarh, India

Skarma Nonzom Department of Botany, University of Jammu, Jammu, India

E. K. Pathan Biochemical Sciences Division, CSIR-National Chemical Laboratory, Pashan, Pune, India

Anjul Rana Department of Microbiology, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Hemant Kumar Rawat Department of Microbiology, Dr. Harisingh Gour Vishwavidyalaya, Sagar, MP, India

Manvika Sahgal Department of Microbiology, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Tulasi Satyanarayana Biological Sciences and Engineering, Netaji Subhas Institute of Technology (University of Delhi), Dwarka, New Delhi, India

Krishna Kant Sharma Laboratory of Enzymology and Recombinant DNA Technology, Department of Microbiology, Maharshi Dayanand University, Rohtak, Haryana, India

Samidha Sharma Department of Botany, Arya College Ludhiana, Ludhiana, Punjab, India

Vijay K. Sharma Centre of Advanced Study in Botany, Banaras Hindu University, Varanasi, India

Kamlesh Shukla School of Studies in Biotechnology, Pt. Ravishankar Shukla University, Raipur, Chhattisgarh, India

R. V. Shukla Department of Botany, C.M.D. College Bilaspur, Bilaspur, Chhattisgarh, India

M. R. Siddiqui Division of Seed Science & Technology, IARI, New Delhi, India

Birbal Singh Indian Veterinary Research Institute, Regional Station, Palampur, Himachal Pradesh, India

Dheeraj K. Singh Centre of Advanced Study in Botany, Banaras Hindu University, Varanasi, India

Itisha Singh Department of Microbiology, Saaii College Medical Sciences and Technology, Chobepur, Kanpur, India

Reena Singh Biotechnology & Bioresources Division, Centre for Mycorrhizal Research, The Energy & Resources Institute (TERI), New Delhi, India

Sanjay K. Singh National Fungal Culture Collection of India, Biodiversity and Palaeobiology Group, MACS' Agharkar Research Institute, Pune, India

Hemant Soni Department of Microbiology, Dr. Harisingh Gour Vishwavidyalaya, Sagar, MP, India

K. R. Sridhar Department of Biosciences, Mangalore University, Mangalore, Karnataka, India

M. Sudhakara Reddy Department of Biotechnology, Thapar University, Patiala, Punjab, India

Geeta Sumbali Department of Botany, University of Jammu, Jammu, India

Akira Suzuki Department of Natural Sciences, Faculty of Knowledge Engineering, Tokyo City University, Setagaya-ku, Tokyo, Japan

Indu Shekhar Thakur School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, India

J. S. Thakur Govt. College Banjar, Kullu, H.P, India

T. S. Thind Department of Plant Pathology, Punjab Agricultural University, Ludhiana, India

Manikant Tripathi Department of Microbiology, Centre of Excellence, Dr. Ram Manohar Lohia Avadh University, Faizabad, India

S. G. Tupe Biochemical Sciences Division, CSIR-National Chemical Laboratory, Pashan, Pune, India

Shilpa A. Verekar Mérieux NutriSciences, Mahape, Navi Mumbai, Maharashtra, India

Satish K. Verma Centre of Advanced Study in Botany, Banaras Hindu University, Varanasi, India

Tuhina Verma Department of Microbiology, Centre of Excellence, Dr. Ram Manohar Lohia Avadh University, Faizabad, India

Significant Contributions of Prof. S.B. Saksena to Indian Mycology

1

R. S. Mehrotra, M. R. Siddiqui and Ashok Aggarwal

Abstract

Late Prof. S.B. Saksena was born on 10th Aug. 1917, therefore, his birth centenary has been celebrated during Aug. 10, 2016–Aug. 10, 2017. On this occasion, his students and associates fondly remembered his endearing qualities, commitment to teaching and research, and significant contributions to Indian mycology. A brief account of his life and achievements are discussed.

Keywords

Prof. Saksena · *Saksenaea vasiformis* · *Gliocladiopsis sagariensis*
Zygomycosis Soil fungi · *Trichoderma viride*

Let us first thank the organizers of the Centenary Celebration Committee of the birth of the celebrated botanist, late Professor Shyam Bahadur Saksena, as 2016–2017 mark the centennial year of the birth of late Professor Saksena. It is a measure

R. S. Mehrotra
Formerly of the Kurukshetra University, Kurukshetra 136119, India

Present Address:
R. S. Mehrotra
263/7, Urban Estate, Kurukshetra 136118, India

M. R. Siddiqui
Formerly of the Division of Seed Science & Technology, IARI, New Delhi, India

Present Address:
M. R. Siddiqui
727, Krishi Apartment, D Block, Vikas Puri, New Delhi 110018, India

A. Aggarwal (✉)
Department of Botany, Kurukshetra University, Kurukshetra 136119, India
e-mail: ashokbotanykuk@gmail.com

T. Satyanarayana et al. (eds.), *Developments in Fungal Biology and Applied Mycology*, https://doi.org/10.1007/978-981-10-4768-8_1

of scholarly stature, breadth of learning and his human nature that the former students, colleagues, friends and well-wishers have decided to celebrate the centenary of the birth of Professor Saksena. We at the outset state that we feel privileged to write about the life and work of late Professor Saksena. Not only Professor Saksena was an eminent mycologist of international stature but was equally good as an ecologist especially with regard to the soil microorganisms, especially fungi. Late Professor S.D. Garrett, FRS of the Botany School Cambridge, wrote in the Festschrift Volume in the year 1980 (Garrett 1980), and we thought nothing can give better appreciation of the scholarly achievements of late Professor Saksena than the quotation which was given in the INSA Memoir Volume 17. Professor Garrett wrote, "It is a privilege to have been invited to contribute to the Festschrift Volume of essays assembled in honour of Prof. Saksena in recognition of his international standing as a mycologist. The writing of this article has been a pleasure for me, because for many years Prof. Saksena and I have shared an interest in soil fungi, including pathogenic root-infecting fungi. This is why he was an honoured guest, for the academic year 1958–1959, in our sub-department of Mycology and Plant Pathology at the Cambridge Botany School. Unlike me, however, Professor Saksena has the further distinction of being an internationally known authority on the taxonomy of soil fungi, to which he has added several new genera and species. This taxonomic competence was an essential ingredient of his distinguished early studies on the synecology of the Indian soil mycoflora".

In 1950s University of Saugar, Sagar had one of the finest faculty of teachers headed by Prof. R. Misra an outstanding ecologist of the country, Dr. Shyam Bahadur Saksena an eminent mycologist, Dr. T.V. Deshikachary an eminent phycologist of the country, Dr. Y. Sundar Rao, an eminent cytogeneticist, Dr. L.P. Mall an eminent autecologist and Dr. Y.D. Tiagi an eminent morphologists of the country.

But before we write anything further about the scientific achievements of Professor Saksena, we would prefer to write about his early years. Shyam Bahadur Saksena was born on 10, August, 1917 at Jabalpur (M.P.) in a middle class family. He lost his mother at the age of eight years. His father, late Munshi Ram Gulam Saksena, was at that time in the Excise department of the old province of C.P., and Berar. Shyam Bahadur was sent to Gwalior for his education under the care of his sister who was nearly 20 years elder to him. He completed his primary and secondary education in the municipal school at Lashkar (Gwalior). It is said that as a young boy he was very much attracted towards zoos and botanical gardens. The headmaster of his school had a very long-lasting influence on his personality. It is also said that young Saksena took interest in the ongoing national movement for independence. This made him quite bold, assertive and confident in his statements, and this trend continued in his future life. Shyam Bahadur joined Victoria College, Gwalior, for his intermediate and B.Sc. examinations. In intermediate he got second division, but in his B.Sc. Examination he secured first division and first position in the Biology Group of the College. It was under Agra University that he took his B.Sc. degree from Victoria College in the year 1937. Because of his brilliance, his family members and well-wishers of the family including his teachers advised him to join Agra College, Agra, for his M.Sc. degree in Botany. Shyam Bahadur did his

M.Sc. under the care of renowned Botanist Late Professor K.C. Mehta, FNA of Agra College, Agra. He passed M.Sc. examination with first division and with first position in the University (Agra University). After passing his M.Sc. examination, he joined the department of Agriculture of Gwalior State in 1939 as a research botanist. He was married to Smt. Sarla Saksena of Gwalior State. Shyam Bahadur Saksena joined the Dept. of Botany of the University of Saugar, Sagar in the year 1948. It is here that he came in close contact with Professor R. Misra an eminent ecologist of the country who laid the firm foundation for research and teaching at Sagar. As a young lecturer in Botany, Shyam Bahadur was encouraged to get registered for the Ph.D. degree of the University of Sagar under the external guidance of Late Professor Ram Kumar Saksena of Allahabad University, Allahabad. He did his work on the ecology, morphology and taxonomy of the fungi of local forest soils and which became a classical work. Dr. Saksena selected the study area for his Ph.D. work, a part of the forests neighbouring the Sagar town on the eastern side which is known as Patharia Forest. Initially when the Saugar University was founded by Late Sir Hari Singh Gour, the old university site was situated near a village Makronia, a few kilometres away from the main town, but now the university campus is situated on a hillock very near to the Patharia Forest. Patharia forest site for Ph.D. study was selected because of a number of interesting features discernible in a small area from the point of view of geology, topography, soil types and the variety of fungal flora. This forest was previously studied by Misra and Joshi in 1952 with respect to higher vegetation (Misra and Joshi 1952). They (Misra and Joshi) collected and studied general data on climate, soil characteristics, physiographic and biotic communities recognized by them.

After Dr. R. Misra left Sagar in the year 1955 as Professor of Botany, Bananas Hindu University, Varanasi, Dr. Saksena took over as Reader and Head of the Department. Dr. Saksena was elevated to the position of Professor in the year 1963. He remained Professor and Head of the department for nearly 15 years and finally retired from the University of Saugar, Sagar in the year 1977. He, however, continued as visiting Professor at Sagar for one more year and then joined Jiwaji University, Gwalior, for four years as Principal Investigator of the UGC Project entitled "Fungi of Madhya Pradesh". Thus, Saksena stayed in Sagar for about 30 years. Professor Saksena produced around 35 Ph.D. students including one from Ravi Shankar University, Raipur. The process continued to produce three more students from Jiwaji University, Gwalior. A list of his Ph.D. students is given in Table 1.1. His first Ph.D. student was Dr. M.R. Siddiqui, who did excellent monographic work on the genus *Alternaria* in India and it is due to the efforts of Dr. Siddiqui, the Department of Botany got built a fully air-conditioned Glass House with temperature and humidity control. Dr. Siddique is the oldest student of Professor Saksena and is residing in New Delhi after retirement as Professor and Project Coordinator in the Division of Seed Science and Technology, Indian Agriculture Research Institute, New Delhi. Reverting back to Professor Shyam Bahadur Saksena's Ph.D. work, it may be said that Dr. Saksena used the phytosociological methods used for vegetational analysis of higher plants towards the study of determination of frequency, abundance and total number of fungi in the

Table 1.1 List of Ph.D. thesis which have been completed under the guidance of Prof. S.B. Saksena

1.	M.R. Siddiqui	1960	Taxonomy and pathogenicity of genus *Alternaria* with special reference to Indian species
2.	R.S. Mehrotra	1961	Studies on soil fungi from *Piper betle* orchards with special reference to the diseases caused by *Phytophthora parasitica* var. *piperina* Dastur and their control
3.	K. Lily (Ku.)	1961	Ecological studies on soil fungi with special reference to the ecology of *Trichoderma viride* Pres. ex. Fries
4.	V.R. Ghurde	1962	Studies on foot-rot disease of wheat in Saugor
5.	P.K. Shetye	1962	Studies in soil fungi: seasonal variation in fungal flora of Vindhyan sand stone and basaltic soils of Sagar
6	A. Thammayya	1964	Ecological studies on soil microorganisms with special reference to their antibiotic activities
7.	G.V. Thampi	1964	Studies on the Fusaria of Sagar with special reference to their taxonomy, pathogenicity and interaction with other microorganisms
8	O.P. Mall	1965	Wilt disease of coriander with special reference to the rhizosphere studies
9	A.S. Saxena	1967	Studies on soil microorganisms with special reference to Actinomycetes and their antibiotic products against soil borne pathogens
10.	Sudha Srivastava (Ku.)	1967	Studies on rhizosphere flora of Potato with view of investigating its relationship with some soil borne diseases (*Rhizoctonia solani* and *Fusarium* spp.)
11.	S.S. Singh	1967	Taxonomical and ecological studies on soil fungi of Chhatarpur
12.	B.S. Somal	1968	Studies on *Helminthosporium* and *Curvularia*
13.	S.C. Aggarwal	1969	Studies on litter fungi of Saugar with special reference to cellulolytic forms
14.	H.N. Satya	1970	Studies on taxonomy and pathogenicity of genus *Pestalotia*
15.	S.S. Ali	1970	A study on post-harvest fruit rot of Musambi (*Citrus sinensis* Linn.) caused by *Rhizoctonia* sp.
16	Manjit Kaur Randhawa (Ku.)	1970	Studies on root nodule bacteria of Sagar soil
17.	Shashi Prabha Singh (Ku.)	1970	Studies on Indian Penicillia with special reference to their antibiotic products.
18	P.K. Rai	1971	Studies on soft rots of Papaya (*Caica papaya* L.) with special reference to the physiological and biochemical aspects
19	Shashi Rai Mrs.	1971	Studies on pathogenesis by *Colletotrichum capsici* (Syd) Butler and Bisby causing fruit rot of chillies (*Capsicum annum* L.)
20.	K.M. Vayas	1971	Studies on ecology and physiology of microorganisms with respect to a soil borne plant disease
21.	Miss. K. Singhai	1973	The phenomenon of soil fungistasis and study of certain aspects.

(continued)

Table 1.1 (continued)

22.	Mrs. M. Choudhari	1973	Study on fungal metabolites with special reference to plant growth regulators produced by some fungi
23	M.C. Kanchan	1973	Studies on soil mciroorganisms with special reference to Bhindi
24.	A.D. Adoni	1975	Study on microbiology of Sagar lake
25.	D.C. Garg	1977	Biochemical and pathological study of fruit rot fungi
26.	D.V.S. Balyan	1977	Studies on isolation of Actinomycetes from soil and their antagonistic activity in relation to pathogens
27.	S.P. Dubey	1977	Studies on production of metabolites with special reference to citric acid production from soil fungi
28.	T.S. Thind	1977	Physiological and pathological investigations on *Clathridium* rot of apple caused by *Clathridium corticola*
29.	D.P. Sharma	1979	Studies on cellulose decomposition by microorganisms
30.	Mrs. N. Pathak	1979	Investigation of leaf surface fungi of *Mangifera indica* L.
31.	J.P.N. Pandeya	1980	Studies on soil microbiology with special reference to litter decomposition
32.	A.K. Kher	1982	Effect of chemical fertilizers and fungicides on soil microorganisms
33.	B. Sundara Singh	1982	Ecological and biological studies of Penicillia
34.	Kartik Ghosh	1987	Limnology of some aquatic ecosystems with special reference to microbes and benthos

world for the first time. This work of Dr. Saksena paved the way for the Banaras School, the initiators being Dr. R.Y. Roy and his student Dr. R.S. Dwivedi and others to do similar type of synecological studies in grasslands of Varanasi and other places in India and other parts of the world. Dr. Saksena discovered several new genera and species of fungi, named a new genus *Saksenaea*, with a new species *S. vasiformis*, a new genus *Gliocladiopsis* with a new species *G. sagariensis*, another new genus *Monocillium* with a new species *Monocillium indicum*, a new species of *Paecilomyces* namely *Paecilomyces fusisporus* and another new species of *Cephalosporium* namely *Cephalosporium roseogriseum*. The genus *Saksenaea* was first placed in the family Mucoraceae by Hesseltine and Ellis (1973) and Ellis and Hesseltine (1974). Ellis and Hesseltine created a new family Sakseneaceae with *Saksenaea* and *Echinosporangium.* The research paper of Ellis and Hesseltine got published in the journal Mycologia a year later, but in the Volume IVB of the edited book entitled "THE FUNGI" by Ainsworth et al. This information was published in the year 1973. It may be pointed out that Canon and Krick (2007) and in the 10th edition of the Dictionary of fungi by Kirk et al. (2008); the genus *Saksenaea* has been placed in the family Radiomycetaceae of the order Mucorales, and they have not recognized the family Saksenaceae (nomen nudum, without a Latin diagnosis; Art. 36.1 of the ICBN, McNeill et al. 2006)

The discovery of the fungus *Saksenaea* has made Dr. S.B. Saksena immortal due to the two reasons, one that this is a very interesting mucoraceous fungus, and secondly of late it has been found to be pathogenic to humans, and the first report came from Ajello et al. in 1976 from USA. This was published in the journal Mycologia. A complete case history of this case was published in American Journal of Medicine by Dean et al. (1975). Professor Saksena discovered this fungus in 1953a, b. Saksena gave a challenging presidential address in the Botanical Section of 66th Session of the Indian Science Congress held at Osmania University, Hyderabad, in the year 1979 where he stated "It was in 1953 when I was working on the ecology of soil fungi of the local forests of Sagar, I found that some of the fungal isolates did not sporulate despite every treatment of temperature, pH, nutrition, etc. and I was greatly puzzled about one of them. When several months passed and I was on the brink of throwing them away, an idea struck me. Since I had some experience on dealing with aquatic species of fungi, I thought that it may be a fungus of aquatic bearings. So I floated small pieces of agar bearing the fungus on the surface of water in Petri dishes. To my great bewilderment, very beautiful flask shaped structures appeared on the surface, which I later named *Saksenaea vasiformis* in honour of Professor R.K. Saksena of Allahabad University under whose guidance I was carrying out this work". This fungus resembles very much with the fungus *Nowakowskiella* of Chytridiomycota. Saksena hypothesized that mucorales or members of Zygomycota have directly evolved from Chytridiomycetous ancestors like *Nowakowskiella* and not from Saprolegniales of Oomycota. There is another sequel to this discovery. Dr. S.B. Saksena sent his paper to the journal Mycologia for publication in 1953, but this fungus was also discovered almost at the same time by Farrow in 1954 from Panama Canal Zone from Barro Colorado Island, but his paper reached the journal Mycologia Editor one month later than that of Professor Shyam Bahadur Saksena, and thus, he got the priority of discovering this new genus. Since then this fungus has been reported from different parts of India and abroad. But the human infection aspect has also become important. Vega et al. (2006) reviewed the previously reported cases of *S. vasiformis* infection, and both immune competent and immunosuppressed patients have been reported from the world including some from India. The first case of subcutaneous zygomycosis in India was reported by Padhye et al. (1988) in a rice mill worker. The infection involved the foot and multiple sinuses. Amputation of the forepart of the foot followed by a split thickness graft and treatment with potassium iodide cured the infection. However, Padhye et al. (1988) in their paper stated that in fact Chakrabarti et al. (1997) reported this fungus from Chandigarh earlier and comparatively recently in 2006 by Padmaja et al. from Vishakhapatnam. Since 2006, *S. vasiformis* has been reported from different places causing serious human infections specially those who were involved in automobile accidents or of several burn cases. A very interesting paper was published by Alvarez et al. (2010) in the Journal of Clinical Microbiology, wherein on the basis of molecular phylogeny, they proposed two more new species of the emerging pathogenic fungus *Saksenaea* (Fig. 1.1). They proposed *Saksenaea oblongispora* characterized by oblong sporangiospores and unable to grow at 42 °C and *Saksenaea erythrospora*

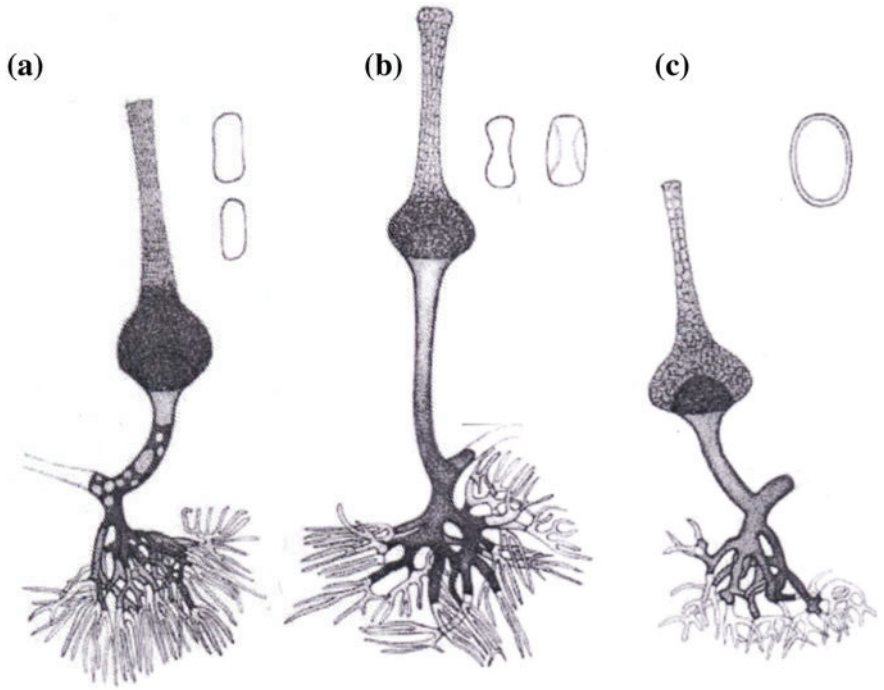

Fig. 1.1 Sporangiophores and sporangiospores of **a** 1 *Saksenaea vasiformis* **b** *S. oblongispora* **c** *S. erythrospora*. *Source* Alvarez et al. (2010)

characterized by large sporangiospores and sporangia and by ellipsoid sporangiospores, biconcave in lateral view. The optimum growth temperature was 25 °C and the minimum was 15 °C. The growth temperature requirements were also different for the two species. Sporangiospores of *Saksenaea vasiformis* were mainly cylindrical with rounded ends. A total of 11 strains from different culture collections of the world were included. None was included from any culture collection from India, but it is presumed that the culture taken from NRRL 2443 which was available in the ARS (NRRL) Culture Collection, Peoroa, Illinois, was the type strain discovered by Professor S.B. Saksena as it was from soil of India. No zygospore formation was reported by them or elsewhere in mating combination so far. So that sexual stage of the fungus is still not discovered or known.

Professor Saksena discovered two more genera, viz. *Monocillium* and *Gliocladiopsis*. The first one *Monocillium* with its species *indicum* was discovered in the year 1955 from the grassland soil of the Patharia Forest, in Sagar. This was however later believed to be the anamorphic stage of the Ascomycetous fungi such as *Nisselia* and *Hyaloseta*. The second new genus was *Gliocladiopsis* which was discovered in the year 1954 with a new species *sagariensis* (Saksena 1954). Agnihothrudu (1959) synonymized the genus with *Cylindriocarpon*. However, the good information is that the Lombard and Crous in 2012 resurrected the genus

using a global set of isolates and phylogenetic approach employing DNA sequence data from five genes (β-tubulin, histone H3, internal transcribed spacer region, 28S large subunit region and translation elongation factor 1 − α); the taxonomic status of the genus *Gliocladiopsis* was re-evaluated, and *Gliocladiopsis sagariensis* was reinstated as a type species for the genus, which proved to be distinct from its former synonym *G. tenuis.*

Saksena discovered a new species of *Paecilomyces* namely *P. fusisporus* in 1953a, b from Patharia Forest soil. The new species has very characteristic fusiform or top-shaped conidia. Samson (1970), however, named the fungus as *Acrophialophora fusispora* (Saksena) Samson in 1970 [synonyms *Acrophialophora nainiana* Edwards (1961) *Massoniella indica* M.A. Salam and P. Rama Rao (1960), *Paecilomyces fusisporus* Saksena (1953a, b)]. It may be mentioned that *Acrophialophora fusispora* is an ascomycetous fungus that is a plant and human pathogen. Saksena described a new species of *Cephalosporium* as *C. roseogriseum* in 1955a, b, c from soil. The mycoparasitic behaviour of this fungus was shown by Chaturvedi and Dwivedi in 1982. Another new species reported by Professor Saksena (Saksena 1965) was *Sporothrix albicans* which was later thought to be synonymous with *Sporothrix schenckii.*

In 1958–1959, Dr. Saksena visited Cambridge University and worked in association with Late Professor S.D. Garrett on the biology of the fungus *Trichoderma viride*. Saksena (1960) showed conclusively that *T. viride* became the dominant colonizer of fumigated and steam sterilized soils in Evan's soil recolonization tubes not only due to its resistance to fumigant tolerant fungal species, but also due to its high growth rate in comparison with other fumigant tolerant species. Here again Dr. Saksena's insight into the ecological characteristics of a fungal species is clearly visible. Thus, Professor Saksena's proposal that the success of *T. viride* in fumigated soils was due to its combination of moderate but sufficient degree of fumigant tolerance with high growth rate through the soil, when the fumigant was dispersing in the soil and his interpretation of data made a significant advancement in our understanding of the problem of dominance of *T. viride* in fumigated soils. One of the Ph.D. students of Saksena and Lily (1967) later showed that in alkaline soils the role of *Penicillium nigricans* parallels with that of *T. viride*.

On his return from Cambridge, Prof. Saksena became interested in biological control of soil-borne plant pathogens and quite a number of his students in his laboratory worked on the biological control of soil-borne plant pathogens. Interest of Prof. Saksena diversified from soil fungi to soil-borne plant pathogens, aquatic fungi, and leaf litter-decomposing fungi, the dermatophytes and the post-harvest pathogens. The leaf rot and foot rot of Pan (*Piper betle*) was considerably investigated in his laboratory. One of us (RSM) worked in detail the role of cuttings and survival of the pathogens in soil. Dr. D.P. Tiwari showed that the pathogens survive in the soil in the form of the chlamydospores, and isolated the pathogen by using the selective medium of pimaricin, vancomycin and PCNB. *T. viride* was utilized for controlling the disease. Another student of Dr. Saksena, late Dr. Vyas and his research associate later found that streptomycin sulphate can be used for controlling *Phytophthora* on pan. Prof. Saksena was elected as President of the Indian

Phytopathological Society in the year 1975 and gave a very thought provoking address in the Bangalore session of the society. The title of his address was "*Phytophthora parasitica* the scourge of Pan (*Piper betle*)" in which the work done by his research associates and students was summarized. He made a fervent appeal for the establishment of Indian Pan Research Institute in the country.

Many honours came to Professor Saksena. He was elected Fellow of the Indian National Science Academy in 1971, President of the Indian Botanical Society, in 1971, President of the Indian Phytopathological Society in 1975, President Mycological Society of India in 1978 and President, Botany Section of the Indian Science Congress in the year 1979. He was a Fellow of the National Academy of Sciences, Allahabad. He was a Fellow/member of the Mycological Society of America and Transactions British Mycological Society of Great Britain. Professor Saksena was looked upon by eminent Botanists of the country with great respect.

As already been stated, Shyam Bahadur Saksena was married to Smt. Sarla Saksena, daughter of Shri Gopal Sahay Saksena who retired as IG Police of the then Gwalior state. They remained issueless. It may be mentioned that Mrs Saksena left for heavenly abode on 8th Feb, 1999. Both, the husband and the widowed wife, took interest in teaching poor children of the locality at their house. Some of the students of Prof. Saksena were entirely supported by them. Prof. Saksena's nephew Dr. D.N. Saksena who retired as Professor in Zoology at Jiwaji University, Gwalior, was one of them. He looked after the widow till her death in Feb, 1999 in the house built by Prof. Saksena. Late Prof. Saksena named his house as Vigyan Kutir. Another name worth mentioning is of Dr. S.C. Garg who studied at Sagar and did his Ph.D. in Chemistry and later became Professor. He is the son of one of his old friends. He was closely associated with Dr. Saksena at Sagar and is now settled in Bhopal.

Professor S.B. Saksena had gradually built up a good library of his own. It was donated to Jiwaji University, Gwalior, which happened to be his last working place.

Professor Saksena had been continuously in touch with his old students and corresponded with most of them enquiring about their family welfare, progress in career and research, and he took pride in talking about them with other scientists.

Prof. Saksena was very regular in habits and strict disciplinarian. He never missed his classes. He took tea usually at 2 pm with his students and colleagues, when he used to be at his best with humour and wit. He would discuss with them about their problems.

Professor Saksena laid great emphasis on field studies and field trips made with colleagues and students. Every year the first field trip was usually to Garhpera Forest about 23–30 km on Jhansi Road. A long excursion was also used to be taken and at least 3–4 teachers, research scholars and M.Sc. students would accompany the trip. Dr. Saksena very often was the leader of the trip. Dr. Saksena was not only interested in fungal collection but was very good in the taxonomy of higher plants. Collecting plants was a fun due to his sense of humour, his enthusiasm and ability to make his students feel that finding even the most common fungus or plant was a discovery. He would very often announce prizes for best collections made. Thus, a competitive spirit was aroused among the students for good collections. Wives of

the teachers often accompanied the trips, and cooking was done while on excursions by the excursion party itself which also included two to three peons or laboratory staff. A family atmosphere was seen during the excursions. Every one cooperated in the successful completion of the trip.

Prof. Saksena became diabetic rather early in life, and his health was deteriorating fast during the last 3 years of his life. He used to tell his friends and admirers that he received two warnings and the bell is ringing, the cruel death can snatch him at any time. On the 21, March, 1988, apparently healthy looking Prof. Saksena left his house 51, Shri Ram Colony, Jhansi Road to show himself to a specialist doctor unaccompanied by his wife. A severe heart attack struck him while going to the first floor of the Medical College which brought an end of this noble soul. Prof. Saksena was a rare combination of scholarship with humility, intelligence with honesty, strong will with compassion, sweetness in behaviour with straight forwardness (Mehrotra 1992/1993).

In an obituary published in The Journal Indian Phytopathological Society, Late Prof. B.S. Mehrotra (1989) of Allahabad University stated that his academic attainments, his amiable temperament and helpful attitude towards his students and colleagues endeared him to all who came in contact with him. We need more mycologists and human like him.

Before close, we want to emphasize that not only Professor Shyam Bahadur Saksena built the Department Botany, University of Sagar (Now known as Dr. Hari Singh Gour Central University, Sagar), but also he and his colleagues especially late Professor Y.D. Tiagi built a botanical garden in the new campus which will remain a living testimony of the love and care that Dr. Saksena had for plants.

Professor Saksena was a scholar and a thorough gentleman. Among the contemporary mycologists and plant pathologists, he can be ranked as one of the topmost. We pay our sincere tribute to him on this auspicious occasion of his Birth Centenary Year.

For the late Professor C.V. Subramanian FNA, it had been said that he started as a plant pathologist and turned into a mycologist, while late Prof. Saksena started as a mycologist and turned into a plant pathologist.

Acknowledgements R.S. Mehrotra, Retd. Professor of Botany, Kurukshetra University, has written about the scientific achievements and later part of personal life of Prof. S.B. Saksena. He was his second Ph.D. student and subsequently a junior colleague of Prof. Saksena. The association lasted for 15 years at Saugar. M.R. Siddiqui, former Professor and Project coordinator in the Division of Seed Science and Technology of Indian Agricultural Research Institute, happened to have obtained Ph.D degree as Prof. Saksena's first student. He had compiled the bibliography. The third author is Ashok Aggarwal, Professor of Botany, Kurukshetra University, Kurukshetra, who has collected the latest information about the discovery of the two species of the genus *Saksenaea* and the latest information on the other new genera or species and the preparation and typing of the manuscript. Most of the personal information of Dr. Saksena has been taken from the memoir of Dr. Saksena published in 1993 (Mehrotra et al. 1993) by Indian National Science Academy, New Delhi, which is duly acknowledged. The personal information was collected by late Prof. R. Misra of Bananas Hindu University, Varanasi, which is also gratefully acknowledged.

Publications of Late Professor Saksena and Along with His Students

1953 A new genus of Mucorales. *Mycol.* 45(3) 426–436.
A new species of Paecilomyces from soil. *J. Indian Bot. Soc.,* 32(4) 186–189.
1954 A new genus of Moniliaceae. *Mycol.* 46(5) 660–666.
1955 Ecological factors governing the distribution of soil microfungi in some forest soils of Sagar. *J. Indian Bot. Soc.*, 34(3) 262–298.
A new species of *Cephalosporium*. *Mycol.* 47(6) 895–898.
A new genus from soil *Monocillium indicum* gen. et sp. nov. *Indian Phytopath.* 8(1) 9–12.
1956 (With NAIDU KK). On *Allomyces anomalous* from Sagar. *Nat. Acad. Sci.* 26, 278–282.
(With SHETYE PK). Some additions to Indian Aspergilli. *Indian Phytopath.,* 9, 138–144.
(With DHORE MA). Taxonomic studies on Aspergilli of Sagar. *Bull. Bot. Soc. Univ. Saugar* 8(2):59.
1957 (With DHORE MA). A study of Penicillia from Sagar. *Saugar. Univ J. B.* 6, 32–34.
Taxonomic studies on soil micro fungi of some forest soils of Sagar. *Saugar. Univ J. B*. 1(5) 13–38.
1958 A brief review of outstanding achievements in the Mycological Laboratory of University of Saugar during 1950–57. *Proc. Myc. Res. Works Con. Shimla*.
1959 On some affinities of Mucorales. *Bull Bot. Soc. Univ Saugar* 9(1&2): 1–6.
(With RAJGOPALAN C). Studies on aquatic fungi of Saugar. *Sagar Univ. J.* II B, 7, 7–20.
1960 Effect of carbon disulphide fumigation on *Trichoderma viride* and other soil fungi. *Trans. Brit. Mycol. Soc.* 43(1)111–116.
1961 (With THAMMAYA A) A study of fungi from stored wheat grains from Saugar. *Proc. Nat Acad. Sci.* India, Annual number 10, 120.
1965 A new species of *Sporothrix*. *Curr.Sci.* Vol. XXXIV (10), 318.
(With VYAS KM). The wood decaying fungi of sagaur. *Madhya Bharti* II B, 11–13, 15–28.
1967 (With LILY K). Studies on the interactions between soil microorganisms with special reference to *Penicillium nigricans*. *J. Indian Bot. Soc.* 46(1) 185–192.
1968 (With ALI SS AND SOMAL BS). Fungi causing fruit and vegetable rot of Sagaur. *Bull. Bot. Soc. Saugar.* 15, (1&2) 44–46.
(With SUDHA SRIVASTAVA). Studies on rhizosphere and rhizoplane microflora of potato with special reference to black scurf and wilt diseases.

Indian Phytopathology symposium on Microbiology of root region in relation to diseases. *Indian Phytopathological Soc. Bull.* 4, 107–119.

1969 (With SOMAL BS) Pathological studies on some species of *Helminthosporium*. *Madhya Bharti* II B, 17, 43–46.
(With KU CHATTERJI R) Studies on production of growth regulators by some fungi. *Bull. Bot. Soc. Univ. Saugar.* Vol. 16, 28–30.
(With SHASHI PRABHA SINGH) Additions to the Indian Penicillia. *Ibid,* 16(1) 31–33.
(With GHURDE VR) Varietal resistance of Wheat against foot rot pathogens. *Madhya Bharti* (*J. Univ. Saugar*) II B 17, 47–49.

1970 Fungal communities in soil. *Proc. Nat. Acad. Sci.* Symposium on diversities in plants and animal population.
(With MEHROTRA RS) Studies on foot rot and leaf rot of *Piper betle* L. Host range and role of cuttings in spread of disease. *J. Indian Bot. Soc.* 49, 24–29. 1970
(With DUBEY SP AND SUDHA MALL) Cultural and nutritional studies on some Myxomycetes of Saugar. *Madhya Bharti*-Gour Memorial Vol. 18: 42–51.

1971 (With KIRAN JOHRI AND SINGH SS) Thickness of agar disc and time of incubation in relation to soil fungistasis. *Bull. Soc. Univ. Saugar* 17&18.
(With SUDHA MALL). Competitive saprophytic ability of *Fusarium* spp. and *Rhizoctonia solani* pathogenic to potato. *Second Internat. Symp. Pl. Path.* Held in Feb. P63–64.

1972 Root diseases and biological control (Presidential Address). J. Indian Bot. Soc. 51(1):1–13.
Soil flora isolated on different selective media. *Bull. Bot. Soc. Saugar* 19, 14–19.
(With AGGARWAL SC AND KUSHWAHA RKS) *Ginkgo biloba* and *Araucaria cookie*- Two new hosts for *Colletotrichum lindemuthianum. Indian J. Mycol. Pl. Path* 2(2) 194.
(With DUBEY GL AND JOHRI BB) Biodeteriortaion of Linseed (*Linum usitatissinum*) under conditions of storage. *Bull. Bot. Soc. Univ*. 19, 41–44.
(With MUTTHAL AK AND AGARWAL SC) Efficacy of some fungicides against the pathogens causing fruit rot of *Luffa aegyptiaca* Mill. *Bull. Bot. Soc. Univ. Saugar*. 19:10–13.
(With SONI NK AND VYAS KM) Effect of cultural filtrates of different fungi on mycelial respiration of *Fusarium oxysporum* Sacc. Hind. *Anti. Bull* 14(4) 170–180.
(With SONI NK AND VYAS KM) Effect of plant growth regulators on oxygen uptake and growth of *Rhizoctonia solani* Kuh and *Colletotrichum capsci* (Syd.) Butler and Bisby Bull. *Bot. Soc. Univ. Saugar*. 19, 24–27.

(With VYAS KM AND JAIN BK) Respiratory characteristics of some soil borne plant pathogenic fungi. *J. Indian. Bot. Soc.* 51(1), 92–96.

1973 (With ADONI AD) Diurnal variation in Saugar Lake, Saugar (India) I Studies in deep-water area. *Hydrobiologia.* 43(3–4), 535–543.

(With MUTHAL AK) Production of cellulase by *Fusarium dimerum* Penz. causal organism of fruit rot of *Luffa aegyptiaca* Mill. *Prot. Nat. Aca. Sci.*B. 43(1/2), 49–52.

(With VYAS KM) Studies on mycelial respiration of *Selerotium rolfsii. Proc. Indian Nat. Sci Acad.* 39(5), 569–575.

1974 (With MEHTA P AND VYAS KM) Production of Pectolytic and celluloytic enzymes by *Alternaria* spp. during pathogenesis of tomato fruits. *Hind. Anti. Bull.* 16(4), 210–214.

(With VYAS KM and SAXENA RK) Physiology of *Tectona grandis* leaves infected with *Uncinula tectonae* Salmon *J. Indian Bot. Soc.* 53(3/4), 265–270.

1975 (With JOHRI BN and KIRAN JOHRI) Evaluation of fungistasis in agar plates colonized from soil inocula. *Acta Bot. Indica* 3(1), 62–67.

(With SATYA HN) Some aspects of taxonomy of the genus *Pestalotia* II. Observation on structure of conidia. *Kavaka* 3(1). 119–123.

(With KIRAN JOHRI AND JOHRI BN) Colonization capacity of soil microorganisms in relation to fungistasis. *Plant and Soil* 43(2), 347–354.

(With KIRAN JOHRI AND JOHRI BN) Soil mycoflora as producer of volatile fungistatic factors. *Proc. Indian Nat. Sci. Acad.* B. 42(2) 148–154.

(With KIRAN JOHRI AND JOHRI BN) Volatile metabolites of soil fungi in relation of spore germination and mycelial growth. *Curr. Sci.* 44, 605–607.

(With VYAS KM AND SONI NK) Effect of antibiotics and fungicides on endogenus mycelial respiration and growth of *Rhizoctonia solani* Kuhn. and *Colletotrichum capsici* (Syd) Butler and Bisby. *Indian J. Expt. Boil.* 13 (2), 216–218.

(With MEHTA P AND VYAS KM) Effect of native carbon sources and pH on the pectolytic enzymes of *Alternaria solani* and *A. tenuis. Proc. Indian Nat. Sci. Acad.* B. 40(4), 433–439

(With MEHTA P AND VYAS KM) Production of pectolytic enzymes by *Alternaria solani* and *A. tenuis* on different culture media. *J. Indian Bot. Soc.* 54(3/4), 200–206

(With MEHTA P AND VYAS KM) Effect of carbohydrate on the production and activity of cellulase of *Alternaria* spp. *Proc. Nat. Acad. Sci.* B. 45(4), 281–284.

(With MEHTA P AND VYAS KM) Effect of native carbon sources and pH on the cellulases of *Alternaria solani* and *A. tenuis. Sci. Cult.* 41(8), 400–402.

(With THIND TS AND AGARWAL SC) Soft rot of apple caused by *Clathridium corticola* (Fekl.) Shoem. and Muller. *Curr. Sci.* 44(19), 714.

1976 (With MEHTA P AND VYAS KM) Metabolic changes during pathogenesis of fruit-rot disease of Tomato. *Indian Phytopath.* 28(2), 253–255.

(With MEHTA P AND VYAS KM) Pathological studies on fruit rot of tomato caused by *Alternaria solani* and *A. tenuis.* 28(2) 247–252.

(With RAO DPC AND AGARWAL SC) *Phomopsis destructum* on *Psidium guajava* fruits in India.. *Mycologia* 68(5), 1132–1134.

(With VYAS KM AND SONI NK) Respiratory response of *Gloeosporium papaya* induced by various substances. *Proc. Indian Nat. Sci. Acad.* B. 41 (5), 458–461.

(With THIND TS AND AGARWAL SC) Evaluation of antibiotics to control *Clathridium* rot of apple. *Hind. Anti. Bull.* 18(3/4), 99–102.

1977 *Phytophthora parasitica* the scourge of pan (*Piper betle* L.) Presidential Address XXIX Annual General meeting of the Indian Phytopathological Society. Jan. 18, 1977. Bangalore (Karnataka). *Indian Phytopath.* 30(1), 1–16.

(With THIND TS AND AGARWAL SC) Post-harvest decay of apple fruits incited by *Aspergillus candidus* in Madhya Pradesh. *Indian Phytopath.* 29 (3), 318.

(With THIND TS AND AGARWAL SC) Effect of temperature in the control of soft rot of apple fruits caused by *Clathridium corticola. Ibid.* 29 (3), 256–258.

(With THIND TS AND AGARWAL SC) Conidial state of *Clathridium corticola* from India. *Ibid.* 29(4), 433–434.

(With THIND TS AND AGARWAL SC) Post infection change in amino acids, sugars, phenolic substances and organic acids of apple fruit by *Clathridium corticola. Ibid.* 30(3), 323–325.

1978 (WITH ALI SS) Production of cellulase by *Botrydiplodia theobromae Act. Bot. Indica* 6(Supll.), 132–135.

(With RAGHVAN U) Efficacy of fungicides in vitro against some isolates of *Botrydiplodia theobromae Pat. Hind. Anti. Bull.* 21(1/2), 28–30.

(With THIND TS AND AGRAWAL SC) Induction of sporulation in *Clathridium corticola*(Fekl.) Shoem. and Mueller. *Curr. Sci.* 47(23), 906–907.

(With THIND TS AND AGRAWAL SC) Post infection changes in amino acids, sugars, phenolic substances and organic acids of apple fruits incited by *Clathridium corticola. Indian Phytopath.* 30(4), 445–448.

(With THIND TS AND AGRAWAL SC) Epidemiology of fruit rots of apple caused by *Clathridium corticola. Ibid.,*30(4), 536–537.

1979 The genus *Phytophthora* in India. *Kavaka* 7, 1–16.
(With CHAUHAN S) Studies on the screening of certain antagonistic Penicillia. *Kavaka* 7, 37–40.
(With RAGHAVAN U AND VYAS KM) Efficacy of three antibiotics against some isolates of *Botrydiplodia theobromae. Indian Phytopath.* 31 (3), 359–360.
(With THAKUR MS AND PATHAK N) Seasonal variation in leaf surface mycoflora of *Azadirachta indica. Indian Phytopath.* 21(2), 255–256.

1980 (With SINGH BS) Fungistasis due to volatile inhibitors produced by some *Penicillium* species. *Crr. Sci.* 49(13), 515–517.
(With CHOUDHARY M) A report on the production of IAA and some unidentified auxins in the culture filtrates of *Helminthosporium rostratum, Curvularia lunata* and *Fusarium culmorum. Marathwada Univ. J. Sci.* (National Science) 18(11), 43–46.
(With RAGHAVAN U) Metabolic changes during pathogenesis of fruit rot of apple. *Indian Phytopath.* 32(4), 551–553.
(With THIND TS AND AGRAWAL SC) Cell wall degrading enzyme complex in diseased fruits of apple infected with *Clathridium corticola. Indian J. Mycol. Pl. Path.* 10(1), 92–93.
(With THIND TS AND AGRAWAL SC) Effect of some phenolic compounds on germination of spores of *Clathridium corticola. Indian Phytopath* 32(2), 273–274.

1981 (With JAIN SK AND SAXENA AK) Two new fruit rot diseases of *Achras sapota*. *Indian Phytopath.* 34(3), 903.
(With JAIN SK AND SAXENA AK) Some new cucurbitaceous hosts of *Botrydiplodia (B. theobromae). Curr. Sci*. 50(7), 328–329.
(With SAXENA AK) A new fungal disorder of Australian *Acacia. Curr. Sci.* 50(19), 862.
(With SAXENA AK) Effect of papaya latex on the germination of conidia of certain fungi. *Indian Phytopath.* 34(4), 505–506.
(With SAXENA AK AND JAIN SK) *Sclerotium* rot of *Grewia asiatica* (Linn) Mant. *Sci. Cult.* 47(12), 440.
(With SAXENA AK AND JAIN SK) A note on new diseases caused by *Alternaria alternata. Nat. Acad. Sci. letters.* 4(7), 267.
(With SAXENA AK AND JAIN SK) Addition to the host range of *Macrophomina phaseolina. Ibid.,* 4(9), 357.
(With SINGH SB) Estimation of extracellular C_1 and C_x cellulases produced by certain species of *Penicillium. Ibid*., 4(11), 431–432.

1982 (With SAXENA AK) A new powdery mildew from Madhya Pradesh. *Ibid*., 51(8), 437–438.
(With SAXENA AK) *Oidium vernomiae*—a new species from Madhya Pradesh. *Ibid.*, 51(16), 786–787.