ABSTRACTS

National Conference
On
Biodiversity and Biotechnology of Fungi
&
47th Annual Meeting of Mycological Society of India

FEBRUARY 22-24, 2021

Under the aegis of

PUNJABI UNIVERSITY PATIALA

MYCOLOGICAL SOCIETY OF INDIA

BOTANICAL SOCIETY
PUNJABI UNIVERSITY PATIALA

Organised by

Department of Botany
Punjabi University, Patiala

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Abstracts

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Punjabi University, Patiala
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and
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Department of Botany
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Co-convener	Prof. J.I.S. Khattar
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Dr. Arneet Grewal

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PREFACE

The present conference pertains to researches in FUNGI- a unique kingdom of fascinating organisms with immense diversity and complexity. Researches in fungal biology over a period of time have led to a better understanding of fungal diversity and their applications in the welfare of the society. Ever since its inception in 1967, the Department of Botany, Punjabi University, Patiala has contributed reasonably well in different areas of Botany including Mycology and Plant Pathology. The fungal taxonomy is one of the major thrust areas and has been recognized by UGC at DRS and DSA-I level and by Department of Science and Technology, New Delhi under FIST Program.

In these hard COVID-19 Pandemic times, it was decided to provide a common platform to the scientists for sharing their experiences and researches**.** Thus this effort was made to organise a three days virtual National Conference on **"Biodiversity and Biotechnology of Fungi" & 47th Annual Meeting of Mycological Society of India from February 22-24, 2021** is being organized. The Conference has received encouraging response from academicians and scientists working in the Universities, National Research Centers and Institutes from all over India and abroad. The abstract volume contains research contributions of over 200 scientists working on various aspects of Mycology and Pathology. In the academic programme besides the Presidential lecture and Life time Achievement Lecture there will be 6 Memorial award Lectures, 11 Lead lectures, 7 MSI Fellow Award Lectures, 35 oral presentations and 40 poster presentations have been planned which are well spread in the three day programme.

Mrs. Ravneet Kaur, Vice-Chancellor, Punjabi University, Patiala has played a pivotal role in the organization of this Conference, for which the organizers are extremely thankful to her. Without her leadership it would not have been possible to organize such an important event. Sincere thanks are due to Dean Academic Affairs, Registrar, Finance Officer and Director, University Computer Center for their ever available support and cooperation. The whole hearted involvement of the students, research scholars, members of the non-teaching staff and faculty of the Department is gratefully acknowledged.

We express our gratitude to Mycological Society of India for choosing Botany Department, Punjabi University, Patiala as venue for organizing its 47th Annual meeting and to Botanical Society, Punjabi University, Patiala for providing financial assistance in organizing this conference and making it a grand success.

Dr. Munruchi Kaur
Convener

Dr. JIS Khattar
Co-Convener

Dr. Avneet Pal Singh
Organizing Secretary

Dated: February 22, 2021

MYCOLOGICAL SOCIETY OF INDIA (MSI)

Mycological Society of India is a scientific body constituted for the advancement of subject of Mycology, the study of fungi including mushrooms, molds, truffles, yeasts, lichens, plant pathogens, and medically important fungi. The Society was founded in January 1973 by a team of mycologists lead by Late Professor C.V. Subramanian, former Director, C.A.S. in Botany, University of Madras, Chennai, India and Former President of International Mycological Association, with a view to bring together mycologists of the country and with the broad objectives of promoting development of Mycology in India in all aspects and in the widest perspective. There are nearly 500 members, including professional and upcoming mycologists with varied interests including taxonomy, ecology, pathology, genetics, molecular biology and physiology. The international members are also encouraged to join in the society. The society publishes its journal Kavaka being Transactions of Mycological Society of India. The word Kavaka represents the Sanskrit word for fungus. Kavaka is an international journal and publishes peer-reviewed, original articles and reviews on taxonomy, phylogeny, diversity, ecology, physiology, biochemistry, molecular biology and biotechnology of Fungi. The journal is published six monthly and free access to all the back volumes is available at the website of Kavaka and MSI. The society also elects its Fellow (FMSI) and Associate Fellow annually on the basis of thorough scrutiny of the applications by a review committee. Since 2006 as many as 32 Mycologists have been elected as Fellows and 2 as Associate Fellows of the society. Every year the Mycological Society of India organizes Annual Meeting along with conference organized by Universities and/or Scientific Organizations in various parts of India. Till now 46 Annual Meetings have been conducted throughout the country spreading scientific knowledge. The society and its journal have independent websites www.fungiindia.co.in and www.kavaka.fungiindia.co.in, respectively. For more details and membership form visit the websites.

Mycological Society of India has constituted following memorial lectures. The awardees are invited to share their research work in the form of invited lectures during the annual meeting of the society.

- Life Time Achievement Award
- Prof. C.V. Subramanian Memorial Lecture Award for Women Scientists
- Dr. V. Agnihothrudu Memorial Lecture Award
- Prof. K. Natarajan Memorial Lecture Award
- Dr. S.K. Shome Memorial Lecture Award
- Prof. K.G. Mukerji Memorial Lecture Award (for scientists up to age of 45 years)
- Prof. P.C. Jain Memorial Lecture Award
- Dr. M.J. Thirumalachar Merit Awards for Young Scientists

CONTENTS

Session – II (12:00 noon – 01:30 pm) Moderator: Dr. Arneet Grewal	
Chairperson	**Dr. D.J. Bagyaraj**, Centre for Natural Biological Resources and Community Development (CNBRD), Bangaluru
Co-Chairperson	**Prof. M. Sudhakara Reddy,** Treasurer, MSI, Thapar University, Patiala
12:00-12:30 pm Prof. C.V. Subramanian Memorial Award Lecture	**Prof. Sarita Nazreth**, Goa University, Goa "Halophilic fungi from different econiches and their osmoadaptation"
12:30-01:00 pm Dr. V. Agnihothrudu Memorial Award Lecture	**Prof. Naveen Kango**, Dr. Harisingh Gour Vishwavidyalaya, Sagar "Production of fungal mannanolytic enzymes for health promoting prebiotic mannooligosaccharides (MOS)"
01:00-01:30 pm Prof. K. Natarajan Memorial Award Lecture	**Prof. Rupam Kapoor**, University of Delhi, New Delhi "Understanding the role of some novel components in modulating virulence of necrotrophic fungus *Botrytis cinerea*"
01:30 pm – 02:00 pm	**BREAK**

Session – III (02:00 – 03:30 pm) Moderator: Dr. Geetika Sirhindi	
Chairperson	**Prof. T N Lakhanpal,** Himachal Pradesh University, Shimla
Co-Chairperson	**Prof. Yashpal Sharma,** Editor-in-Chief, Kavaka, University of Jammu, Jammu
02:00 pm – 02:30 pm Dr. S.K. Shome Memorial Award Lecture	**Dr. V. Sarma,** Pondicherry University, Puducherry "Diversity of Ascomycetous fungi in Andaman Forests, India"
02:30 pm – 03:00 pm Prof. K.G. Mukerji Memorial Lecture for Middle-Aged Scientists	**Dr. Avneet Pal Singh,** Punjabi University, Patiala "Polypore diversity in North West India"
03:00 pm – 03:30 pm Prof. P.C. Jain Memorial Lecture	**Prof. R.N. Kharwar,** Banaras Hindu University, Varanasi "Fungal endophytes: A hidden treasure trove of structural and functional diversity"
03:30 pm – 03:45 pm	**BREAK**

Session – IV (03:50 – 06:45 pm) Moderator: Dr. Manish Kapoor		
Chairperson		**Prof. T. Satyanarayana,** Netaji Subhas University of Technology, New Delhi
Co-Chairperson		**Dr. V. Kumaresan,** Kanchi Mamunivar Centre for PG Studies, Puducherry
03:50 – 04:20 pm Lead Lecture – 1		**Prof. T.N. Lakhanpal,** Himachal Pradesh University, Shimla "Health Benefits of Mushrooms"
04:20 – 04:50 pm Lead Lecture – 2		**Dr. T.S. Suryanarayanan,** Vivekananda Institute of Tropical Mycology (VINSTROM), RKM Vidyapith, Chennai "The need to study different facets of the endophyte-plant association for their application in agriculture"
04:50 – 05:00 pm		**BREAK**
05:00 – 05:45 pm		Executive Council Meeting of Mycological Society of India
05:45 – 06:45 pm		General Body Meeting of Mycological Society of India

February 23rd, 2021 (TUESDAY)

Session – V (09:00 – 11:00 am) Moderator: Prof. D.P. Singh		
Chairperson		**Dr. Sunil Deshmukh,** TERI-Deakin Nano Biotechnology Centre, TERI, New Delhi
Co-Chairperson		**Dr. K. Malarvizhi,** University of Madras, Chennai
9.00 – 9.30 am Lead Lecture – 3		**Dr. Roo Vandegrift,** Institute of Ecology and Evolution, University of Oregon, Eugene "The foraging Ascomycete hypotheses: spatial ecology of the fungal genus *Xylaria* in a tropical cloud forest"
9.30 – 10.00 am Lead Lecture – 4		**Dr. Harish C Gugnani,** Vallabhbhai Patel Chest Institute, University of Delhi, Delhi "Milestones in the development and progress of medical mycology in India"
10.00 – 10.30 am Lead Lecture – 5		**Prof. N.S. Atri,** Shoolini University of Biotechnology and Management Sciences, Solan "Mushrooms in service of society"
10.30 – 11.00 am Lead Lecture – 6		**Dr. R.B. Sadaba,** University of the Philippines Visayas, Miagao, Iloilo, Philippines "Fungi and Oil Spills"

Session – VI (11:30 – 12:50 pm) Moderator: Prof. Munruchi Kaur		
Chairperson		**Prof. Rupam Kapoor,** President, MSI, University of Delhi, New Delhi
Co-Chairperson		**Prof. J. Savitha,** Bangalore University, Bangaluru
11:30 – 11:50 am MSI Fellow 2020 Lecture		**Prof. C. Manoharachary,** Osmania University, Hyderabad "Diversity and Taxonomy of Fungi"
11:50 – 12:10 pm MSI Fellow 2020 Lecture		**Dr. Sanjeeva Nayaka,** CSIR-National Botanical Research Institute, Lucknow "Lichen genus *Lecanora* (*Ascomycota*, *Lecanorales*) in India"
12:10 – 12:30 pm MSI Fellow 2020 Lecture		**Prof. Pradeep Verma,** Central University of Rajasthan, Ajmer "Bioprospecting of Fungi: A Bio-logic Solution"
12:30 – 12:50 pm MSI Fellow 2020 Lecture		**Dr. Mahaveer Prasad Sharma,** ICAR-Indian Institute of Soybean Research, Indore "Appraisal of native AM fungi in improving the plant productivity, soil health and sequestering soil carbon in agroecosystems"
12:50 – 2.00 pm		**BREAK**

Session – VII (2:00 – 03:30 pm) Moderator: Prof. J.I.S. Khattar		
Chairperson		**Prof. Gurpaul Singh Dhingra**, Punjabi University, Patiala
Co-Chairperson		**Prof. Geeta Sumbali,** University of Jammu, Jammu
2:00 – 2:30 pm Lead Lecture – 7		**Prof. Ewald Langer,** University of Kassel, Kassel, Germany "Mycology - past, present and future"
2:30 – 2:50 pm MSI Fellow 2020 Lecture		**Prof. Raj Kumar Salar,** Chaudhary Devi Lal University, Sirsa "Biotechnological potential of filamentous fungi in modulating bioactive compounds of food grains"
2:50 – 3:10 pm MSI Fellow 2020 Lecture		**Prof. Munruchi Kaur,** Punjabi University, Patiala "My ardour for Agaric diversiy"
3:10 – 3:30 pm MSI Fellow 2020 Lecture		**Prof. D.V. Hande,** Shri Shiva Ji Science College, Amravati "Endophytic fungi from medicinal plants: a source of bioactive secondary metabolites"
3:30 – 4:00 pm		**BREAK**

Session – VIII Dr. M. J. Thirumalachar Young Scientist Award Lecture (04:00 – 06:00 pm) Moderator: Dr. Arneet Grewal		
Chairperson		**Prof. M. Kalaiselvam,** Annamalai University, Parangipettai
Co-Chairperson		**Dr. D. Nagaraju,** Government Degree College, Eturnagaram,Warangal
04:00 – 04:10 pm		**Arya C.P.,** Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram, Kerala "Morphological and molecular characterization of genus *Agaricus* in Kerala state"
04:10 – 4:20 pm		**Sanjay Yadav,** Banaras Hindu University, Varanasi, U.P. "Four novel fungal species reported from Uttarakhand, India"
04:20 – 04:30 pm		**Vineet Vishala,** Dr Shyama Prasad Mukherjee University, Ranchi, Jharkhand, India. "Cross morpho -anatomical structural analysis of Earthstars (*Agaricomycetes*) using-integrative taxonomic approach"
04:30 – 04:40 pm		**Anju Joseph,** Mangalore University, Mangalagangothri, Karnataka, India. "Isolation and identification of fungi and analysis of secondary metabolites of *Fusarium oxysporum* from *Coccinia grandis* of Malabar regions of Kerala"
04:40 – 04:50 pm		**Sushma Jadhav,** National Centre for Microbial Resource (NCMR), National Centre for Cell Science (NCCS), Pune, Maharashtra "Biodiversity of fungus isolated from Achanakmar -Amarkantak biosphere reserve and their antimicrobial properties"
04:50 – 05:00 pm		**Uzma Altaf,** University of Jammu, Jammu, J&K, India "Morphological and molecular characterization of four new macrofungal records from India"
05:00 – 05:10 pm		**Amandeep Kaur,** Punjabi University, Patiala, Punjab, India "Morpho-anatomical and molecular characterization of species of *Russula* (*Russulaceae*) from Narkanda, India"
05:10 – 05:20 pm		**Navpreet Kaur,** Punjabi University, Patiala, Punjab, India "Family *Hymenochaetaceae* in Himac hal Pradesh: Some interesting polypores and evaluation of selected taxa for antioxidative potential"
05:20 – 05:30 pm		**Ramandeep Kaur,** Punjabi University Patiala, Punjab, India "Some noteworthy additions to family *Polyporaceae* Agaricomycetous fungi from district Sirmaur (Himachal Pradesh)"
05:30 – 05:40 pm		**Anil Kumar,** University of Jammu, Jammu, J&K, India "Studies on genus *Amanita* from mixed forests of Jammu, India; one new record and three regional records"
05:40 – 05:50 pm		**Puja Kumari,** Banaras Hindu University, Varanasi, UP, India "Biofabrication and characterization of fluorescent nanostructures derived from endophytic fungus for sensing, bioimaging and biotic stress"
05:50 – 06:00 pm		**Anica Dadwal,** Netaji Subhas Institute of Technology, New Delhi, India "Heterologous expression and structural insights of cellobiohydrolase of the thermophilic mold *Myceliophthora thermophila* (MtCbh) for lignocellulose bioconversion to ethanol"
06:00 -7.00 pm		**Poster Presentations**

February 24th, 2021 (WEDNESDAY)

Session – IX (09:00 – 11:00 am) Moderator: Dr. Avneet Pal Singh	
Chairperson	**Prof. K. R. Sridhar**, Mangalore University, Mangalore
Co-Chairperson	**Dr. M. Krishnamohan**, Birla Institute of Scientific Research, Jaipur
9:00 –9:30 am Lead Lecture – 8	**Prof. David Hibbett,** Clark University, Worcester Massachusetts, USA "Phylogenetic and phylogenomic analyses of the shiitake genus, *Lentinula*"
9:30 –10:00 am Lead Lecture – 9	**Dr. D.J. Bagyaraj,** Center for Natural Biological Resources and Community Development (CNBRCD), 41 RBI Colony, Anand Nagar, Bangaluru "Can agricultural practices affect arbuscular mycorrhizal fungal population and diversity?"
10:00 –10:30 am Lead Lecture – 10	**Prof. Gurpaul Singh Dhingra,** Punjabi University, Patiala "Non-poroid an d poroid A garicomycetous taxa new to science – our contribution"
10:30 – 11:00 am Lead Lecture – 11	**Dr. Suresh LM,** International Maize and Wheat Improvement Center (CIMMYT), Nairobi, Kenya "Maize Lethal Necrosis (MLN): Effort towards containing the spread the spread and impact of a devastating transboundary disease in sub-Saharan Africa"
11:00 – 11:15 am	**BREAK**

Session – X: Dr. M. J. Thirumalachar Young Scientist Award Lecture (11:15 am – 01:25 pm) Moderator: Dr. Geetika Sirhindi	
Chairperson	**Prof. Krishnendu Acharya**, University of Calcutta, Kolkata, WB, India
Co-Chairperson	**Dr. Samir Damare**, CSIR - National Institute of Oceanography, Goa, India
11:15-11:25 am	**B.N. Narendrababu,** Davangere University, Shivagangothri, "Antifungal activity of the pigments produced by *Aspergillus nidulans*"
11:25-11:35 am	**Gagan Brar,** Punjabi University, Patiala, Punjab, India "Domestication of wild edible Agaric: *Macrocybe gigantean*"
11:35-11:45 am	**Sankrita Gaonkar,** Goa University, Goa "Effects of bio-inoculants on the growth and phosphorus uptake of *Rhizophora mucronata* Lam."
11:45-11:55 am	**Natasha Barnes,** CSIR- National Institute of Oceanography, Goa "Crude oil hydrocarbon-degrading fungi isolated from marine environments as potential bioremediation agents"
11.55-12.05 pm	**Taranjeet Singh,** Punjabi University, Patiala, Punjab, India "Purification and characterization of fungal endoinulinase for the preparation of fructooligosaccharides from inulin"
12:05-12:15 pm	**Maninderjeet Kaur,** Panjab University, Chandigarh, India "Evaluation of Laccase byautochthonous white rot fungus*Ganoderma* sp. Under solid-state fermentation forvarious applications in textile industry"

12:15-12:25 pm		**Apurva Sawant,** Goa University, Goa "Characterization of bioactive compounds isolated from mangrove endophytic fungi and its potential activity against A549 lung cancer cell line"
12:25-12:35 pm		**Thokchom Sarda Devi,** University of Delhi, New Delhi "Effect of *Rhizophagus intraradices* on the chemical profile of *Ocimum tenuiflorum* essential oil"
12:35-12:45 pm		**Anik Sarkar,** University of Calcutta, Kolkata, India "Nitric oxide: A signal mediator in Chilli - *Alternaria alternata* interaction"
12:45-12:55 pm		**Pooja,** University of Delhi, New Delhi, India "Diversity of Secreted in Xylem genes and Phylogenetic Relationships among the members of *Fusarium oxysporum* species complex "
12:55-01:05 pm		**Sudeshna Nandi,** University of Calcutta, Kolkata, WB, India "Astrakurkurol potentiates apoptosis, autophagy and attenuates cell migration, via fine tuning the AKT signaling in human lung adenocarcinoma cells (a549)"
01:05-01:15 pm		**Tahira Akther,** B.S. Abdur Rahman Crescent Institute of Science and Technology, Vandalur, Chennai, TN, India "Efficacy of endophytic fungus mediated silver nanoparticles against plant pathogens and multi-drug resistant *E. coli* strains"
01:15-01:25 pm		**Samta Gupta,** University of Delhi, New Delhi "Colonization by Arbuscular Mycorrhiza Fungi reduces arsenic accumulation, improve growth and promote nutrient acquisition in *Triticum aestivum* L. grown in arsenic contaminated soil"
01:25 – 02:00 pm		**BREAK**

Session – XI: Oral Presentation for Middle-Aged Faculties/Scientists (02:00 – 04:30 pm) **Moderator: Dr. Manish Kapoor**		
Chairperson		**Prof. B. F. Rodrigues,** Goa University, Goa
Co-Chairperson		**Dr. K.B.Vrinda,** JNTBGRI, Thiruvananthapuram, Kerala
02:00 – 02:15 pm		**C.K. Pradeep,** JNTBGRI, Thiruvananthapuram, Kerala **"The fungal dimension of biodiversity conservation"**
02:15 – 02:30 pm		**Paras N. Singh**, NFCCI, Agharkar Research Institute, Pune **"**Isolation and qualitative analysis of phosphate solubilizing fungi: an ecofreindly approach**"**
02:30 – 02:45 pm		**Vandana Ghormade**, Agharkar Research Institute, Pune "Antifungal activity of oil Nanoformulations against the plant pathogenic and spoilage fungi *Fusarium graminerum* and *Aspergillus ochraceus*"
02:45 – 03:00 pm		**T.S. Murali,** Manipal Academy of Higher Education, Manipal, India. "Epigenetic modification to improve metabolite production in endophyte cultures"
03:00 – 03:15 pm		**Somanjana Khatua,** *Krishnagar Governm ent College, Krishnagar, Nadia, West Bengal, India* "Immune boosting effect of traditionally appraised wild edible mushrooms"

03:15 – 03:30 pm		**Ranjeet Singh**, DAV College, Bathinda, Punjab **"**Assessment of elements in some *Ganoderma* species and their potential contribution to dietary intakes**"**
03:30 – 03:45 pm		**Nazir Ahmad Malik,** Central University of Jammu, J&K "Characterization and identification of some novel taxa and new records of lamellate fungi from Himalayan Belt of India"
03:45 – 04:00 pm		**Manoj Kumar. A,** Government College for Women, Thiruvananthapuram, Kerala **"**Morphological and molecular perspectives on systematics of genus *Crepidotus* in Kerala state**"**
04:00 – 04:15 pm		**Sapana Sharma,** DAV College, Jalandhar, Punja b "The potential of arbuscular mycorrhizal fungi for the cultivation of important medicinal herb – *Picrorrhiza kurroa*"
04:15 – 04:30 pm		**Mridu,** Dyal Singh College, Karnal, Haryana "A study on fruiting phenology, distribution, ecology and economic utility of wild lamellate mushrooms from Haryana."

VALEDICTORY FUNCTION (04:30 – 05:30 pm)		
04:30 – 04.35 pm		**Invocation**
04:35 – 04.40 pm Welcome address		**Prof. Munruchi Kaur,** Convener & Head, Department of Botany, Punjabi University, Patiala
04:40 – 04.45 pm Summary of the conference		**Dr. Avneet Pal Singh ,** Organizing Secretary, Department of Botany, Punjabi University, Patiala
04:45 – 04.55 pm Award Announcement		**Prof. N. Raaman,** Secretary, MSI
04:55 – 05.00 pm Remarks		**Prof. Rupam Kapoor,** President, MSI, University of Delhi, New Delhi
05:15 – 05.20 pm Vote of thanks		**Prof. J.I.S. Khattar,** Co-Convener, Department of Botany, Punjabi University, Patiala
05:20 – 05.25 pm Vote of thanks		**Prof. N. Raaman,** Secretary, MSI
05:25 – 05.30 pm		**National Anthem**

PATIALA - A PRINCELY STATE

Patiala, an erstwhile Princely State of Punjab, is situated in one of the geographically well defined Malwa region of Punjab. Malwa, surrounded by Sutlej and Ghaggar, has Himachal Pradesh in the North, Haryana and Rajasthan in the South-East and Pakistan in the North-West. The city was founded by Baba Ala Singh in 1763. The foundation of the Patiala Fort, now called Qila Mubarak, was laid in 1763 on the site which Baba Ala Singh had acquired in 1756. The fort is located in the center of the city. Baba Ala Singh and his descendents later on ruled over this state till the freedom of India. In the wake of reorganization of states, Patiala was merged into the Patiala and East Punjab State Union (PEPSU). The city of Patiala continued to be the capital in the new set-up. On 1st November, 1956 PEPSU was merged into the Punjab State. Keeping in view the historical significance of the city, some state level organisations like Punjab Public Service Commission, Punjab Language Department, North Zone Cultural Centre and Punjab State Electricity Board are located at Patiala. Partition of the country resulted in large scale migrations from West Punjab which created a change in the culture. It also marked the beginning of dismantling of the feudal structure built over the years. Earlier, being capital of PEPSU, Patiala became a vibrant town, bustling with political, social, administrative, educational and cultural activities.

A famous educational institute Government Mohindra College was founded at Patiala as early as in 1870 by Maharaja Mohinder Singh, the great patron of modern education. Other colleges, such as State College of Education, Bikram College of Commerce, Govt. College for Girls, College of Physical Education, GSSDGS Khalsa College, M.M. Modi College, Gurmat College, Govt. Medical College, Govt. Dental College and MSK Khalsa college came into existence afterwards. By late fifties Patiala became an important educational centre in the state of Punjab. The establishment of Punjabi University in 1962 acted as a catalyst for the process of expansion of education. Punjabi University, the first University in India and second in the World named after the language, was set up for the promotion of Punjabi language, art and culture. Two more universities, Thapar University and Rajiv Gandhi National University of Law were established in the recent past.

Patiala is also known for its Pagree (turban), Paranda (tussled tag for braiding hair), Patialavi Salwar (Ladies dress) and Jutti (footwear).

Patiala is a sports capital of India, as it has unparalleled tradition of modern and royal games such as cricket, polo, skating, etc. It was due to the great efforts of Maharaja Bhupinder Singh that India was put on the World map of cricket. Gymkhana club in the Baradari Gardens used to be the hub of eminent cricketers of the world. Royal patronage to Athletics, Hockey, Polo and Wrestling was so significant that Patiala teams acquired International excellence. Even today, excellent sports coaching facilities are available at Netaji Subash National Institute of Sports (N.I.S.) at Patiala. It is the city which besides being centre of Physical activity has also been and cultural hub. Patiala darbar attracted a large number of writers and singers. Their contribution to music was so significant that their style came to be known as Patiala Gharana.

The city is widely known for its beautiful historical shrines of Sikhs, Hindus and Muslims. Gurudwara Dukh Niwaran Sahib is held in great veneration by the devotees. Kali Devi Mandir on the Mall Road is the centre of pilgrimage for the devotees of mother Goddess. The tomb of Bute Shah attracts not only muslims but also Hindus and Sikhs.

Moti Bagh Palace, now housing N.I.S., is surrounded by lush green gardens, beautiful fountains and adjoining to it is Sheesh Mahal (The Hall of Mirrors). Patialavis have played a significant role in the freedom struggle. It is from here that Parja Mandal movement gathered momentum. The statue of Sardar Sewa Singh Thikriwala that adorns a square on the Mall road stands as a monument to the saga of struggle and sacrifice for the cause of freedom from the Maharajas and Britishers. Patiala city is marching ahead from its old tradional image yielding place to new vibrant modern image.

PUNJABI UNIVERSITY-AT A GLANCE

Punjabi University Patiala, one of the premier institutions of higher education in the north of India, was established on the 30th April, 1962 under the Punjabi University Act 1961. This is the second University in the world to be named after a language, the first being Hebrew University of Israel. The University that started with the objective of developing and promoting the language, literature and culture of the Punjabi people, has evolved into a multi-faceted multi-faculty educational institution. Presently it has sixty five teaching and research departments including 14 science departments under the faculties of Life Sciences, Physical Sciences and Medical Sciences. The University provides international standard facilities for students and researchers in various disciplines.

The University has a modern well planned campus situated on Patiala-Chandigarh road at a short distance from the main city. Sprawling across 316 acres, the campus is away from the din and noise of the city. It presents a splendid sight of magnificent buildings which includes the famous Guru Gobind Singh Bhawan.

The University was awarded Five Star Status by the National Assessment and Accreditation Council (NAAC), an autonomous institution of the U.G.C. in the year 2000. Similarly, was accredited as A-Grade University in the year 2008. Recently, NAAC has accredited this University again with A-Grade. The University has received the prestigious Maulana Abul Kalam Azad Trophy consecutively for ten years (2006-07 to 2016-17) to claim the status of the best University of the country in sports.

The University has twelve regional centres/Neighbourhood campuses namely Guru Kashi Campus, Talwandi Sabo; Regional Centre, Bathinda; Regional Centre for Information Technology and Management, Mohali; Nawab Sher Mohammad Khan Institute of Advanced Studies, Malerkotla; Dr. Balbir Singh Sahitya Kendra, Dehradun; Neighbourhood Campus, Rampura Phul; Neighbourhood Campus, Jhunir; Punjabi University Baba Jogi Peer Neighbourhood Campus Ralla; Punjabi University Akali Phula Singh Neighbourhood Campus Dehla Seehan; Punjabi University Neighbourhood Campus Sardoolgarh; Punjabi University Neighbourhood Campus, Jaitu and Punjabi University Neighbourhood Campus Karandi and Mour.

The University has maintained the estate of Dr. Norah Richards at Andhretta in Himachal Pradesh which the noted artist donated to Punjabi University. The buildings of the estate have been renovated keeping the original architecture intact. Arrangements have been made for the stay of faculty members and students who wish to carry out study and research in the field of Theatre and Television. The Department of Youth Welfare organizes youth activities during the summer at Andretta (Youth Leadership Camps) and the Department of Theatre and Television also arranges theatre performances at Andhretta.

The University has maintained research facilities for scholars at Dr. Balbir Singh Sahitya Kendra at Dehradun. There is a rich library with rare books and manuscripts bequeathed by Bhai Vir Singh, Dr. Balbir Singh and Prof. Puran Singh, the doyens of Punjabi literature. Research on comparative religions is carried out there. This centre is being developed as an Advanced Centre for Sikh Studies.

Bhai Kahn Singh Nabha Library is a hub of academic and research activities. Centrally air conditioned Library housed in a spacious building and kept open for 360 days of the year from 8.15 a.m. to 8.15 p.m. It possesses 5,00,000 books and subscribes to 600 new journals and 26 newspapers. Approximately 10,000 latest books are added every year. Besides this, CDs and Microfilms are also available. It has a majestic reading hall with a seating capacity of 400 readers. A separate air conditioned Reading Hall for using personal books has been provided at the ground floor. The night reading room remains open upto 2.00 a.m. at night. The Library is being run on modern lines with on-line catalogue services. Internet Access Lab has been established for using electronic documents. The Library also provides photocopying, reference and Inter-Library Loan (ILL) facilities for readers.

Dr. Ganda Singh Punjabi Reference Library, which is an integral and precious part of the library is housed in a building which is interlinked with the main building. This library has 55,000 books on Punjabi Language and Literature, Punjab History, Punjabi Culture and Sikh religion. It subscribes to 122 current journals, 48 journals en gratis and 10 Punjabi newspapers. Approximately 400 Microfilms are also available. Fifty two donors have donated their personal collections to this library which is a valuable treasure. In addition to the Main Library, most of the teaching departments have their own department libraries. Bar-Coding of documents has been completed and issue and return of books is computerized. Membership of all the university employees has been computerized.

The Department of Distance Education was established in the University in 1968 and has been a pioneer institute imparting education through the distant mode. It is the second institute in the country to adopt the non-formal mode of imparting education. For the first time in the country, this Department offered regional language as the medium of instruction and examination. Presently, the Department is managing 33 multi-faculty programmes including professional and job-oriented courses, like B. Ed., M. Ed., M. Com., Diploma in Journalism & Mass Communication, Diploma in Library Science, Bachelor of Library & Information Science and PG Diploma in Insurance Business. The Department has a well-equipped library which supplies text and other reading material to the students.

The University Computer Centre provides central facility to cater to the needs of students, research scholars, faculty and the various wings of the University administration. The Centre has three labs with a sitting capacity for 50 students. The Centre has established a local area network and all University Departments enjoy the facilities of Internet and e-mail through this network. The Centre as well as the teaching Departments are equipped with the latest computers and software. The University has its own website-www.punjabiuniversity.ac.in, which is being maintained by the Centre. The website provides rich information about the University which is not only beneficial for the University community but also for the outside world.

An Advanced Centre for Technical Development of Punjabi Language, Literature and Culture has also been established on the Punjabi University, Campus. The objective of the centre is to give fillip to research in the development of Punjabi Language, expand the network of usage of Punjabi, make available E-learning of Punjabi Language globally and help overcome the limitations imposed by scripts (Gurmukhi and Shahmukhi). The most important achievement of this centre is the development of a Gurmukhi to Shahmukhi (Urdu) transliteration software. This software named Sangam can be used to convert any Punjabi text typed in Gurmukhi script to Shahmukhi script. A website for online teaching of Punjabi has also been developed by the centre. The website aims to fulfill the long pending demand of Punjabis settled outside Punjab and abroad for learning Punjabi on internet while sitting in their homes.

Centre for Advanced Media Study (CAMS) located at Punjabi University, is one of the seventeen centres in the country. It has been promoted under the Consortium for Educational Communication (ECE) Programme of Inter-University Centre of University Grants Commission for Countrywide Class Room teaching through educational films being telecast by the Doordarshan. This Centre has a well-equipped full-fledged studio which is equipped with the latest digital apparatus. The Centre has already produced more than 64 educational films covering various aspects of different fields of education including art and culture of Punjab.

The Publication Bureau, established in 1966 has a unique and important place in the academic life of the University. It has been publishing the research works, books and journals, produced by different departments of the University. A special scheme called 'book bank' has been introduced by the University to make the university publications easily available to the masses at low cost.

The Directorate of sports works for promoting sports in the University and its affiliated colleges. It organizes inter-college competitions in various games and trains students for participation in inter-university, National and International games. Well maintained infrastructure and facilities for games such as hockey, football, cricket, basketball, volleyball, archery, athletics, etc. have been maintained. The Punjabi University also has a large gymnasium and a hall for indoor games. It is one of the very few institutions in India to possess its own Velodrome.

The Youth Welfare Department of the University organizes youth activities all round the year. The Punjabi University has won unique distinctions in Youth Festivals organized by the Association of Indian Universities in collaboration with the Ministry of Youth Affairs, Govt. of India; Directorate of Youth Services, Punjab; Directorate of Higher Education, Punjab and Panjabi Academy of Delhi State. Students of Punjabi University have had the privilege of representing India in the Festivals of India held in Russia, Mauritius, Spain, China, Germany and U.A.E. (Dubai). This department also organizes Hiking, Trekking, Mountaineering, Rock Climbing courses, and Youth Leadership Training Camps.

The National Service Scheme is one of the most significant programmes of the University. It inculcates the spirit of voluntary work among students and teachers through sustained community interaction. The major activities of NSS on the campus include regular camping programmes, environmental pollution control, health awareness, adult education and blood donations.

A well equipped Health Centre, with qualified physicians and paramedical staff, is at the service of the students round the clock. The Centre has an AIDS awareness wing. Students of various teaching departments at the campus are entitled to free medical aid by the University Health Centre. The Health Centre is equipped with basic necessary and modern equipments.

A Counselling Cell for students and employees of the University has been established in the University. This cell is monitored by the Department of Psychology.

\ There are thirteen residential Hostels on the campus : six for boys and seven for girls. The Hostels have all modern amenities for comfortable living for about 3500 students. There are two (one for boys and one for girls) hostels at Guru Kashi Campus, Talwandi Sabo and two hostels (one for boys and one for girls) at Punjabi University Neighbourhood Campus, Rampura Phul. The strength of these four hostels is 550 for boys and 550 for girls. All the hostels have wi fi facility.

The University Enquiry and Information Centre has been set up at the Main Gate to provide all facilities under one roof to the students and parents with regard to admissions, results, information regarding Distance Education and general courses, receipt of examination forms and canteen facilities. The Centre also provides computerized results to the students and handles enquiries of all sorts. The students also get counseling services during admissions.

The Transport Department of the University runs a fleet of buses for linking the campus to various parts of Patiala city.

The Carrier Counselling cum Placement Cell strives to bridge the gap between industry and academia and take care of the training and placement requirements of our students. In this regard, experts from industrial organizations/premier institutes are invited from time to time. Working in collaboration with Infosys Technologies under their "Campus Connect" initiative, training is being provided to students for development of technical as well as soft skills. A large percentage of our students have been receiving job offers from various prestigious organizations viz. Infosys, TCS, Tech Mahindra. Atos Origin. Soma. Swaraj Mazda Ltd., Honda 2 Wheelers, etc. For management streams, offers were received from IDB1 Bank, HDFC Bank, Hindustan Times, Jupiter International, Mahindra Finance, etc. Besides these, students from other departments also find placements with industry/professional institutes.

About 11,000 students are enrolled in various departments of the University besides about 10,000 receive education through the Department of Distance Education. Over 2300 scholars are presently enrolled or registered for Ph.D. in various departments of the University. With 207 colleges affiliated to the University it is the largest University of the state.

Women's Studies Centre was allocated to Punjabi University by University Grants Commission under XIth Plan, in August 2009. Its main objective is the pursuit of a comprehensive critical and balanced investigation of the cause of gender disparity. The centre also aims at revitalizing University education bringing it closer to burning social issues and working towards their solutions.

Department of Tourism, Hospitality and Hotel Management established in 2010 with a vision of a world class Hotel Management training centre with state of the art facilities is all set to offer students Global perspectives and prepare them to face challenges in Hospitality and Tourism sectors. The

objective of the Department is to impart students with latest Hospitality knowledge, skills, concepts and management teachings to make them productive and professional for taking up leadership positions in Hospitality and Tourism sector all over the world.

Punjabi University took the 'exclusive initiative' by setting up a Centre for Advanced Media Studies (CAMS) with new kinds of technical, professional, advanced and specialised courses to befittingly train students for a plethora of jobs awaiting them in the glamourous Television and Film worlds. The lastest milestone that CAMS has now achieved is signing of an agreement with Communications Studies and Integrative Media Department of Wilkes University, Pennsylvania, USA.

Three Engineering Colleges have been established by the University one each on the campus (UCOE), Talwandi Sabo (YCOE) and at Rampura Phul. In these colleges specalized courses including Computer, Mechanical, Electronics, Electrical and Civil Engineering streams are being run successfully.

The Sophisticated Instruments Centre (SIC) was established in 2012 as a necessary and very important facility for carrying out research work in the field of Life Sciences, Medical Sciences and Physical Sciences. The latest models of various scientific instruments like Scanning Electron Microscope (SEM), HPTLC, Flash Chromatograph, Real Time PCR, Thermo-cycler, Gel electrophoresis, Gel Doc System, Autoclave, Ultra-centrifuge, Ultra-Freezer (-80°C), Spectrophotometer, Spectroflourimeter, Lyophilizer and Florescent Microscope, etc. have been installed in the SIC laboratories. The building and majority of the instruments have been purchased with grant from UGC and DBT. A Fossil Museum has been established in the centre which attracts lot of visitors.

Three departments of the University have been bestowed with the status of Centre for Advanced Studies by UGC. Similarly, some of the departments have been covered under the SAP schemes of DSA and DRS, respectively. Nine science departments of the University have been covered under the FIST scheme of DST. The list of the departments covered under different schemes is given below:

1. Department of Physics (CAS)
2. Department of Punjabi (CAS)
3. Department of Economics (CAS)
4. Department of Botany (ASIST, FIST, DSA-I under SAP of UGC)
5. Department of Computer Science (FIST)
6. Department of Zoology (FIST, SAP)
7. Department of Biotechnology (FIST)
8. Department of Chemistry (FIST, SAP)
9. Department of Human Biology (FIST, SAP)
10. Department of Pharmaceutical Sciences & Drug Research (FIST)
11. Department of Forensic Science (FIST, SAP)
12. Department of Physiotherapy (FIST)

DEPARTMENT OF BOTANY

The Department of Botany at Punjabi University started functioning with effect from February 1, 1967 and celebrated year 2016 as Golden Jubilee year. It was the fourth department in the Faculty of Science being started after Mathematics, Physics and Chemistry. The work for establishment and development of department was initiated by Prof. S.S. Bir assisted by a team of dedicated teachers. Besides the Head of the department, the staff during 1967-68 session was represented by two lecturers, two instructors, Superintendent Botanic garden and Curator of Museum and Herbarium. During the first academic year in 1967-68, twenty students were admitted to M.Sc. (Previous) course and later on the students' strength has been raised to 30. From academic session 2003-04 semester system was re-introduced. M.Phil. course was introduced from 1976 academic session with the admission of 10 students. Another course after 10+2, M.Sc. (Honours) Botany (Five Year Integrated Course) was started with 20 seats from the academic session 2012-13. During the academic session 2017-18, the department has converted the M.Sc Botany (Two year) course into M.Sc. Honours Botany (Two year).

Since its inception, the Department has been engaged in imparting instructions at M.Sc. and M. Phil. level besides guiding students for Ph.D. Degree. So far, 120 students have been awarded Ph.D. Degrees. Most of the students of this department have taken up teaching as a profession at School, College and University levels. Some of them have gone for research jobs, administrative services (IRS, IFS, PCS, etc.) and some even have floated their own enterprise.

During the last 54 years of its existence, the faculty members of this department have published 38 books and over 1720 research papers in various international and national journals with impact factor ranging 0.5-5.3 In addition, many research projects have been successfully completed or are under execution in the department.

The Department has signed MoU with IHBT (CSIR), Palampur and Directorate of Mushroom Research (ICAR), Chambaghat, Solan for collaborative research. There are number of students pursuing research in collaboration with neighbouring departments including Department of Biotechnology and Department of Pharmaceutical Sciences of Punjabi University, Patiala. A research project ('Support to Establish DBT Interdisciplinary Life Science Programme for Advanced Research and Education' with budget of about Rs. 4 crores) was allocated by DBT, New Delhi which was executed with other Departments of Life Sciences in the University.

The University Grants Commission, New Delhi has inducted the department of Botany in Special Assistance Programme DSA-I to conduct researches in the thrust areas of Cytogenetics, Mycology & Plant Pathology and Algal Physiology for a period of five years from 1st April 2016 to 31st March 2021. DST has also funded the Department under FIST programme. In 2014, Ministry of Environment and Forests, Government of India sanctioned an amount of Rs. 40 lakhs for upgradation of facilities in the Botanic Gardens of the department. The department has successfully completed DRS Phase-I,II & III of UGC.

HEADS OF THE DEPARTMENT OF BOTANY

(Established February 1, 1967)

1.	Professor S. S. Bir	February 1, 1967 to January 31, 1982
2.	Professor B. S. Gill	February 1, 1982 to January 31, 1985
3.	Professor S. S. Saini	February 1, 1985 to January 31, 1988
4.	Professor M. L. Trivedi	February 1, 1988 to January 31, 1991
5.	Professor M. Sharma	February 1, 1991 to January 31, 1994
6.	Professor T. A. Sarma	February 1, 1994 to January 31, 1997

7.	Dr. P. Kumar	February 1, 1997 to May 12, 1999
8.	Professor J. S. Dargan	May 13, 1999 to May 12,2002
9.	Professor (Mrs.) M. K. Sidhu	May 13, 2002 to May 12, 2005
10.	Professor (Mrs.) Santosh Kumari	May 13, 2005 to May 12, 2008
11.	Professor R. C. Gupta	May 13, 2008 to May 12, 2011
12.	Professor N. S. Atri	May 13, 2011 to May 12, 2014
13.	Professor M.I.S. Saggoo	May 13, 2014 to June 30, 2015
14.	Professor J.I.S. Khattar	July 01, 2015 to June 30, 2018
15.	Professor Munruchi Kaur	July 01, 2018 onwards

FORMER MEMBERS OF THE FACULTY

1.	Professor S.S. Bir	11.	Professor T.A. Sarma
2.	Professor B.S. Gill	12.	Professor (Mrs.) M.K. Sidhu
3.	Professor S.S. Saini	13.	Dr. Gurpreet Kaur
4.	Professor M.L. Trivedi	14.	Professor (Mrs.) Santosh Kumari
5.	Professor M. Sharma	15.	Professor Gurpaul Singh
6.	Dr. Parshotam Kumar	16.	Professor Amajeet Singh
7.	Dr. C.K. Satija	17.	Professor V.K. Singhal
8.	Professor P.D. Mangal	18.	Professor R.C. Gupta
9.	Professor J.S. Dargan	19.	Professor M.I.S. Saggoo
10.	Professor S.M. Vasudeva	20.	Professor N.S. Atri

CURRENT FACULTY

Professors:

1. J.I.S. Khattar (b. 4th April, 1962): M. Sc. (Punjabi Univ., 1983), M. Phil. (Punjabi Univ., 1985), Ph.D. (Punjabi Univ., 1989); Date of joining this Department: 13th December, 1991; Field of Specialization: Physiology, Biochemistry and Biotechnology of Cyanobacteria; Research Activities: Published 65 papers, edited one Book, guided 16 Ph.D., 8 M. Phil. and 12 M. Sc. students. Completed 5 major research projects (CSIR, UGC) and one minor research project (UGC); One CSIR Research Project continuing. Dean, Faculty of Life Sciences, Head of the Department (2015-2018), Professor Incharge Examinations (2020 on wards); Member Senate and Syndicate, Punjabi University, Patiala, Member Editorial Board, Journal Indian Botanical Society, Vice President Indian Botanical Society-2018, Fellow Indian Botanical Society; Councilor of Indian Botanical Society (2014-2017); Coordinator DSA-I of UGC; Coordinator FIST of DST, Life Member, Indian Botanical Society, Association of Microbiologists of India, Indian Science Congress Association, Biotechnological Research Society of India. Associate Editor Vigyan De Nakash (1990-91); Editor Children Encyclopedia, Punjabi University, Patiala, International Journal of Environment Monitoring and Assessment.

Contact: jisk_pbi@rediffmail.com; +91-175-2220986; +91-94172-42986

2. Munruchi Kaur (b. 27th June, 1968): M.Sc. (Gold Medalist, Punjabi Univ., 1990), M. Phil. (Punjabi Univ., 1992), Ph.D. (Punjabi Univ., 1996); Worked in Punjab Government College Cadre 1996-2006; Date of joining this Department: 2nd January, 2006; Field of Specialization: Mushrooms, Mycology & Plant Pathology; Research Activities: Published 71 papers and 1 book in Punjabi; Guided 8 Ph.D., 6 M. Phil and 8 M.Sc. Students; One DBT Project continuing; Member Editorial Board KAVAKA

Journal of Mycological Society of India, Dy-Coordinator DSA-I of UGC, Coordinator, FIST of DST, Head Department of Botany; Director, UGC-HRDC, and Former Director, Directorate of International Students, Punjabi University, Patiala. Membership: Indian Science Congress, Life Member of Mushroom Society of India, Life Member Mushroom Growers Association, Life Member Mycological Society of India, Life Member Punjab Academy of Sciences, Indian Society of Mycology and Plant Pathology, Life Member The Biotech Research Society of India, Indian Association of Biology Teachers.

Contact: munruchi@gmail.com; +91- 99881-95434

3. Davinder Pal Singh (b. 30th May, 1964): M.Sc. (Punjabi Univ., 1986), Ph.D. (Punjabi Univ., 1993); Date of joining this Department: 2nd January, 2006; Field of Specialization: Physiology & Biochemistry of Cyanobacteria; Research Activities: Edited Book 01, Published **40** papers, Guided 0**6** Ph.D., 04 M.Phil. and 0**7** M.Sc. students. Research Projects Completed: Four; Ex-Councilor of Indian Botanical Society; Life Membership: Indian Botanical Society, Biotechnological Research Society of India, Indian Association of Biology Teachers, Association of Microbiologists of India.

Contact: dp.khokhor@rediffmail.com; +91-0175-5136265; +91-98761-60834

Associate Professors:

1. Manish Kapoor (b. 27th Nov., 1975) : M.Sc. Landscaping and Floriculture (Punjab Agricultural University, Ludhiana, 1999); Ph.D. Horticulture (G.B. Pant University of Agriculture and Technology, Pant Nagar, 2012); Date of joining this department: 25th June, 2003; Field of Specialization: Floriculture, Landscaping, Urban Horticulture, Seed production, Micropropagation and Mutation Breeding. Research activities: Published 48 research papers, 25 book chapters, 16 popular articles and delivered radio talk on All India Radio. Guided 1 Ph.D., 1 M.Phil and 8 M.Sc. Students, Membership: Life member Indian Society of Ornamental Horticulture, Punjab Academy of Sciences, Indian Science Congress Association, International Consortium of Contemporary Biologists, The Horticultural Society of India, Indian Botanical Society, International Journal of Agriculture Science. Awards and Honours: Gold Medalist in B.Sc. Agriculture (Hon's in Horticulture) Guru Nanak Dev University, Amritsar (1997); Merit Certificate in M.Sc. Landscaping and Floriculture, Punjab Agricultural University, Ludhiana (1999). Merit Certificate in Ph.D. Horticulture (Floriculture and Landscaping) G.B. Pant University of Agriculture and Technology, Pantnagar (2012); Conferred Young Scientist Award by Academic Council of International Consortium of Contemporary Biologists, 2009. Member Editorial Board Journal of Environmental and Agricultural Sciences, Pakistan and Universal Journal of Plant Sciences, USA. Member NCERT working group on vocational courses. Member International Union for Conservation of Nature (IUCN) (Commission on Education and Communication, Seed Conservation Specialist Group of Species Survival Commission) 2017 onwards.

Contact: jdmanishkapoor@yahoo.com; +91-94170-57589

2. Geetika Sirhindi (b. 8th May, 1972): M. Sc. (Punjabi Univ., 1995), Ph. D. (Punjabi Univ., 2001), Date of Joining this Department: 26th August, 1999; Field of Specialization: Plant Physiology & Stress Physiology; Research Activities: Published 45 Papers; 8 Book Chapters, Guided 15 Ph.D., 4 M.Phil and 9 M.Sc. students; Handled 3 research projects (UGC, DST); Membership: Life Member Indian Society of Plant Physiologists, Life Member Punjab Academy of Sciences, Life Member Indian Fern Society, Life Member Indian Science Congress Association, Life Member Indian Botanical Society, Life Member of Biotechnology Research Society.

Contact: geetikasir123@gmail.com, geetika@pbi.ac.in; +91-94178-07407

Assistant Professors:

1. Arneet Grewal (b. 4th February, 1976): M.Sc. (Punjabi Univ., 1998), Ph. D. (Punjabi Univ., 2005); Date of Joining this Department: 2nd July, 2007; Field of Specialization: Cytogenetics, Environmental Mutagenesis, and biochemical analysis; Research activities: Published 21 papers, 1 book. Guided 3 Ph.D., 2 M.Phil and 6 M.Sc. students; Life Member Punjab Academy of Sciences. Biotechnology Research Society of India, Indian Science Congress Association.

Contact: arneet@pbi.ac.in; +91-94171-73865

2. Avneet Pal Singh (b. 7th October, 1978): M.Sc. (Punjabi Univ., 2002), Ph. D. (Punjabi Univ., 2008); Date of Joining this Department: 01st August 2011; Field of Specialization: Mycology and Plant Pathology; Research activities: Published papers 58, Guided 5 Ph.D., 2 M.Phil and 6 M.Sc. students; Life Member, Mycological Society of India, Punjab Academy of Sciences. One DST Research project; Managing Editor, KAVAKA.

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HERBARIUM, MUSEUM AND BOTANICAL PHOTOGALLERY

The Herbarium and Museum was established with the inception of Botany Department in the year 1967 and for about 20 years it was situated in the departmental building. Since 1986 it is housed in a separate building adjacent to the department.

MUSEUM

The ground floor of the building is devoted to the museum whereas the first floor to the herbarium. In the museum the materials of botanical interest are displayed group wise in museum jars and show-cases numbering more than 2,000. Fossil specimens of Pteridophytes, Gymnosperms and Angiosperms are important possession of the museum, especially procured for the study purpose. A separate section has been earmarked for economic plants. Pieces of important timbers of Punjab showing annual growth rings are also displayed. Besides, research publications and books published by the department faculty are displayed for consultation by the researchers. Plants and other specimens for the museum have been collected from Eastern and Western Himalayas, Okha Port, Rameshwaram, Kodai Kanal, Ooty, Palghat, Pachmarhi, Mysore, Calicut, Valley of Flowers, Darjeeling, Hem Kunt, Badri Nath, Kinnaur, Kedar Nath, Gangotri, Rohtang Pass, Churdhar Peak, Yamunotri, Kashmir Valley, Chakrata, etc. Some representative types of different groups are listed in the ongoing account against the respective group.

Algae: The herbarium and museum has rich collection of Algae particularly of Conjugales and marine algae. Some of the marine algae collected from Okha Port and Rameshwaram and other sea beaches displayed in the museum are the species of *Caulerpa*, *Iyengaria*, *Sargassum*, *Botryocladia*, *Helimeda*, *Sarcomenia*, *Calpomenia*, *Codium*, *Padina*, *Agardhielia*, *Nemalion*, *Corallina*, *Gracilaria*, *Ulva*, *Halymenia*, *Neomeris*, *Champia*, *Dasya*, *Rhizoclonium*, *Boodlea*, *Valonia*, *Udotea*, *Myriogloea*, *Laminaria*, *Furcellaria*, *Dictyosphaeria*, *Ceramium* and *Liagora*.

Fungi: Large number of diseases of economic plants and important trees are displayed in museum jars and show cases. Museum is quite rich in collection of members of Russulaceae, wood rot fungi and *Agaricus*. Besides, other important species include, *Halvella*, *Morchella*, *Ramaria*, *Podaxis*, *Thelephora*, *Xylaria*, *Lepiota*, *Amanita*, *Lenzites*, *Tremella*, *Agrocybe*, *Coprinus*, *Geaster*, *Lycoperdon*, *Lactarius*, *Fomes*, *Schizophyllum*, *Ganoderma*, *Nectria*, *Russula*, *Auricularia*, etc.

Byrophytes: Several liverworts and mosses collected from Darjeeling, Mussoorie, Nainital, Dalhousie and Shimla Hills have been displayed in the museum. Important among these are: *Riccia fluitans*,

Marchantia palmata, *M. polymorpha*, *Conocephallum conicum*, *Haplomitrium hookeri*, *Sewardiella tuberifera*, *Stephensoniella brevipedunculata*, *Lejeunea* sp., *Sphagnum* sp., *Rhodobryum* sp., *Pogonatum* sp., *Funaria* sp., etc.

Pteridophytes: Museum is especially rich in the collection of Pteridophytes from almost all the regions of India. Some of the rare Pteridophytes in the departmental museum include: *Psilotum triquetrum*, *Isoetes panchananii*, *Lycopodium clavatum*, *L. cernuum*, *L. phlegmaria*, *L. serratum*, *L squarrosum*, *L. wightianum*, *Ophioglossum nudicaule*, *O. vulgatum*, *Botrychium lanuginosum*, *Helminthostachys zeylanica*, *Angiopteris evecta*, *Marattia fraxinea*, *Osmunda regalis*, *O. claytoniana*, *Dicranopteris* linearis, *Vittaria elongata*, *Cheilanthes tenuifolia*, *Didymoglossum insigne*, *Selaginella adunca*, *Tectaria macrodonta*, *Nephrolepis exaltata*, etc.

Gymnosperms: Besides common Indian gymnosperms, several exotic species have been kept in the museum. These are mainly collected from Darjeeling, Shimla, Manali, Dalhousie, Mussoorie and Nainital. These are: *Cupressus cashmeriana*, *C. arizonia*, *C. funebris*, *C. macrocarpa*, *C. glabra*, *Cunninghamia lanceolata*, *Cryptomeria japonica*, *Cephalotaxus drupacea* var. *pedunculata*, *Cycas circinalis*, *Araucaria cookii*, *A. cunninghamii*, *A. bidwillii*, *Agathis robusta*, *Ginkgo biloba*, *Ephedra gerardiana*, *Metasequoa glyptostroboides*, *Podocarpus chinensis*, *Pinus densifolia*, *P. insularis*, *P. laricio*, *P.* patula, *P. taeda*, *Retinospora ellewangeriuma*, *Thujopsis dolobrata*, etc.

Angiosperms: Large number of flowering plants have been kept in the Museum which have been collected from almost all the places. Some plants of special interest are: Balanophora indica - a root parasite from the forests of Kodai Kanal; *Viscum nepalense* - a stem parasite from Bombay; *Cistanche tubulosa* - a stem parasite; *Piper nigrum* (Pepper); *P. longum* (Magan); *Rauvolfia serpentina* (Sarpagandha); *Nepenthes khasiana* (Pitcher plant from Assam); *Theobroma cacao* (Cocoa plant from Calicut); *Arceuthobium minutissimum* (smallest dicot - a parasite on the bark of *Pinus wallichiana* in J & K); *Santalum album* (Sandal wood from Tamil Nadu); *Mesua nagasaurium* (Iron wood from Tamil Nadu); *Elaeocarpus sphaericus* (Rudraksh); *Areca catechu* (Supari from Calicut); *Tylophora indica* (used against Asthama); *Humulus lupulus* (J & K); *Betula utilis* (Bhoj patra, J & K); *Colchicum luteum* (colchicine plant, J & K); *C.* autumnale, *Digitalis lanata* (J & K); *D. purpurea* (J & K); *Atropa belladona* (J& K); *Saussurea obvallata* (Braham Kamal - Hem Kunt), etc.

HERBARIUM

The herbarium is considered as one of the best amongst the Indian Universities. It has been recognized by the International Bureau of Plant Taxonomy, Netherlands with PUN as its abbreviation. It has a collection of nearly 65,280 angiosperms, 5,123 pteridophytes, 8130 fungi and 630 algal specimens which are well preserved/mounted, identified and catalogued. The angiosperm flora is separated into the sections as Monocots and Dicots, and are further arranged according to Bentham and Hooker's system of classification. The herbarium is especially rich in collections of Indian Pteridophytes which are arranged according to Jermey and Carbe's system of classifications. The collection of materials/plants for Herbarium and Museum was started in 1967. It now includes representative collections from almost all the Indian regions and is being enriched every year through collections from different phytogeographical regions of the country. The department has started its own website www.pupbotany.org on which digitized data of the herbarium and museum is being uploaded.

BOTANICAL PHOTOGALLERY

A unique feature of the Herbarium and Museum is a botanical photogallery based on the top floor of the building created and designed aesthetically on International standards. Photographs and paintings of plant wealth have been displayed in various sections such as Plant Diversity, Indian Forests, Horticulture, Plants and Human welfare, Fungal Diseases, Sacred plants, Poisonous plants and Threatened and endangered plants. A separate section of Photographs depicting the various activities of the department is the prime possession of the photogallery. The gallery is open to public including students and teachers of various schools and colleges.

S.S. BIR BOTANIC GARDENS AND PLANT CONSERVATORY

Ever since the inception of the Department of Botany at Punjabi University, Patiala in 1967, the necessity for a botanic garden was immensely felt in order to cater to the needs of teaching and research. Firstly, a nursery was established in December, 1967 within an area of one hectare in order to serve as a core for the development of the garden. The living plants or their seeds were collected during various collection trips to the Himalayas and other parts of the country. The work on the present site of the botanic gardens, which is well laid and spread over an area of 12 hectares of land with sound underground irrigation facilities, concrete roads and zigzag paths began on April 9, 1971 with the plantation of Ginkgo biloba sapling by Sardar Kirpal Singh Narang, the then Vice-Chancellor of the university. The plant is a rare Buddhist tree of Japan commonly known as 'Maiden Hair Tree', generally considered a living fossil plant. The botanic gardens lies at 30° 20' N latitude and 76° 28' E longitude. It falls in the sub-tropical climatic belt at an altitude of 251 m above mean sea level. The area experiences an average annual rainfall of 870 mm and a temperature range of 3 to 45 °C. The soil of the garden is highly productive clay-loam.

LAYOUT: Broadly, the garden is divided into four sectors through intersecting concrete roads and each sector is well connected through concrete zigzag paths. The major plantation of the garden is on the basis of "Bentham and Hooker's system of classification of plants". The plants are divided into two main groups i.e. dicotyledons and monocotyledons. In the first group, the separate sector has been provided for Polypetalae, Gamopetalae and Monochlamydeae, where both indigenous and exotic trees, shrubs and climbers have been planted. Under the second major group, special attention has been given in raising bamboos, palms and bulbs. Stress is laid on the collection of North Indian flora and its conservation. The following different sections have been designed to accommodate the plant wealth of the garden.

1. Arboretum: About half of the area of the garden is under this section, where broad-leaved trees, high altitude conifers and flowering trees of aesthetic and recreational value, occupy a place of prominence.
2. Rosarium: It has been established on the left hand side of the entry point and has a collection of 48 rose varieties, which gives an aesthetic look to the garden.
3. Bougainvillea garden: It is a significant section near the tropical house with 40 Bougainvillea varieties in splendid colours.
4. Cactus and succulent garden: It is a vast area with sandy features and has more than 35 species of the xerophytic plants, which are well maintained.
5. Bamboo garden: It is a unique section with 10 different types of bamboos growing luxuriantly.
6. Palm garden: This section has a well grown collection of 15 types of palms and cycads.
7. Experimental plots: To cater to the needs of the research and education, the garden has a section for the experimental trials.

PLANT WEALTH: In the above sectors the plant wealth includes more than 450 species and varieties of plants, both native and exotic. Prominent among gymnosperms are cycads, pines, araucarias, podocarps, kauripines, junipers and ephedra. Important angiospermous plants are *Ficus elastica*, *Pterospermum lancaefolium*, *Sapindus emarginatus*, *Acacia auriculiformis*, *Albizia lucida*, *Melaleuca leucodendron*, *Strychnos nuxvomica*, *Oroxylum indicum*, *Sapium insigne*, *Ulmus integrifolia*, *Couroupita guianensis*, Pterygota alata, Chrysophyllum canito, etc. Rare plants such as, *Ginkgo biloba*, *Zamia floridana*, *Dioon* sp., *Podocarpus gracilior*, *P. neriifolius*, *Ravenala madagascariensis*, *Rauwolfia serpentina* and *Tylophora indica* are growing well. Each plant is provided with a name plate, giving information about the botanical name, family and country of origin.

INFRA-STRUCTURE: The garden has 5 structures which are of special interest and importance.

1. Poly house: This structure is being used for the propagation and hardening of the plants and has the facilities to control the temperature, humidity and light. The structure was constructed with the help of the grant from the 'Ministry of Environment and Forests' under the project 'Improvement of infra-structural facilities in the existing Botanical Garden of Punjabi University, Patiala.
2. Net house: It is a structure which is used for the propagation and cultivation of the indoor plants. It is also fitted with the misters.
3. Cactus house: A glass house structure designed specifically for the cultivation of xerophytic plants and has a collection of over 50 cacti.
4. Indoor plant house: This structure was constructed for growing the indoor/ shade loving plants.
5. Tropical house: It stands out as a good attraction, which has the facilities for providing the tropical conditions. It houses many tropical plants brought from the tropical region of the country and are growing well in this house.

VIP SECTOR: It is the heart of the garden. Prominent dignitaries and botanists viz. S. Kirpal Singh Narang, Mrs. I K. Sandhu, Dr. S.S. Johal, Dr. J.S. Puar and Dr. J.S. Ahluwalia, Dr. Jaspal Singh (Vice-Chancellors, Punjabi University, Patiala), Dr. Manmohan Singh and Prof. G. Rama Reddy (Chairman, UGC), Dr. T.N. Khoshoo (Director, NBRI, Lucknow), Dr. M.S. Swaminathan (Member Planning Commission, India), Prof. U.R. Rao (President 83rd Indian Science Congress), Nobel Laureate Mother Teresa, Harnam Dass Johar (Higher Education Minister, Punjab), and Prof. V. L. Chopra (Member, Planning Commission) have planted theme based saplings from time to time on their visits to the garden. The grown up plants now add charm and elegance to the site.

RECOGNITION: The garden is internationally recognized by an International Association of Botanical Gardens with its name "PATPU". Now the garden is well known throughout the world especially in south-west Asia. This recognition by the international organization has been widely acclaimed. The department exchanges plant wealth in the form of seeds, seedlings and cuttings with different institutions including colleges and Univerties.

PLANT CONSERVATORY

In order to conserve the fast vanishing flora of Punjab state, the plant conservatory spread over 10 acres has been established just adjoining the Botanical gardens. In addition to the conservation of indigenous and exotic plants, major emphasis is being given to the establishment of economic and timber plants of the state.

MEDICINAL GARDEN

A separate section of medicinal plants has been raised with over 70 well labelled plants, for which information about their medicinal utility has been provided on the respective name plate. This is a part of the attempt to conserve rare, threatened and endangered plants.

BOTANICAL SOCIETY, PUNJABI UNIVERSITY, PATIALA

For providing a platform for curricular and extra-curricular activities and to properly channelise the energies of the students, Botanical Society, Punjabi University, Patiala was started with the admission of first batch of students in 1967. The membership of the society is obligatory for all M. Sc. students, research scholars and members of the staff. All the members contribute to run the activities of the society.

The activities of the society include organization of seminars, tutorials, botanical excursions and paper reading contest amongst M. Sc. students. The society awards various prizes to the students regularly on the basis of these competitions. The affairs of the society are managed by the Student - Secretary under the guidance and supervision of teacher incharge and President of Botanical Society.

In order to provide financial assistance to the needy students, the Departmental Students Aid Fund was created in the department. Books, Journals and Scientific periodicals of the value of about Rs. 25,000 have been added to the departmental library through this society. Amongst the various prizes 'Hooker Memorial Prize" for the best plant album and 'Dr. A.C. Joshi Memorial Prize' for the best preparation of permanent slides are awarded to M.Sc. Students every year.

Presidential Address

ARBUSCULAR MYCORRHIZA IN SUSTAINABLE AGRICULTURE: PROSPECTIVE AND CHALLENGES

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At a time in which global food demand is exponentially increasing with concomitant shrinkage in the availability of farmable lands, microbes furnish a key role in sustainably optimizing agricultural processes. One such significant group of microbes that is extremely instrumental in sustainable agriculture is Arbuscular Mycorrhizal Fungi (AMF). This group of fungi thrives in soil and is crucial to multitudinous biological functions of plants. My interest in Plant-AMF interactions would not have had the spirit it has without the inevitable support of my supervisor, Late Prof. K.G. Mukerji, whose wisdom, passion for science, and authoritative guidance have been immeasurably valuable in my growth as a person and blossoming scientific temperament in me over all these years. My greatest degree of appreciation goes out to him for exposing me to the realms of this promising group of beneficial fungi that serve as agro-ecosystem engineers by fostering crop growth, securing nutrients, and even fending off pests and pathogens. The natural benefits of these microbes are a powerful complement to existing plant and soil treatments. I place on record my sincere gratitude to the honorable members of Mycological Society of India (MSI) for entrusting me and putting me on the forefront. I appreciate the very foundation and vision of MSI that has the endeavor to bring together the mycologists of the country and with the broad objective of promoting growth of mycology in India with wider perspectives. It is with great pleasure and humility that I express my deep sense of gratitude for having been able to serve this society over the years and pledge to continue to do so to the best of my ability. We, as a society, can go long in cultivating the interest of young researchers in mycology and its application and in realizing the long chased vision of sustainable agriculture.

Lifetime Achievement Award Lecture

MY ENDURING JOURNEY WITH FUNGI.....

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I am deeply honoured to have been nominated for 'Life-time Achievement Award of Mycological Society of India for 2020'. My journey with fungi commenced when I formally joined for doctoral studies under the guidance of world renowned mycologist, late Professor C.V. Subramanian, Centre of Advanced Studies in Botany, University of Madras, Chennai, in June 1974. On the advice of my guide, I first did one-year Post-M.Sc. Diploma in Mycology and Plant Pathology and then registered for Ph.D. in July 1975. With the pre-Ph.D. diploma providing needful basics on mycological techniques, I instantly started my doctoral work on taxonomic significance of perfect-imperfect connections (= holomorph) in Hypocrealean fungi. To begin with, I worked on a plant-pathogenic strain, then referred as *Fusarium nivale* (= *Monographella nivalis*). It was an interesting fungus, readily produced both sexual and asexual states in culture. So, my investigative work on the developmental morphology and life cycle of *F. nivale*, from an ascospore to conidial asexual state and sexual phase with ascocarp, asci and ascospores, was an easy run. Not only I studied the conidial ontogeny using Riddel's slide culture technique but also learnt step-by-step development of the entire sexual state using microtome-cut thin sections of paraffin-embedded ascocarps. Within six months, I unravelled the taxonomic placement of this fungus which turned out to be unlike a hypocrealean. Meanwhile, from literature I found out that, barring a couple of strains such as *Nectria haematococca,* easily growing holomorphic strains in Fusaria are very rare. This forced me to search for holomorphic Hypocrealean strains in nature and thus continued my journey with fungi..... In search of hypocrealean fungi, I crisscrossed the entire Western Ghats stretch in southern India, from scrub jungles to shoal forests, streams to rivers and coastal mangroves to inland plains. It was a great experience of seeing fungi from close proximity in nature, not only many Hypocrealeans but also myriad other microfungi. My interest in mycology grew many folds. On completion of doctoral thesis in June 1979, I joined a UGC-sponsored research project entitled 'Fungi of South India' with Prof C.V. Subramanian. Next two years, I travelled extensively in the forests of Western Ghats in Tamil Nadu, Kerala, Karnataka and Goa, collected hundreds and hundreds of microfungi and brought them to lab. I cultured most of the fungi, studied under the microscope, illustrated using Camera Lucida apparatus, pictured with camera fitted to a light microscope and finally described them with decisive taxonomic clarity. As I studied more and more of microfungi, my knowledge on fungal taxonomy also grew steadily....

In July 1981, I took up a teaching post in Asmara University, Eritrea, East Africa. Besides teaching biology, this assignment offered a rare and challenging opportunity of working on Ethiopian fungi. I travelled extensively along the Ethiopian highland forests and lowland depressions, the most difficult natural terrains in the world, and gathered some of the rarest microfungi which I described in a series of papers in the Transactions of British Mycological Society in the 1980s...

On returning to India after seven years of stay in Ethiopia, I briefly worked in Mangalore University before joining Goa University in 1990 as a teaching staff, from where I retired in Nov 2011. While in Goa University, not only I studied fungi in their entirety but also trained many young students in mycology and built facilities to work on and preserve fungi. Post-retirement, I have been collaborating with students of mycology in the Asian countries such as Thailand, Malaysia, China, Sri Lanka and Myanmar, besides India. These works are well documented in many publications.

From the times of E.M. Fries, different criteria have been used to identify and classify fungi. Initially, it was micro-morphological such as shape, colour and size of the fungi as seen under the microscope and subsequently, use of ontogeny or developmental morphology of spores and spore-bearing structures, as additional characters. In between, attempts were made to use biochemical features

such as pigments, both intra- or extra-cellular. In all these efforts, from the time of Tulane brothers to the present, mycologists relied primarily on stable characters. Since the beginning of this century, more than microscope-based morphology, fungal phylogeny using molecular sequence data became the important criterion to distinguish and recognise fungi. Renewed efforts are now being made around the world to understand the fungi based largely on molecular sequence data and to arrive at most stable taxonomy.

I moved with time and fungi, from morphology to molecular and floristics to diversity. In between, with my students, I dabbled a little bit on ecology and biology of fungi. In this lecture, I will narrate the efforts made in the last four and half decades in identification and taxonomy of microfungi.

Memorial Award Lectures

Prof. C.V. Subramanian Memorial Lecture Award for Women Scientists

HALOPHILIC FUNGI FROM DIFFERENT ECONICHES AND THEIR OSMOADAPTATION

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Research on halophilic fungi has been a pioneering work in Goa, at the Department of Microbiology, Goa University, and has focused on isolation of these fungi from hypersaline econiches that are athallasohaline as of the Dead Sea, and from thallasohaline solar salterns, and polyhaline environments of estuary and mangroves, from Goa. The halophilic fungi obtained under the given conditions of isolation, belonged to the genera of *Aspergillus*, *Penicillium*, *Cladosporium*, *Eurotium* and *Hortaea*, the dominant genera in all the saline habitats being that of *Aspergillus* and *Penicillium*. These fungi were capable of growth in presence of high concentrations of salt, either *in situ* and/or *in vitro*, growing better in a hypersaline medium than in physiological salinity, thus displaying a halophilic or salt-loving nature, with some aspergilli compulsorily requiring a hypersaline condition for growth, exhibiting their obligate or true halophilic nature.The obligate halophiles amongst these were all aspergilli, and notably *Aspergillus penicillioides*. The isolated halophilic fungi were shown to be characteristically moderately halophilic in salt requirement of 1-2 M for optimal growth, but capable of growth in extremely saline condition of 20-25 % salt, typically euryhaline in nature displaying growth over a wide range of salt concentrations, with a few being steno haline. Adaptation to hypersaline conditions and its consequential osmotic pressure, necessitated the accumulation by the fungi, of compatible solutes or osmolytes comprising sugars and sugar alcohols of four to six carbons, for survival, the total osmolyte concentrations increasing with increased salt concentrations in the growth medium. The fungi did accumulate Na^+ and K^+ ions and adsorb considerable amount of salt on its cell surface, characteristic of fungi; however, this did not have a significant role in the cells' osmoadaptation to salt. The highlights of the work comprised a first record of obligately halophilic *Aspergillus penicillioides* from the Dead Sea, of the black yeast *Hortaea werneckii* from non-hypersaline waters of mangroves, and of obligate halophilic fungi from polyhaline waters of the estuary. Research in the area of halophilic fungi has much scope as a newer field of scientific investigation, particularly with respect to study on osmolytes as well as halophilic or halotolerant enzymes, for their varied and rich potential in cosmeceutics, as well as in pharma, food and agriculture industry.

Dr. V. Agnihothrudu Memorial Lecture Award

PRODUCTION OF FUNGAL MANNANOLYTIC ENZYMES FOR HEALTH PROMOTING PREBIOTIC MANNOOLIGOSACCHARIDES (MOS)

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Mannans such as locust bean gum, konjac gum, and guar gum are heteropolysaccharides chiefly composed of mannose. The complete hydrolysis of mannan involves collaborative action of endo-β-mannanase (EC3.2.1.78), β-mannosidase (EC 3.2.1.25), β-glucosidase (EC 3.2.1.21) and α-galactosidase (EC 3.2.1.22). Endo-β-mannanase randomly hydrolyse internal β-1, 4-glycosidic bonds present in mannans and release MOS with different degrees of polymerization (DP). MOS are gaining

considerable interest as emerging prebiotic oligosaccharides as they make a suitable alternative of conventional prebiotics due to their broad range of bioactive properties emerging prebiotic oligosaccharides as they make a suitable alternative of conventional prebiotics due to their broad range of bioactive properties. In this presentation the optimized production of fungal mannanases from various fungi including *Malbranchea cinnamomea*, *Aspergillus terreus*, *Aspergillus quadrilineatus, Aspergillus oryzae* etc. and their use for generation of prebiotic MOS will be discussed. The use of low-value mannan-rich agro-waste substrates such a copra meal, palm kernel cake and guar gum in generation of prebiotic MOS has been demonstrated. Further, the prebiotic properties of MOS such as anti-oxidant, anti-cancer and growth promotion of probiotics are demonstrated.

Prof. K. Natarajan Memorial Lecture Award

UNDERSTANDING THE ROLE OF SOME NOVEL COMPONENTS IN MODULATING VIRULENCE OF NECROTROPHIC FUNGUS *BOTRYTIS CINEREA*

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Botrytis cinerea is the second most destructive necrotrophic phytopathogen affecting over 500 plant hosts, including several commercially valuable crop species. The infection is characterized by the presence of grey colored mold on pre as well as post harvest fruits and vegetables. It is a highly efficacious pathogen due to its broad host range, adaptable infection styles, and high reproductive potential. Application of fungicides is not effective in managing the disease as the pathogen rapidly develops resistance to it. Huge commercial losses and unavailability of suitable measures make it imperative to intensely comprehend the molecular mechanism of pathogenicity in *B. cinerea*. The availability of complete errorless genome and advancement of molecular tools for genetic study has proven fundamental in elucidating the infection techniques of the pathogen. However, I will focus on genes of *B. cinerea* studied by examining mutants with emphasis on few genes that have been functionally analysed by us. I sincerely hope my presentation will encourage young researchers to take up research on plant-pathogen interactions with respect to economically important fungal diseases in India.

Dr. S.K. Shome Memorial Lecture Award

DIVERSITY OF ASCOMYCETOUS FUNGI IN ANDAMAN FORESTS, INDIA

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Examination of 2120 dead and decaying twig samples, randomly collected from different sites in the reserved terrestrial forests of Andaman Islands including the North, Middle and South Andaman Islands, during 2015 to 2018, through 7 field trips, showed 1655 specimens were supporting sporulating fungi (67% colonization). Totally 316 Ascomycetous fungi belonging to 172 genera, 79 families, 30 orders and 7 classes, were recorded. *Xylaria* was the most speciose genus while Xylariales was the most dominant order in the class *Sordariomycetes*. *Sordariomycetes* shared 47 % (148) of the species followed by *Dothideomycetes* 39 % (122). Together they formed 86% of total fungi. Through this study one new

family (*Paralophiostomataceae*), two new genera viz. *Murinectria* and *Paralophiostomata,*78 new species of ascomycetous fungi new to science were introduced. Of these, 26 new species have already been published viz., *Cytospora fusispora, Kamalomyces polyseptatus, Fussuroma kavachabeejae, F. microsporum, Neoastrosphaeriella alankrithabeejae, Astrosphaeriella uniseptata, Pithomyces hyalosporae, Bertiella striatispora, Allocryptovalsa truncata, Murinectria murispora, Paralophiostoma hysterioides, Botryobambusa apiculiformispora, Brunneiapiospora appendiculata, Cilioplea macrospora, Cryptoascoma shodasabeejae, Diatrypella macroasca, Leptosphaeria sadvibhajanabeejae, L. verruculosa, Montagnula vakrabeejae, Ostreichnion beejakoshae, Rizalia falcata, Rosellinia attentuata, R. tetraspora* and *Ascobolus gomayapriya.* The maximum number of new fungi belonged to the *Tubeufiaceae* family. Of the 316 fungi, only two were recorded in almost all the samplings. These were *Eutypa flavovirens* and *Hysterium hyalinum* and were classified as 'most common'. Twenty-two fungi were recorded in 4-5 samplings and were considered as 'common' in their periodicity of occurrence. While 78 fungi were recorded in only 2-3 samplings coming under occasional category a large number (214) of fungi were sporadic in their occurrence as they were found in only one sampling. Of the 316 fungi 155 could be connected to the plant hosts on which they thrive. Among the different hosts, *Calamus andamanicus* (21 fungal species)*, Pterocarpus dalbergioides* (16 fungal species) and *Gliricidia sepium* (12 fungal species) have shown a rich fungal diversity. Based on the percentage occurrence of fungi, frequency groupings were made. The most frequent fungus was *Eutypa flavovirens* followed by *Daldinia eschscholtzii* which was recorded frequently. While 13 fungi were shown to be infrequent a large number of fungi (299) were rare in their occurrence. This indicates that frequent collections and exploration for a longer duration is required for a thorough analysis of diversity of ascomycetous fungi from the Andaman Islands.

Prof. K.G. Mukerji Memorial Lecture Award

POLYPORE DIVERSITY IN NORTH WEST INDIA

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Polypores are the major group of wood decaying fungi with annual to perennial, resupinate to effused-reflexed to pileate gymnocarpic basidiocarps with poroid hymenophore. The pilei are variable in shape and may be solitary, imbricate, or in groups. The piler surface ranges from smooth to warted, zonate to azonate, glabrous to tomentose, concentrically sulcate to irregular sulcate. The pores vary from round to cyclic to angular to radially elongated to irregular to daedaleoid to lamellate. These fungi have been classified under 17 families with in 7 orders of class *Agaricomycetes* of phylum *Basidiomycota*. These are responsible for different types of rots of both coniferous and broad-leaved hosts. The present paper provides illustrated account of 185 polypore taxa based on more than 550 specimens collected from various parts of North-West India. These include about 16 taxa new to science and more than 100 new records for India/study area.

Prof. P.C. Jain Memorial Lecture Award

FUNGAL ENDOPHYTES: A HIDDEN TREASURE TROVE OF STRUCTURAL AND FUNCTIONAL DIVERSITY

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Fungal diversity is an important and alternative source that could be harnessed and used to modern biology and biotechnology, and has the potential to be developed as innovative and sustainable solutions to a wide range of problems. In animal systems, diseases such as cancer, malaria, multi drug resistant bacteria, parasitic protozoans, non-curative diseases, and pathogenic fungi are important problems. In plant systems, different stresses like drought, salt and temperature tolerance, industrial effluents, as well as disease resistance are of concern. These ever growing threats require immediate serious efforts for the acquirement of new, more effective agents that have the potential to be developed into new industrial products. Natural products are often produced by microbes and may have specific functions in nature. The abundance of microbial biodiversity is as yet largely unknown, and the defined microbes representing but perhaps a small fraction of the potential, and as such, the search and identification of novel biotopes that may provide unique and useful products, will likely be a successful endeavor.

Woody plants are found to harbor novel endophytic fungal biotopes. These endophytes reside within the living tissues of plants, and have been largely overlooked and unexplored for their potential to produce novel natural products to ultimately be developed for industry. However, the process from discovery to production is complex. The utilization of endophytic fungi and their functional metabolites on an industrial scale begins with intelligent screening of endophytes, and then requires growth of the microbe(s) and subsequent scaling up for fermentation, as well as optimization of many other necessary factors. The isolation and characterization of bioactive substances from culture filtrates is done using bioassay guided fractionation and spectroscopic methods. Some examples of novel natural products produced by endophytic microbes that have been successfully produced on an industrial levels includes taxol, jesteron, pestacin, isopestacin, pseudomycin, jasmonic acid, torryanic acid, javanicin and ambuic acid to name a few. The focus of this lecture is to discuss endophytic biodiversity, their role to protect plants against abiotic environmental stresses with special reference to drought, heat and dyes. One of the active fungal endophytes *Colletotrichum gloeosporioides* isolated from plant *Thevetia peruviana* was screened for laccase production and congo red dye decolorization. Various physicochemical parameters like dye concentration, carbon sources, nitrogen sources temperature and pH were optimized and maximum decolorization rate was achieved at 100mg/l of dye concentration (82%), glucose (79%), yeast extract (80%), 30°C(80%), and 7 pH (78%). SEM image and fungal biomass changes represent that fungus actively participated in the dye decolorization and had less/or no effect on biomass. Potentiality of endophytes were also explored for discovering the natural products that are active against different diseases representing to both humans and plants.

The mycosynthesis of metal nanoparticles using fungi is considered as a unique and eco-friendly method as it is free from any solvent or toxic chemical, capping agents and also easily amenable to large-scale production. The fungal isolates *Aspergillus clavatus, A. terreus, Phoma herbarum*, *Phomopsis helianthes*, *Chaetomium globosum* and *Trichoderma viride* were used for biosynthesis of silver and gold nanoprticles using aqueous solution of silver nitrate ($AgNO_3$), and tetra auro chlorate ($HAuCl_4$), respectively. *A. clavatus* and *C. globosum* induced AgNps were antimicrobial in nature while AuNps were non-toxic and stable with polymorphic shapes. UV-Vis spectroscopy, transmission electron microscopy (TEM), Atomic force microscopy (AFM), FTIR and X-ray diffraction (XRD) were used to characterize the NPs.

MSI Fellow Lectures

1. DIVERSITY AND TAXONOMY OF FUNGI: INDIAN PERSPECTIVE

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Diversity is the variation among living organisms in morphology, genera species, genes, biochemical and physiological aspects and in other related characters. Fungi are second species rich organisms group after insects. It is more challenging to complete the fungal inventory as compared to other organisms such as plants. Fungi play key role in ecosystem as decomposers, mutualists and pathogens besides playing important role in industry, agriculture, medicine, biotechnology and others related to human welfare. The role of individual fungi in nature is still unknown. Hawksworth and Lucking stated that there may be 1.8 3.8 million of fungi as an estimate. Wu *et.al,* have made an estimate of 13 million of fungi which may be occurring in the world. Around 1,20,000 fungal species have been identified in the world. In order to identify 13 million of fungi it may take around 10000 years. In india around 29000 fungal species are reported. To identify the probable number of 4 lakhs which may be occurring in India may take around 20 years. There is a hidden wealth of fungi underneath different ecological niches in nature which needs to be identified while keeping the mankind in view. IUCN Red Data indicates that around 1512 species are facing threat in the world. In india such data is not available with reference to fungi.

Taxonomy is the science of classification, naming and describing organisms. It is a part of scientific practice known as systematic which entales the evaluationary and phylogenitic relationships between organisms. Aspects of nomenclature of fungi and related codes, classifications as envisaged by Whittaker, Hibbett et.al, Saptora, and Tedersoo et.al., will be discussed. Fungal conversation strategies will also be discussed. The aspects and prospects of fungal diversity and taxonomy from Indian prospective will be discussed.

2. LICHEN GENUS *LECANORA* (*ASCOMYCOTA*, *LECANORALES*) IN INDIA

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India has a rich diversity of lichens represented by 2900 species, which is about 15% of the species known in the world. The macro lichens (foliose and fruticose) of the country are well studied whereas microlichens (crustose) have not received much attention. *Lecanora* is one such common, microlichen having cosmopolitan distribution, but poorly studied in India. *Lecanora* is the second largest genus of lichenized fungi represented by 550 species in the world. The genus is characterized by crustose to effigurate or squamulose thallus containing Trebouxioid photobiont, lecanorine apothecia, hyaline, simple, small to medium sized ascospores. *Lecanora* is a heterogenous genus where *Lecanora sensu stricto* includes species with crystals in the amphithecium, atranorin as major chemistry, filiform conidia and with or without algal cells in amphithecium. Where as *Lecanora sensulato* includes species of *Lecanora sensustricto* as well as all the other species matching the general characteristics of *Lecanora.* The genus *Lecanora* has two subgenera -*Lecanora* subgenus *Lecanora* with purely crustose forms and *Lecanora* subgenus *Placodium* with crustose to squamulose or placodioid forms. In year 2001when the revision of the genus initiated only 47 species were known from India. At present the genus is represented by 83 species, one subspecies and four varieties. A total of 36 species are added to the Indian lichen biota under the genus *Lecanora* including four new species (*L. girigangaensis* Papong, Nayaka & Lumbsch, *L. leuteomarginata* Nayaka, Upreti & Lumbsch, *L. subpraesistens* Nayaka, Upreti & Lumbsch, *L. Upretii*

Papong, Nayaka & Lumbsch). Nine species of *Lecanora* reported earlier from India are excluded as their identity and existence is doubtful and the specimens are untraceable. Due to rapid changes in the lichen taxonomy eight species of *Lecanora* are now transferred to other genera. Among 88 taxa known under the genus 76 belong to subgenus *Lecanora* while 12 belongs to subgenus *Placodium.* Further, within subgenus *Lecanora* maximum number of species belong to *subfusca* group with 69 species. The Western Himalaya records the maximum number of species followed by Western Ghats.

3. BIOPROSPECTING OF FUNGI: A BIO-LOGIC SOLUTION

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Fungi are a reservoir of industrially important products and are used on large scale for the production of biomolecules and biochemicals. The fungal diversity of the different ecological regions in India is still unexplored e.g., Assam. The microbes are an integral part of the ecosystem and the climatic conditions of the Assam provides optimal conditions for the growth of fungus throughout the year. Thus, considering the biodiversity of Assam, in the present study screening for fungal strains were carried out from the soil and decaying tea leaves samples that were collected from tea gardens, rice, and vegetable fields located around Cachar district of Assam. A total of thirty-six (36) fungal strains were isolated using potato dextrose media and incubated at 25±1°C. The isolated fungal strains were characterized on the basis of morphological and phenotypic characterization. The majority of fungal strains were identified from genus *Aspergillus, Trichoderma, Schizophyllum, Rhizopus* and *Penicillium,* etc. The antagonistic properties of some of the fungal isolates were also performed and four (4) strains showed antagonist property against *Aspergillus* suggesting its antifungal potential. Also, the isolated strains were subjected to qualitative analysis for the production of industrially important enzymes such as xylanase, cellulase, amylase based on plate analysis. The strains LC1 and COC showed high xylanase and cellulase activity and were subjected to molecular characterization. These strains isolated from various ecological niches ofAssam can bea bio-logic solution and reservoirs for various industrial applications based on their inherited properties.

4. APPRAISAL OF NATIVE AM FUNGI IN IMPROVING THE PLANT PRODUCTIVITY, SOIL HEALTH AND SEQUESTERING SOIL CARBON IN AGROECOSYSTEMS

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As per the United Nations Agenda 2030, the Sustainable Development Goals (SDGs) needs to be implemented by all the countries to ensure sustainability in terms of food sufficiency and productivity to achieve a better future for all without degrading the environment and resources. Currently India's food grain production is being achieved at the cost of natural resources. The atmospheric carbon dioxide (CO_2) concentration is rising and may likely to go up to 450 ppm in next 20 years. The soils under tropical and sub-tropical region are generally nutrient deficient, marginally fertile and growers rely on sub-optimal yields. Hence, to mitigate the declining trend in carrying capacity of lands and other natural resources under the adverse conditions there is need to have alternatives for improving the soil biological health, resource use efficiency and overall productivity of crops to sustain and support the ecosystem and human

life as a whole. Among the soil biota, particularly the role of arbuscular mycorrhizal (AM) fungi, the most common fungal association formed nearly more than 80% of plant families of cultivated and wild plants and is gaining importance. The role of AM symbiosis in nutrient uptake, carbon mitigation, stress alleviation, soil aggregation and ecosystem stabilization has been widely recognized. The uses of native strains of AMF in sustainable plant production systems have been reported. Inoculation of plants with mycorrhizal fungi during seedling stage, post- *in vitro* of micro-propagation stage and then transplantation in fields can certainly help in plant stand and supplement (up to 25%) the chemical fertilizer inputs. Apart from growth and mineral nutrition promotion (especially P), AMF also protects plants from soil-borne diseases e.g., nematodes, high temperature, heavy metal reclamation and soil structure improvement through aggregation. The productivity further improved when AMF applied with PGPRs for example soybean yield and nodulation enhanced when AM-plants co-inoculated with bradyrhizobia. Soil aggregation is taking place through production of a sticky glycoprotein termed as 'glomalin' that stabilizes soil aggregates which contributes to soil carbon pool. The functioning of native AMF influenced due to soil and crop management practices where organic and conservation tillage with inclusion of maize in rotation with cereal crops has been found to improve the system productivity and enhances soil carbon sequestration assessed through long-term field studies. These AM fungi can be produced routinely on host plants in potting substrates, on-farm and using Ri-plasmid hairy roots under *in vitro*. Besides employing the conventional microscopic methods (spore density and root colonization) in AMF application, the efficacy of AMF in mass production, growth promotion and soil carbon sequestration can be carried out through quantification of biochemical methods such as AM-signature 16:15 phospholipid and neutral fatty acids and glomalin. The production of AMF, their quality assurance, mode of application with increased efficacy for nutrient mobilization, soil reclamation and carbon mitigation under field conditions needs popularization through large scale field demonstrations at multiplications.

5. BIOTECHNOLOGICAL POTENTIAL OF FILAMENTOUS FUNGI IN MODULATING BIOACTIVE COMPOUNDS OF FOOD GRAINS

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Greek Physician Hippocrates, known as father of Medicine said several centuries ago "Let Food be Your Medicine" The philosophy behind is: "Focus on Prevention". The Indians, Egyptians, Chinese and Sumerians are just a few civilizations that have provided evidence suggesting that foods can be effectively used as medicine to treat and prevent disease. Nutraceutical, a portmanteau of "nutrition" and "pharmaceutical", is a food or food product that reportedly provides health and medical benefits, including the prevention and treatment of disease. Epidemiological studies have strongly suggested that consumption of whole grain and whole grain products rich in antioxidants is protective against certain chronic diseases, cardiovascular diseases, diabetes, obesity and cancer. These protective effects are ascribed mainly due to the presence of several important constituents occurring in the whole grains such as polyphenols, dietary fibre, resistant starch, proteins, lipids, lignans, vitamins and minerals as they are involved in inhibition of the formation of free radicals. With an insufficiency of antioxidant protective system or under severe oxidative stress, reactive oxygen species (ROS) are overproduced and can damage biomolecules, such as DNA, proteins, lipids and carbohydrates leading to the development of several diseased conditions.

The current trends of dietary modifications have shifted to focus on the prevention of diseases. However, most phenolic acids in cereals occur in bound form as conjugate with sugars, fatty acids or proteins. Therefore, in order to achieve maximum yield of the phenolic acids, a hydrolysis process has to be adopted. Chemical hydrolysis processes involving the use of acids or alkali for the extraction of

polyphenolic compounds may lead to degradation of certain phenolic acids. Similarly, the enzymes (*e.g.*, pectinases, cellulases, α-amylases, xylanase, β-glucosidase, β-xylosidase, β-galactosidase and β-hesperidinase etc.) are also employed for the degradation of carbohydrate linkages. However, the process involving enzyme hydrolysis is not considered economically feasible because the commercial enzymes are highly expensive, and thus the process is not cost effective. The alternative is the use of solid state fermentation with microorganisms, particularly filamentous fungi. Solid state fermentation has perpetual history of its use in different time for different purposes. Additionally, SSF holds tremendous potential for the production of enzymes which are helpful in breakdown and to carry out metabolism of substrate used. The biotechnological potential of GRAS (Generally Recognized As Safe) fungi employed for the commercial preparation of fermented foods will be discussed in this lecture.

6. MY ARDOUR FOR AGARIC DIVERSIY

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It was in my early childhood while accompanying my father on his mushroom hunting forays that created my interest in the field of mushroom diversity, which culminated into a Doctorate degree on the diversity of genus *Russula* from North West Himalayas. My ardour for agaric diversity was further realized by my Ph.D. scholars. Since last three decades this passion has been by livelihood. In this search for agaric diversity numerous fungal forays were undertaken to the hilly tracts as well as Gangetic plains of North India. As a result of the work on diversity approximately 2000 collections were made of which 38 species have been described as new to science some of which have been authenticated through molecular taxonomy also, while more than 100 are species were reported as new to India, further putative ectomycorrhizal as well as edible ones were also sorted. Common putative ectomycorrhizal agarics being species of *Russula, Lactarius, Calocybe, Amanita, Inocybe, Cortinarius, Hebiloma* and *Tricoloma* etc. While working on the diversity of lamellate mushrooms the ethnomycological data was collected from the local people, it was realized that these people collect certain mushrooms for consuming and selling in the local markets, which further created my interest in domestication of wild agarics, as a result the screening of wild edible taxa started. Some of the interesting edible taxa being *Russula cyanoxantha, R. virescens, R. xerampelina, Lactarius deliciosus, Agaricus bisporus, A. bernardii, A. augustus, A. silvaticus, A. blazei, Coprinus comatus, Floccularia luteovirens, F. straminea, Amanita constricta, A. cesarea, A. vaginata, Bolbitius titubans, Neolentinus ponderosus, Gymnopus dryophilius, Pleurotus dryimus, P. cystidiosus, P. sapidus, P. sub-cervinus, Volvariella bombycina, Lentinus crinitus, L. tigrinus, L. kashmirianus, L. transitus, Homophron spadiceum, Clitocybe gibba, Neolentinus suffrutescens, Hygrocybe calyptriformis, Pluteus petasatus, Coprinellus micaceus, Panaeolus antillarum, Macrocybe gigantea, Protostropharia semiglobata* and *Termytomyces hemii.* Nutritional and Nutraceutical aspects of *Russula brevipes, R. cyanoxantha, R. heterophylla, R. virescens, Lactarius deliciosus, L. sanguifluus, Lactifluus piperatus, Pluteus petasatus, Lentinus squarossulus, L. tuberregium, L. tigrinus, L.connatus, L. kashmirianus, L. transitus, Pleurotus cornucopiae, Calocybe gambosa, C. gigantia* and *Podaxis pistilaris* etc. were studied. Successful domestication of *Pleurotus cystidiosus* has been done while such studies are under way for the taming of *Macrocybe gigantea* and *Lentinus tigrinus* collected from the wild.

7. ENDOPHYTIC FUNGI FROM MEDICINAL PLANTS: A SOURCE OF BIOACTIVE SECONDARY METABOLITES

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Plant endophytic fungi are defined as the fungi which spend the whole or part of their lifecycle colonizing inter-and/or intra-cellularly inside the healthy tissues of the host plants, typically causing no apparent symptoms of disease. Endophytes play significant role to establish fungal diversity. The research interest has been increasing in ecology, biology and applications of endophytic fungi. In the past two decades, many valuable bioactive compounds with antimicrobial, antioxidant, insecticidal, cytotoxic and anticancer properties have been successfully discovered from endophytic fungi. For examples, *Muscodor* is a novel endophytic fungal genus that produces bioactive volatile organic compounds (VOCs). An endophytic fungus *Taxomyces andreanae* isolated from pacific yew plant could produce the valuable anticancer drug 'Taxol'. Moreover, the hydrocarbon profile of an endophytic fungus, *Gliocladium roseum* was discovered with various compounds associated with diesel fuel, which has been described as 'myco-diesel'. The development of new antimicrobial metabolites is important to prevail the problems related to the treatment of diseases caused by resistant pathogens. Thus, endophytic fungi have emerged as an alternative source to synthesize new antimicrobial compounds. In the present investigations diversity of endophytic fungi were studied isolated from medicinal plants collected from different locations of Amravati region, including Melghat forest. Plant samples were collected in three different seasons (monsoon, winter and summer). All the isolated endophytes revealed great variations in occurrence and colonization in each season of the study. Antibacterial potential of isolated endophytic fungi was tested against selected pathogenic bacteria by disc diffusion method. To test antibacterial potential of isolated endophytes, three pathogenic bacteria were used namely *Escherichia coli* (MTCC 1698), *Staphylococcus aureus* (MTCC 2639) and *Pseudomonas aeruginosa* (MTCC 6458). Antibacterial potential of endophytic fungi was determined by measuring zone of inhibition. The results were interpreted in the present studies.

Lead Lectures

1. REVOLUTIONIZING THE NAMING OF FUNGI

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The way fungal organisms have been named has undergone a series of major changes since 1753, especially in the last few decades. The process is now subject to a series of international agreed provisions that relate only to fungi and not to plants or any other organisms covered under the *International Code of Nomenclature for algae, fungi, and plants* (ICNafp). This address considers these, why they were made, and explains what they mean in practice. The naming is ruled as starting in 1753, and the procedures are now detailed in the Code, revised at International Botanical Congresses now held every six years, but with any changes regarding fungi being determined at four-yearly International Mycological Congresses. Topics covered include: the change in starting point date; the concept of sanctioned names; abandonment of the naming of separate morphs of the same species; registration of newly proposed scientific names and also new typifications of older names; English being accepted for diagnoses of new taxa as an alternative to Latin; the governance of the rules; introduction of lists of names which are protected from any competing names whether known or unknown; and simplification in the citation of sanctioned names. Challenges ahead are how to regularize the naming of so-called "dark taxa" (ones that are only known from environmental sequences with no specimens or cultures), and to revisit and clarify the status of living cultures as types. Fungal nomenclatural practices are leading the way in developing systems suited to the 21st century, and becoming a model which both botanists and zoologists are trying to emulate.

2. HEALTH BENEFITS OF MUSHROOMS

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There has been a close link between medicine and plants. But, there was not so close a link between mushrooms and medicine. In the recent years, their health benefits have come to the forefront with a bang. Mushrooms are an interesting group of organisms which attracted and distracted people alike since times immemorial. They appear and disappear mysteriously. Many legends are associated with them. Their potential in medicine for health benefits was appreciated only during the late 1990's. When their medicinal properties were recognized, their importance immediately gained significance and now they are in the forefront for the treatment of some dreaded diseases. So there potentialities in health sector have grown tremendously. This appreciation was first limited only to a few well known species but now a consensus seems to have developed that every mushroom possesses one or the other trait which accrues health benefits to man. Out of the 16,000 species recorded from the world over, around 7,000 are classified as edible and around 3,000 are perhaps the prime edible species, around 200 amongst them have been experimentally grown, 100 economically cultivated and 30 commercially cultivated in one or the other parts of the world and about 6 species are grown on industrial scale. Around two dozen species have been investigated for their nutraceutical traits. In near future, it is anticipated that medicinal mushrooms are likely to prove as potential sources of new biological drugs for counteracting life style diseases. The health benefits of some of the important mushrooms will be discussed.

3. THE NEED TO STUDY DIFFERENT FACETS OF THE ENDOPHYTE-PLANT ASSOCIATION FOR THEIR APPLICATION IN AGRICULTURE

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The Class 3 type endophytes have a broad host range and are transmitted horizontally. These fungi could be isolated from every plant studied. Several studies project endophytes as a bioresource with high promise for crop improvement especially because of their universal occurrence, non-pathogenic nature, ability to enhance the biotic and abiotic stress tolerance of their plant hosts, increase nutrient uptake from soil, and increase the plant yield. A search of the United States patents awarded for endophyte mediated crop improvement during 2000-2018 include fungi such as species of *Acremonium*, *Colonostachys*, *Colletotrichum*, *Dothideomycetes*, *Gliocladium*, *Lophodermium*, *Muscodor*, *Piriformospora*, *Phialocephala*, *Sarocladium* and *Trichoderma*. Despite such investigations, very few of the benefits of endophytes have been translated into real-world agricultural applications. In this talk which is primarily based on our review, I underscore the importance of more basic studies on endophyte-plant interactions to identify the bottlenecks which hinder the exploitation of endophytes in agricultural applications.

4. THE FORAGING ASCOMYCETE HYPOTHESES: SPATIAL ECOLOGY OF THE FUNGAL GENUS *XYLARIA* IN A TROPICAL CLOUD FOREST

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Fungal symbioses with plants are ubiquitous, ancient, and vital to both ecosystem function and plant health. However, benefits to fungal symbionts are not well explored, especially in non-mycorrhizal fungi. The Foraging Ascomycete hypothesis proposes that some wood-decomposing fungi may shift life-history strategies to endophytism to bridge gaps in time and space between suitable substrates. To test this hypothesis we examine spatial relationships of *Xylaria* endophytic fungi in the forest canopy with *Xylaria* decomposer fungi on the forest floor using a spatially explicit sampling scheme in a remote Ecuadorian cloud forest. We found evidence of spatial linkage between life stages in two species and demonstrated that direct transmission of endophytes from leaves to woody substrates is possible. These results indicate that endophytism may represent one way for decomposer fungi to escape moisture limitation, and that endophytic fungi may act as sources of dispersal for decomposer fungi consistent with predictions of the Foraging Ascomycete hypothesis.

5. MILESTONES IN THE DEVELOPMENT AND PROGRESS OF MEDICAL MYCOLOGY IN INDIA

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A brief account is given of history and early progress of medical mycology in India, including the contributions of British Army physicians, surgeons and our physicians (MDs, DM) and scientists with PhD in mycology, medical mycology, or medical microbiology. A noteworthy feature is the discovery by

our eminent mycologists, Prof. SB Saxena and Prof. PC Misra of new genera and species of fungi, namely, *Saxenaea vasiformis*, and *Apophysomyces elegans*, which are now recognized as agents of human fungal infections worldwide. A mention is also made of the discovery of several new species of species of pathogenic molds and yeasts, novel pathogens and novel lab techniques by medically mycologists. Recent progress of medical mycology in different medical institutions including the four internationally recognized centers of research on ocular fungal infections in India is covered in detail with lists of important publications (2000-2020) from these institutions. Aspects of training of graduates in medicine, and postgraduates in microbiology, medical microbiology biological sciences are adequately dealt with re given including the mention of self-learning resources, and the need for their attending workshops and training courses offered by premier medical institutions in India. Suggestions are given in detail for surveys by Departments of Preventive and Social Medicine in medical colleges with the collaboration of state departments of health/primary health centers in communities representative of their areas to investigate the occurrence of fungal infections like ringworm, keratitis, mycetoma to estimate their burden and chalk out preventive measures. The need for exploring antifungal therapy by herbal drugs by our mycologists and physicians is emphasized The history of Indian Society of Medical Mycologists (ISMM), and its present status, ISMM awards, and ISMM Newsletter is also mentioned.

6. MUSHROOMS IN SERVICE OF SOCIETY

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Mushrooms are a group of fungi which produce large fleshy sporophores. These come up especially during monsoon season from the branching mycelia infiltrating the soil or leaf litter or in the wood of living or dead trees. Mushroom sporophores are primarily concerned with the production of spores and their dissemination. The different fungal groups produce their own distinctive type of sporophores. Even within a species there is immense variation. Due to their contrasting qualities, mushrooms are wrapped in superstitions and prejudices, because of which their relevance to mankind and the essential role they play in ecosystem maintenance and sustenance has remained largely ignored.

The identification of any wild food with 100% certainty before consumption is a qualification, if gradually attained, can make one generate extra income along with awareness. The real treasure of information in this regard is our rural population who is trained in their identification and use through generations. There is an urgent need to document this hidden treasure by interacting with the people on the country side so as to make full use of this minor forest product in human welfare. We know many of these mushrooms including guchhi and truffles amongst the ascomycetous mushrooms and shaggy mane, termitophillous, lepiotoid, russulloid, canthrelloid, boletoid and gasteromycetoid mushrooms amongst the agaricomycetous members which are being collected in bulk by the locals from their natural habitats during monsoon season. In different parts of the country these are known by their different folk names and the people engaged in their collection mainly do so for personal consumption as well as for earning revenue. There is a well regulated trade of morels in Jammu, Himachal Pradesh and Uttrakand which is largely monopolized. The locals normally sell their booty @ of Rs. 1500-2000/ kg which reaches the consumers at the exorbitant price ranging from Rs. 20,000-25,000/ kg after passing through number of middlemen. There are other mushrooms including *Podaxis pistilaris, Coprinus comatus, Termitomyces heimii, T. mammiformis,* etc. which are being sold in the local roadside markets and by vegetable venders in different parts of the country including Rajasthan, Chattisgarh, Madhya Pradesh, Punjab, and North Eastern States. *Cordyceps militaris* and other species of *Cordyceps* present huge potential for use in human medicines which are being collected from the wild in Uttrakhand and traded for huge premium. These mushrooms whether cultivated or wild contain substantial amount of

polysaccharides, proteins, unsaturated fatty acids, crude fibres, minerals especially K, Cu, Na, Ca, Se, vitamins including niacin, biotin, thiamin, riboflavin, folic acid, pantothenic acid, essential amino acids, oligosaccharides, terpenoides, alkaloids, phenols, carotenoids, *etc* which accounts for their nutritional and nutraceutical potential and importance in human nutrition. They are a low calorie food free from cholesterol. Specific products with medicinal utility prepared from *Ganoderma lucidum, Tramates versicolor, Grifola frondosa*, etc., which are immuno-potentiating and are being prescribed by the medical practitioners against diseases like AIDS, cancer, atherosclerosis, hypertension, diabetes, etc are available in the market.

Mankind is facing depletion of resources because of overexploitation, loss of habitats and release of toxic substances into the earth's repositories which is also affecting mushroom population. There are mushroom based solutions for the amelioration of many of these problems because of their capability in the recycling of agro-wastes and utility of mushroom mycelia in bioremediation and myco-filtration. Vast majority of these mushrooms besides being saprophytes are also intimate associates of multipurpose plants and form a wood wide web because of which they play a significant role in the recycling of dead organic matter , replenishment of nature and sustenance of plant health and hence the ecosystem as a whole. Because of these multifarious advantages mushrooms offer to the mankind, they have been referred as the special creation of God.

7. FUNGI AND OIL SPILLS

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Marine oil spills have continued to occur and caused damage to coastal areas in spite of the precautions and safety measures taken by oil companies and shipping vessels. Petroleum hydrocarbon continues to be used as the main source of energy and has become an important global and environmental pollutant. The response of microorganisms to organic contaminants has been studied for many years with an increasing amount of microbiological research devoted to bioremediation of oil-contaminated sites using various microbial species including fungi. Fungi are of interest because of their ability to synthesize relatively nonspecific enzymes involved in cellulose and lignin decay that can degrade high molecular weight, complex and more recalcitrant toxic compounds, including aromatic structured hydrocarbons- PAH (polycyclic aromatic hydrocarbons). These compounds pose health hazards and there is a need for their clean-up in contaminated sites when oil spills occur. Physical and chemical methods have been applied to clean up the oil affected areas. However, fungi are potentially viable clean up option after physical removal of large quantities of oil. Bioremediation of oil spill contaminated sites could either be via stimulation or addition of fungi or their metabolites. This talk will cover the following : a) enumeration of fungi from oil-spilled areas; b). biostimulation experiments, 3). Degradation of TPH by fungal consortia, and 4). basidiomycetes as biodegraders of PAH.

8. MYCOLOGY - PAST, PRESENT AND FUTURE

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The science of mycology starting some 300 years ago with the works of e.g. Linné, Persoon and Fries used macromorphology of fruiting bodies to describe and classify fungi. Since then, the development of new techniques like microscopy, physiology test, ontogeny tests, electron microscopy and finally DNA-sequencing led to massive accelerated new results in mycology. Next generation sequencing with various methods will lead us in future to overwhelming data which can only be interpreted by bioinformatic specialists. In this talk I will give an overview of nearly 40 years working in the discipline of mycology from a very personal perspective. Beginning with simple microscopic analyses and line drawings followed by transelectron microscopy studies elucidating the relationships of some corticioid fungi, first attempts to infer phylogeny from small DNA fragments to the big picture of basidiomycete phylogeny and ending up with next generation sequencing of important tree pathogens. No matter what we will get from next generation sequencing in future: Thousands of new sequences, whole genome phylogenies or DNA-based community analyses: We still have to know the fungus as an organism. Not in an abstract way (DNA) but in a comprehensive way (morphology, ontogeny, ecology). Therefore we need young mycologist in future which still know about the "old fashioned" traits of fungi.

9. PHYLOGENETIC AND PHYLOGENOMIC ANALYSES OF THE SHIITAKE GENUS, *LENTINULA*

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Lentinula Earle is a group of wood-decaying *Agaricomycetes* that is best known for *Lentinula edodes*, commonly known as shiitake or xiang-gu, which is the most widely cultivated edible mushroom in the world. Pegler recognized five species in his 1983 monograph of *Lentinula*, including three in Asia-Australasia and two in the Americas. Using a combined dataset of ITS and *tef*-1 sequences, were solved thirteen lineages in *Lentinula* that might correspond to species, five in Asia-Australasia, and eight in the Americas. We selected 12 isolates from Asia-Australasia and 13 isolates from the Americas for genome sequencing. The genome-based phylogeny represents all species recognized by Pegler (except *L. guarapiensis*, which is known only from the type collection) and is largely consistent with the ITS-*tef*-1 topology. *Lentinula aciculospora*, from Costa Rica, is the sister group of a clade containing the Asian-Australasian isolates, rendering the *Lentinula* assemblage in the Americas paraphyletic. An expanded analysis including 60 newly-assembled genomes of "*L. edodes*" suggests that two of the ITS-based lineages may not be phylogenetically distinct, implying a history of hybridization or maintained intragenomic polymorphism in ITS genes.

10. CAN AGRICULTURAL PRACTICES AFFECT ARBUSCULAR MYCORRHIZAL FUNGAL POPULATION AND DIVERSITY?

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Modern agricultural practices to enhance food production to meet the needs of increasing human population are posing problems to arbuscular mycorrhizal (AM) fungi. It is now well established that agricultural practices alter the composition and diversity of AM fungal communities. Agricultural practices like application of fertilizers, herbicides, pesticides and cropping systems affect these fungi. Monocropping with a particular crop results in the development of a predominant AM fungus in soil. Mixed cropping stimulates the proliferation of AM fungi, compared with monocropping. Cultivating a non-mycorrhizal host or leaving the land fallow will reduce the propagules of AM fungi in soil. Solarization of soil reduces the AM fungal population. Alley cropping also influences AM fungal population depending on the tree and annual crop involved. Recent studies on shifting cultivation (slash and burn) has revealed an adverse effect on AM fungal population and diversity. In tropical soils, application of organic matter either in the form of compost or organic amendments stimulates proliferation of AM fungi. Application of heavy doses of fertilizers, especially phosphorus, have a negative effect on AM population. Studies have revealed that plant P concentration is more deleterious to AM fungi than soil P. Most pesticides inhibit colonization and development of AM fungi in plants, though some have no effect and a few even increase mycorrhizal colonization. Diversity of AM fungi decrease as the land use intensity increases. Minimum tillage and non-weeding enhance AM fungal population than intensive tillage. Modern intensive agricultural practices are evidently a threat for AM fungi. Studies related to the effect of agricultural practices on AM fungi give an idea of managing these fungi for improving crop productivity.

11. NON-POROID AND POROID AGARICOMYCETOUS TAXA NEW TO SCIENCE OUR CONTRIBUTION

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The nonporoid and poroid Agaricomycetous fungi are unique group of wood inhabiting organisms, in which the carpophores vary from resupinate to reflexed to pileate (sessile/subsessile/stipitate), with hypochnoid, smooth, grandinioid, warted, tuberculate, merulioid, odontoid hymenial side in non-poroid members and poroid, irpicoid or lamellate hymenial side in the poroid members. The hymenium in these fungi is unilateral, organized in the pores/lamellae in poroid members and aculei, tubercles, warts, ridges/grooves or smooth surface in nonporoid members. The carpophores are whitish to mostly in shades of yellow, gray and brown, and rarely in shades of violet, blue and red. Traditionally, these fungi were classified under order *Aphyllophorales* of *Basidiomycota* based on morpho-taxonomic approach, but the modern phylogenetic studies based on molecular techniques, have made significant changes in the systematic position of the poroid and resupinate, nonporoid fungi.

As per the online repositories like Mycobank and Index Fungorum these fungi have been placed in class *Agaricomycetes*, sub-phylum *Agaricomycotina* and phylum *Basidiomycota*. Of the three sub-classes proposed for *Agaricomycetes*, majority of these fungi have been grouped in *Agaricomycetidae* (*Agaricales*, *Atheliales* and *Boletales*) and *Agaricomycetes* incertae sedis (*Cantharellales*, *Corticiales*,

Gloeophyllales, *Hymenochaetales*, *Polyporales*, *Russulales*, *Sebecinales*, *Thelephorales* and *Trechisporales*). The contribution of 108 taxa (7 genera, 90 species and 11 varieties) new to science is based on the material collected from the Eastern Himalaya (Tripura, Assam, Meghalaya, W. Bengal, Manipur, Sikkim, Arunachal Pradesh, The Royal Kingdom of Bhutan) and North Western Himalaya (Himachal Pradesh, Uttarakhand, Jammu & Kashmir, Uttar Pradesh) and adjoining areas in the above-mentioned states and the states of Punjab and Haryana by myself and my research team (Dr. Kuldip Lalji, Dr. Avneet Pal Singh, Dr. Priyanka, Dr. Jaspreet Kaur, Dr. S.K. Sanyal, Dr. Harpreet Kaur, Dr. Samita, Dr. Jyoti, Dr. Gurpreet Kaur, Dr. Maninder Kaur, Dr. Navpreet Kaur, Dr. Jyoti Sharma, Nishi Singla, Malika Rani, Shruti Sood, Navneet Kaur and Ramandeep Kaur) .

The genera new to science are as under:

1. *Confertextum* Priyanka & Dhingra,
2. *Cordochaete* Samita, Sanyal & Dhingra
3. *Dendrophlebia* Dhingra &Priyanka
4. *Hallenbergia* Dhingra & Priyanka
5. *Radulomycetopsis* Dhingra
6. *Repetobasidiopsis* Dhingra &Avneet P. Singh
7. *Trimitiella* Dhingra

12. MAIZE LETHAL NECROSIS (MLN): EFFORT TOWARDS CONTAINING THE SPREAD THE SPREAD AND IMPACT OF A DEVASTATING TRANSBOUNDARY DISEASE IN SUB-SAHARAN AFRICA

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Maize (*Zea mays* L.) is the most important cereal crop in sub-Saharan Africa (SSA), covering over 35 million ha, largely in smallholder farming systems that produce over 70 million metric tons (MMT) of grain. Maize Lethal Necrosis (MLN) disease first appeared in Kenya in 2011 and became a major threat to maize production in eastern Africa in subsequent years. In eastern Africa, MLN is caused mainly by synergistic interaction between two viruses, Maize Chlorotic Mottle Virus (MCMV) and Sugarcane Mosaic Virus (SCMV). MLN can cause up to 100% yield loss in susceptible maize varieties. The disease poses a complex challenge as the MLN-causing viruses are transmitted by insect vectors, and also through contamination of the seed, especially by MCMV. CIMMYT implemented a multipronged strategy in partnership with several international and national partners to tackle the MLN challenge. These efforts included: a) b) establishing a state-of-the-art MLN Screening Facility in partnership with Kenya Agriculture and Livestock Research Organization (KALRO) in Naivasha for identifying sources of resistance to MLN, MCMV and SCMV under artificial inoculation; b) accelerated breeding and deployment of MLN-tolerant/resistant maize varieties with other relevant traits preferred by African small holders; c) optimizing MLN diagnostic protocols; c) strengthening capacities of national plant protection organizations (NPPOs) across sub-Saharan Africa on MLN diagnostics, monitoring and surveillance system; d) creating awareness among the maize seed sector institutions on SOPs for producing and exchanging MLN-free commercial seed; e) disseminating information on farming practices for minimizing MLN incidence; e) establishing an MLN Phystosanitary Community of Practice involving various stakeholders, including national plant protection organizations (NPPOs), seed

companies, regional/sub-regional organizations, etc.; and f) probing the epidemiology of the disease, especially the factors underlying seed contamination by MCMV. These comprehensive efforts have led not only in preventing the further spread of MLN into other major maize-growing countries in sub-Saharan Africa, especially southern and West Africa, but also minimized the incidence of the disease in the MLN-endemic countries in eastern Africa.

SECTION-A

Fungal Diversity, Systematics, Evaluation and Conservation

1. DIVERSITY OF *CHAETOMIUM* SPECIES FROM PACHMARHI BIOSPHERE RESERVE AND NEW PERSPECTIVE ON THE BASIS OF RECENT MULTIGENE ANALYSIS

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Chaetomium is one of the ubiquitous Ascomycetous fungus, recently explored for its potential for production of various cellulolytic enzymes. It is also important in medical mycology and known for its cellulose deteriorating ability. Recent studies have shown that *Chaetomium* has potential to secrete antimicrobial compounds as well as economically important organic pigments. Diversity of *Chaetomium* in India is still not fully explored. Central India is one of biodiversity rich area blessed with rich forest cover and Pachmarhi biosphere is especially known for its biodiversity. Present work is carried out to understand diversity of *Chaetomium* from the Pachmarhi biosphere. Leaf litter in forest is a good source to harbor fungi. *Chaetomium* species were isolated from the leaf litter were collected from different localities of biosphere reserve. Twenty eight species of *Chaetomium* were isolated out of which twenty two species were identified on the basis of morphological and cultural parameters, aid of molecular identification was also taken to identify few species. Recent studies have revealed a new taxonomic arrangement in the family *Chaetomeaceae* on the basis of the multigene analysis. The recent phylogenetic assessment of *Chaetomeaceae* needs to be discussed.

2. EFFECT OF PHYSICO-CHEMICAL PARAMETER ON THE DIVERSITY OF FRESH WATER FUNGI FROM MUMBAI REGION (MS)

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There are more than 500 species of freshwater fungi. The presence of aquatic fungi is directly correlated with the parameters such as pH, temperature, salinity, organic carbon, and phosphorus. Ten different locations like Banganga tank, Siontalao, Bandratalao, Powailake, Vihar lake, Tulsi lake, Manoritalao, Kharodi lake, Shri Dingeshwartalao, and Seawoods Lake were visited for sample collection at different intervals of time. A total of 12 species isolated were identified as *Aspergillus* sp. *Flabellospora acuminate, F. amphibia, Flagellospora curvula, Isthmotricladia gombakiensis*, and *Jaculispora submerse*. Other water quality parameters that influenced the development of aquatic fungi were organic matter and algal biomass which are responsible for water eutrophication.

3. MUSHROOM DIVERSITY OF PUTHUPET SACRED GROVE, TAMIL NADU

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Sacred groves, patches of near natural vegetation dedicated to ancestral spirits/deities and preserved on the basis of religious beliefs, have assumed immense importance from the point of view of anthropological and ecological considerations. Sacred groves and reserve forests provide fairly

undisturbed natural habitats for a variety of macrofungi. These biomes are the ideal sites for successful conservation of macrofungi as natural repositories. Mushrooms that belong to *Basidiomycota* and *Ascomycota*, constitute one of the largest groups among fungi. In India, as per earlier estimates 1155 species of agarics have been reported. The studies on mushroom diversity are however meagre when compared with vast forest cover in southern India. This is especially true of sacred groves that are relatively less explored. The present study were done to document the mushroom species in Puthupet sacred grove that covers an area of around 17 hectares. The identified mushrooms have been assigned to genera *Agaricus*, *Auricularia*, *Conocybe*, *Favolus*, *Ganoderma*, *Gymnopilus*, *Hexagonia*, *Inonotus*, *Lentinus*, *Lepiota*, *Leucocoprinus*, *Marasmius*, *Microporus*, *Schizophyllum, Termitomyces* and *Trogia.* These genera have also been reported from other parts of southern India as well. A continuous survey work has to be done for a longer period of time to understand the ecology of this group of fungi. Further, as some of these fungi are edible and also known to have medicinal values other than being important in nutrient cycling, it becomes imperative to study this group of organisms.

4. THE FUNGAL DIMENSION OF BIODIVERSITY CONSERVATION

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Biodiversity, the extent of biological variation on Earth, has come to the fore as a key issue in science and politics especially after the Rio Convention on Biological Diversity which was signed in 1992. While most of our attention has been directed towards the role of animals and plants in biodiversity conservation, fungi have received little importance in conservation biology discussions. It may be due to several reasons and mostly because of its hidden lifestyle and challenging diversity. However, an increased knowledge on the fungal species estimates coupled with their role in ecosystem services brought them now to the conservation discussions. In order to formulate conservation measures for any organism one must know the potential susceptible threats to the organism, though it may be fundamentally the same for other organisms. The factors that threaten animals and plants such as degradation, loss and fragmentation of natural and managed habitats, climate change, and pollution are fundamentally the same for fungi also. Recently, fungal red-listing is usually used for management and conservation activities across Europe which ultimately help in launching action plans to protect specific fungal habitats and species. However, inadequate mapping of the tropical and subtropical regions of the world is posing a serious challenge in formulating common conservation measures for fungi. In view of the critical roles fungi play in ecosystems, inclusion of fungal component in biodiversity will certainly benefit conservation in general. This paper discusses general issues related to the conservation of mushrooms with particular reference to the state of Kerala.

5. DO MANGROVE HABITATS SERVE AS A RESERVOIR FOR *MEDICOPSIS ROMEROI*, A CLINICALLY IMPORTANT FUNGUS

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Medicopsis romeroi is one of the frequent pathogens causing subcutaneous infections in immunocompromised patients. In this study a sexual morph of *Medicopsis romeroi* was found on a decaying woody stem of the mangrove plant *Suaeda monoica* and its asexual morph was produced on malt extract agar. The sexual morph connection was established based on both morphological data and multigene phylogenetic analyses. *Neomedicopsis chiangmaiensis* comb. nov. is proposed by transferring *Medicopsis chiangmaiensis* to the genus *Neomedicopsis* based on morphology and multigene phylogenetic analyses. The preliminary pathogenicity tests on *Medicopsis romeroi* strain demonstrated beta haemolysin and esterase activities, and its ability to grow at 37 °C. It also exhibited strong activity in *in vitro* tests for aspartyl proteases, extracellular phospholipase, lipase and chitinase and mild activity for amylase and urease suggesting that this strain of *Medicopsis romeroi*, isolated from a mangrove habitat, could be an opportunistic pathogen to immunocompromised patients.

6. *UROMYCES*: OVERVIEW ON DIVERSITY AND DISTRIBUTION IN INDIA

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Uromyces (Link) Unger is second largest genera of rust fungi after *Puccinia* in the family *Pucciniaceae* proposed by Unger. The genus contains more than 1568 epithets and 600 reported species. The genus is an important plant pathogen which parasitizes both monocots as well as and dicots throughout the world and attack a number of crops that annually cause varying amounts of losses in yield. The rust disease symptoms produced by *Uromyces* spp. are characterized by numerous small, rust-like orange/yellow or brown pustules formed on infected plant tissues. This pathogen causes necrotic symptoms and *formed* light yellow halo around disease pustules. Dark brown to blackish brown Telia are mostly formed by the rust fungi during infection. Single celled teliosporesare formed by these fungi. These rust fungi are reported from different states of India on various plant families like *Asteraceae, Euphorbiaceae, Fabaceae, Liliaceae, Poaceae* and *Loranthaceae*. Ninety-seven species of *Uromyces* have been identified and reported from India on 180 plant host species that belong to 85 genera and 32 families. The plant families *Fabaceae* (30 species) and *Poaceae* (23 species) are predominantly vulnerable to infection of these fungi.

7. SEASONAL MYCOLOGICAL ASSESSMENT FOR WATER QUALITY OF VARANASI CITY

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Seasonal variation and distribution of fungi from six different sites of water were studied for a period of one year employing byplating technique. A marked variation in mycoflora of the river has been found. Extra-aquatic fungi were isolated by plating organic detritus on PDA+strepto-penicillin medium. Temperature and concentration of pollutant showed a marked effect on the fungal population. The drain water consists of domestic sewage also increases the fungal population. Low temperature during the winter reduces the number of fungi. Higher numbers of fungi were recorded during the spring season. The present data shows that the common fungi isolated are the species of *Achalya, Pythium, Rhizopus, Mucor, Trichoderma, Aspergillus, Penicillum, Alternaria, Cladosporium, Curvularia, Fusarium, Sclerotium* and *Gliocladium. Alternaria alternata, Aspergillus flavus, A. fumigatus, A. niger, Penicillium chrysogenum,* white sterile mycelia have found in higher percentage thought the year.

8. THE GENUS *COPRINOPSIS* (*PSATHYRELLACEAE*, AGARICALES) IN COPROPHILOUS HABITATS OF THE STATE PUNJAB, INDIA

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The diversity of *Coprinopsis* species has been studied from the coprophilous habitats throughout the Punjab state from 2007 to 2011. Thirteen taxa namely *Coprinopsis cinerea, C. cordispora, C. cothurnata* var. *equsterca, C. foetidella, C. lagopides* var. *lagopides, C. lagopus, C. macrocephala, C. nivea, C. pseudonivea, C. radiata, C. radiata* var. *macrocarpa, C. scobicola* and *C. vermiculifer,* have been reported growing on herbivorous dung. Out of these, C. *radiata* var. *macrocarpa* and *C. cothurnata* var. *equsterca* are reported as new varieties and two species, viz. *Coprinopsis pseudonivea* and *C. vermiculifera* are the new records from India. In the present paper, all these taxa are described, illustrated, and compared with similar species.

9. AGARICS DIVERSITY IN THE SAL FOREST OF NORTH-WEST INDIA

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Agarics are cosmopolitan basidiomycetous fungi which grow in a wide variety of habitats, from the tropics to arctic. Studies on taxonomy and diversity of agarics are inviting more attention nowadays primarily because of their importance in human welfare, ecosystem functioning and stability. To

investigate the mushrooms diversity, frequent fungal forays were undertaken to different localities of the Sal forest of Shiwaliks of North West India. A total of 50 species of agarics were documented during the survey from Sal forest, most of which were ectomycorrhizal. Out of fifty fungal species studied and identified in the present investigation, as many as twenty-seven species were of family *Russulaceae*, followed by eight species of *Amanitaceae,* six of *Agaricaceae*, four of *Lyophyllaceae,* two of *Inocybaceae*, and one each of *Tricholomataceae*, *Strophariaceae* and *Physalacriaceae*. In the present study one species i.e. *Lactarius shiwalikensis* has been proposed new to science based upon classical and molecular taxonomy. The two new varieties of *Russula viz*. *R. camerophylla* var. *reticulospora* var. nov. and *R. aurea* var. *minuta* have also been proposed. Besides these, four taxa are new records for India. These include *Russula chlorinosma* Burl., *Amanita battarrae* (Boud.) Bon, *Inocybe albodisca* Peck and *Asproinocybe lactifera* Heim.

10. DIVERSITY AND PHARMACEUTICAL POTENTIAL OF THE HALOPHILIC FUNGI FROM SOLAR SALTERNS OF TUTICORIN AND MARAKANAM ALONG THE SOUTHEAST COAST OF INDIA

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Solar saltern serves as a hotspot for many hidden microorganisms, where the fungal community seems to be a most unexploited one. Halophilic fungi represent a wide source of yet undiscovered compounds, besides its unprecedented chemical structures, often possess interesting biological activities. These fungal metabolites are expected to be more stable owing to the fact that the halophiles thrive under varied environmental disturbance such as temperature, salinity and pH when compared to that of fungi from other environments. The present studies were aimed to investigate halophilic fungi from two different solar salterns along the southeast coast of India and the synthesis of bioactive metabolites. The species frequency, periodicity, percentage occurrence were recorded and correlated with interrelationship between fungal diversity and physico-chemical parameters. The results were statistically analyzed by Shannon-Wiener index, Pielou's evenness index, cluster analysis and metric multi-dimensional scaling. The potential halotolerant strains as *Alternaria alternata* was identified both conventional and molecular techniques. Further, mass scale culture of *A. alternata* for the extraction of active biomolecules was carried out and characterized as *5*-Oxa-6-azaspiro [3.4] oct-6-ene based on analytical methods such as HPLC, Semi-preparative HPLC, GC-MS, UV-Vis spectrophotometer, FT-IR and ^{1}H and ^{13}C NMR, ^{1}H and ^{13}C NMR. The characterized biomolecule were also analysed for anticancer and anti-inflammatory activities and the results suggested that the halotolerant strain *A. alternata* could be provided an excellent alternative source for the pharmaceutical products.

11. CHARACTERIZATION AND IDENTIFICATION OF SOME NOVEL TAXA AND NEW RECORDS OF LAMELLATE FUNGI FROM HIMALAYAN BELT OF INDIA

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The present paper aim at documenting the agaric flora, their characterizations and identifications. Thus, periodic fungal forays were undertaken to collect agarics growing in various habits and habitats of Kashmir himalayas. Thus, 78 taxa falling under 32 genera, 17 families and 05 orders were identified. The importance of macrochemical and microchemical reactions were emphasized along with the utility of chemotaxonomic and numerical taxonomic methods, although all such characters play a supplementary role in the taxonomic categorization of presently studied taxa. These studies enabled to reach right taxonomic conclusions. All the presently studied agarics exhibit immense variation of shape, texture, colour, smell, taste and have varied ecological preferences. In the present paper, the characterization of fungi viz. morphological, anatomical, chemical, numerical and molecular aspects in modern lines has been discussed. The newly described taxa were confirmed through molecular taxonomy viz. *Lentinus transitus* sp. nov., *Xerula megnaspora* sp. nov., *Lactarius wallichianus* sp. nov. and *Clarkeinda indica s*p. nov. The present work depicts the different seasons among which the maximum collections were found in the summer followed by spring and autumn. Out of total, 28% have been found in foliocolous habitat followed by lignicolous (21%), terrestrial (18%) and only 4% were coprophilous and 51% were solitary in habit followed by 22% caespitose, 19% groups and only 8% in scattered.

12. DIVERSITY OF MICROFUNGI FROM AMRAVATI DISTRICT MS

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The present paper deals with the study of diversity of micro fungi from Amravati district of Maharashtra. The biodiversity richness of Amravati district is represented by the Melghat tiger reserve forest located in the northern part of the district. The forest is dominated by tropical dry deciduous vegetation. During the fungal forays conducted in the forest authors collected many interesting samples which were identified as *Karstenula rhodostoma* (Albertini & Schweinitz ex Fries) Spegazzini and *Parapericonia angusii* Ellis. The aim of the present paper is to describe and illustrate these species.

13. MACROFUNGAL DIVERSITY OF MAHUR AND MANDAVI FOREST RANGE (KINWAT) IN NANDED DISTRICT OF MAHARASHTRA

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The present work deals with the macrofungal diversity in the Mandavi forest Range (Kinwat) and Mahur forest ranges of Nanded district. Mahur is famous for "Mahur fort" and the sacred temple "Renuka Mata, Anusaya devi and Dattatraya". As a result, this forest has nicely been protected by forest department. The study are is dominated by deciduous forests with dominance of *Tectona grandis*, *Ficus benghalensis, Ficus relgiosa, Acacia arabacia, Acacia catechu, Butea monosperma. Bauhinia racemosa. Pongamia pinnata. Azadirachta indica,* etc. During the survey of these areas in all twenty species of macrofungi were collected from wooden logs and dried branches of the forest trees. The macrofungal species were mainly observed on *Acacia* sp. and *Delonix regia*. Some of the species were also collected from forest floor. Some of the important fungal genera recorded are *Ganoderma, Phellinus, Polystictus*, *Agaricus*, *Hydnum , Daldinia, Schizophyllum, Polyporus,* etc.

14. PROTEIN DIVERSITY AMONG THE SPECIES OF *TRIMATOSTROMMA*

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Fungi are found to be the ultimate source of unlimited opportunities that provide noble chemicals to the human beings. In the present work classical taxonomy of hyphomycetes fungi was carried out which is a universal approach for many groups. It has been observed that morphological criteria often overlap among the closely related species thus leading to taxonomic confusion, making identification and classification very difficult at species level. So in the present work some closely related species of *Trimmatostroma* have been identified by using SDS-PAGE technique. SDS-PAGE was successfully applied in many fungal species for estimating fungal identification. Three *Trimmatostroma species in* SDSPAGE electrophoresis revealed very distinctive protein banding pattern on electrophorogram. In total 12 bands were scored among three *Trimmatostroma* species. Out of 12 bands, 5 bands (42%) were monographic, while 7 bands (58%) were polymorphic. The dendrogram generated from similarity table clearly grouped three *Trimmatostroma* species into two distinct clusters. Cluster-I was formed of two species while; cluster-II comprised single species.

15. *LABOULBENIALES* (*ASCOMYCOTA*): AN INTERESTING GROUP OF INSECT ASSOCIATED FUNGI

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The order *Laboulbeniales* (*Ascomycota*) constitutes of well-defined, extremely diversified, group of fascinating little fungi which are obligatorily associated with living arthropods (mostly insects and rarely mites) and spend the entire life cycle on their host. The hosts for *Laboulbeniales* may be collected from water, soil, decomposing plant and animal remains. These fungi differ from most other Ascomycetous fungi in that they do not form hyphae but instead form discrete microscopic, and multicellular thalli. Being very small, only about 0.1 to 0.3-millimetre they are hardly visible to naked eyes. The specialized vegetative body of the fungus consists of definite or limited number of cells and show clear individuality. These fungi grow on the surface of exoskeleton of hosts singly or in small clusters and sometimes look like short brownish bristles or hairs of the host. These fungi have a very wide distribution suggesting that even in those regions from where they have not been reported, these may be present but are undetected so far. We have worked on taxonomy, morphology, ecology and development of these fungi from India and reported many dioecious and monoecious genera from this part of the world. Some of these are: species of *Laboulbenia*, *Dioicomyces*, *Misgomyces*, *Dimeromyces*, *Rickia*. All members of the group possess an extreme level of specificity. They are host-specific, specific in relation to sex of the host and position specific. Specificity for a particular position on the host has been observed by us for a number of species, e.g. *Herpomyces periplanetae* was observed only on the antennae of the cockroach, *Periplaneta americana*. To add more to the list, we are routinely collecting and examining insects for the presence of *Laboulbeniales* from India.

16. INDIAN FUNGI: *ASCOMYCOTA* DIVERSITY, CURRENT STATUS AND CHALLENGES

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Ascomycota is one of the largest phylum in the Fungal kingdom which are ubiquitous and flourish the world over. In India, fungal studies began three centuries ago and are now being intensified by budding mycologists in different parts of India. The traditional taxonomy of *Ascomycota* is based on microscopic morphological studies and now the trend is mixed with modern molecular taxonomy. Relatively, the *Ascomycota* have been extensively studied and documented both in India and around the world. The Indian fungi currently consist of more than 30,000 species, of which the *Ascomycota* number is still unclear, but according to current literature it is approximately >55% and it contributed more than 500 new genera to the *Ascomycota* world. The dominant group includes class *Sordariomycetes*, order *Xylariales*, family *Xylariaceae* and genus *Xylaria*. So far, in Gujarat and Andaman and Nicobar Islands, the *Ascomycota* report checklist has been made. Indian Ascomycetology, founded by eminent mycologists who studied *Ascomycota* and its literary contributions, research facilities, and conventional and modern classifications, is extensive. With their inspiration, we are encouraged to compile all the Indian fungi bit by bit. We have completed the checklist for the Andaman Nicobar Islands and are now working on a complete checklist for the Northeast, which hits 2000 plus.

17. DIVERSITY OF WOOD ROTTING APHYLLOPHORACEOUS FUNGI FROM BHOOM TEHSIL (OSMANABAD DISTRICT) MAHARASHTRA

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Wood rotting is normally caused due to macro fungi belonging to the Aphyllophoraceous fungi. Present survey deals the availability of diverse Aphyllophoraceous fungi from Bhoom tehsil of Osmanabad district of Maharashtra state. Around more than 36 specimens were collected found on different host of angiospermic trees. These wood deteriorating lignicolous macro fungi fall under the 14 taxa. Species enumeration shows that *Phellinus* were abundant followed by *Ganoderma* and *Trametes*, *Scytinostroma*. Frequently occurring hosts were *Acacia arabica*, *Leucaena leucocephala, Gliricidia sepium, Mangifera indica*, *Tamarindus indica, Azadirachta indica,* etc. *Phellinus badius* and *Ganoderma lucidum* was also observed as dominating representative of these areas. Species like *Duportella tristicula*, *Irpex vellereus*, *Loweporus tephropours, Navisporus floccosus, Podoscypha petalodes, Porostereum spadiceum, Pyrofomes albomarginatus* and *Trametes leolina, Trametes variegate, Phellinus allardii* were rarely found.

18. A STUDY ON FRUITING PHENOLOGY, DISTRIBUTION, ECOLOGY AND ECONOMIC UTILITY OF WILD LAMELLATE MUSHROOMS FROM HARYANA

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Agarics, like other fungi require high humidity and low temperature for their growth and derive their nutrition from complex organic matter. For their sustenance they occupy a wide variety of substrates such as soil, leaf litter, living or decaying wood, dung, and some of them are also found forming intimate association with higher plants and termitaria. Every agaric has its own habit of growing either solitary, scattered, in groups, in caespitose clusters or in fairy rings. In the present investigation, a study on fruiting phenology, growth habits, habitat and association, edibility status as well as frequency of occurrence of various species, genera and families in Districts Panchkula, Ambala and Yamunanagar which form major part of the the Shivaliks of Haryana was undertaken. All 76 collections representing 51 species and 24 genera were gathered from different localities surveyed during the monsoon season. It was found that maximum number of fruit bodies (62%) appeared during the month of August followed by July and September. Majority of the investigated mushroom genera (21%) and species (29%) were the members of family Agaricaceae. Out of the documented taxa maximum number of taxa were terrestrial (47%) while rest were either lignicolous, termitophilous, foliicolous, coprophilous, either growing on wheat straw or having mycorrhizal association. Most of the examined mushrooms were found growing either solitary (25%) or scattered (25%). As far as edibility status is concerned, 21% were found to be edible, 31% edible species were having medicinal utility, 12% were inedible, 4% hallucinogenic, 12% poisonous and the edibility status of 20% of the taxa could not be ascertained. Investigations of phenological, distributional, ecological and economic aspects of mushrooms are quite important from sociobiological point of view.

19. FUNGAL DIVERSITY IN RICE CROP FIELDS AND THEIR WEED PLANT

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In a natural ecosystem study the paddy field for fungal diversity, in this study found out in the plants' symbiotic relationship with the beneficiary a few endophytic fungi contributing to its host plants while a few taxa are caused the disease. The present study aims to distinguish the fungal diversity of endophytic and pathogenic fungal communities associated with healthy rice plant of *Oryza sativa* and weed plant of *Echinochloa crus-galli*. The CR 1009 rice plant is a long duration short bold grain rice variety. It is submergence tolerance cultivates during samba season to the flooding prone area of Delta region of Tamil Nadu. The Delta area is a 'Rice bowl of Tamil Nadu', in southeastern India. The Delta region above the sea level with latitude ranging from 10 20′ and 11 07′ and longitude 79 15′ and 79 45′, annual rainfall averages 1105 mm. A total of 19 endophytic fungi was isolated using the culture-dependent approach from leaf tissues part of the two plants. A few fungal species disclosed the association among the isolates common to both plants. Although, the pathogen fungi have occurred in disease only in paddy plant. A genus of *Acremonium* sp., *Aspergillus* spp., *Chaetomium* sp., *Cladosporium* sp., *Colletotrichum* sp., *Curvularia* spp., *Fusarium* spp., *Gliocladium* sp., *Penicillium* spp., *Phoma* sp., *Trichoderma* sp., *Rhizopus* sp. were commonly isolated in both the crops whereas *Pyricularia* species of the blast disease and *Helminthosporium* species of the brown spot disease were identified of pathogen fungi from Paddy crops. A total of 19 endophytic fungi belonging to different species was isolated from 200 (each 100) tissue segments of leaves of healthy rice and weed samples, out of which, 16 were weed associated and 15 isolates were from rice plant. A parasite fungus of *Ustilaginoidea virens* is caused by disease in a fruiting stage of paddy plants. It is seeing a sclerotium like body grows and bursts out literally between the closelypressed glumes. There was a significant similarity between the occurrence of the endophytic fungal isolates in tissues of both the plants. In both, the *Aspergillus* sp., *Cladosporium* sp., *Fusarium* sp., *Penicillium* species were frequently isolated. The pathogenic fungal species were identified according to the age of paddy plants.

20. DIVERSITY OF MARINE FUNGI IN SELECTED WETLANDS OF KERALA

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A range of fungi occur in coastal ecosystem although they differ as to their location. They play a vital role in detritus decomposition, nutrient cycling and energy flow in marine food web. During a marine mycological survey along Kerala coast a total of 59 marine fungi comprising 37 Ascomycetous, 2 Basidiomycetous and 20 Mitosporic fungi were encountered from selected wetlands *viz*. backwater, brackish water and estuarine ecosystem. Fungal composition and frequency varied from one ecosystem to another. Maximum number of species (44) was recorded from backwater ecosystem and minimum from brackish water ecosystem (17).

21. DIVERSITY OF TOMENTELLOID FUNGI: GENUS *TOMENTELLA* FROM HIMACHAL PRADESH, INDIA

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The genus *Tomentella* belongs to family *Thelephoraceae*, order *Thelephorales* under the class *Agaricomycetes*. It is one of the most frequent and widespread ectomycorrhizal (EM) fungi found in the sub-tropical to temperate forests. The hymenophore of this genus is resupinate, loosely adnate, effused, with hypochnoid to granulose to arachnoid to smooth to colliculose surface. Hyphal system can be monomitic or dimitic. The fungi sometimes also make rope-like cord of hyphal growth known as hyphal cordon. Sterile structures may or may not be present. Basidia narrowly clavate to subclavate to subcylindrical. Basidiospores subglobose to globose, regular to irregular, lobbed, subhyaline or yellowish brown or brown, thick-walled, echinulate, inamyloid, acynophilous. The earlier workers have documented 45 taxa of this genus from various districts of the state. The aim of the present paper is to present and illustrated account of the genus *Tomentella* from Himachal Pradesh.

22. ISOLATION AND MORPHOLOGICAL IDENTIFICATION OF *CANDIDA* SP. FROM THE NECTAR OF FLOWER OF *TECOMA STANS* (L.) JUSS. EX KUNTH

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In this study we have isolated the *Candida* species from nectar of flowers of *Tecoma stans* (L.) Juss. ex Kunth belonging to the family *Bignoniaceae,* The *Candida* species have oval-elongated cells. On PDA the colonies were observed as white, convex, circular and stick. Microscopically the cell are elongated, oval or spherical. Few cells showed budding and even hyphal formation.

23. MORPHOLOGICAL AND MOLECULAR PERSPECTIVES ON SYSTEMATICS OF GENUS *CREPIDOTUS* IN KERALA STATE

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Crepidotus is a small lamellate genus of family *Crepidotaceae* with about 200 species known world over. The taxonomic literature on *Crepidotus* is scarce and the statistics on Indian *Crepidotus* indicates that no serious study was so far made to understand the species diversity in the genus. From India only 24 taxa and from Kerala State only 11 taxa were known prior to this study. This set the stage for the present study with the prime objective of analyzing the species diversity in *Crepidotus* of Kerala State in a morphological and molecular perspective. During the period 2014 to 2018, *Crepidotus* specimens were collected from different forest localities of Kerala and critically studied by morpho- and molecular methods. All fresh and herbarium

specimens of *Crepidotus* were critically studied, identified and assigned to 29 species. Molecular studies of all collections were attempted, however, isolation and amplification of DNA could be made only from 22 species. The remarkable outcome of the present study is the discovery of 16 new species, 6 new Asian records, 2 new Indian records and 1 new record for Kerala. Furthermore, the nrLSU sequences generated from 22 species of *Crepidotus* of Kerala seems significant as the number of sequences for *Crepidotus* in NCBI GenBank is scanty and represents mostly from temperate regions of the world. The tropical and subtropical species representation was poor and no sequences were deposited from India prior to this study. The present work is thus significant as it forms the first major attempt to sequence the nrLSU region of *Crepidotus* from India. This will eventually pave way for better understanding of *Crepidotus* taxonomy with a phylogenetic perspective.The sequences from new species along with its voucher specimens will add further dimensions to the tropical sampling of *Crepidotus* and play vital role in constructing a meaningful phylogeny of the genus. Details of all 29 species of *Crepidotus* is discussed here.

24. SURVEY OF WOOD ROTTING FUNGI FROM KOLHAPUR DISTRICT, MAHARASHTRA

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Wood rotting macrofungi are the most intensively studied Fungi by Indian as well as other mycologist globally. However, many potential diversity rich areas are still waiting to be demystified. One such patch is Kolhapur district, falling under Deccan peninsular India, mostly consisting of combined elements of evergreen rainforest of Western Ghats and dry plateau. Here, we are presenting the observations of 60 wood rotting fungal taxa, inferred from their geographical distribution, ecology and the economic impact caused by them, due to rotting. Overall 45 localities representing two types of vegetation were surveyed, in which two major types of wood rottors *i.e.* White rot and brown rot were observed on 43 types of trees and timbers. Overall, 17 Families, 45 Genera and 60 Species of wood rotting macro fungi are presented alphabetically and separate keys are given for identification of each taxon within the two major fungal phyla naming *Ascomycota* and *Basidiomycota*. The work presented here will create a framework for upcoming taxonomic and diversity studies which will result in a strong mode of communication among the forest managers, policy makers, amateurs, students and teachers, natives and nature lovers. An avenue for further survey, collection and documentation of wood rotting fungi is ultimate goal of present research.

25. CORTICIOID FUNGI REPORTED FOR FIRST TIME FROM THE STATE OF HIMACHAL PRADESH

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Corticioid fungi are characteristic in having resupinate, effused basidiocarps with gymnocarpic, unilateral hymenium; hymenial surface varying from smooth, ridged, tuberculate, toothed, warted to merulioid, generally varying in colour from different shades of orange, grey or yellow to sometimes more

bright shades of blue, red and classified under various orders of class *Agaricomycetes* (phylum *Basidiomycota*, subphylum *Agaricomycotina*). Presently an account of 10 species of corticioid fungi (*Athelia epiphylla*, *Ceraceomyces serpens*, *Granulobasidium vellereum*, *Leucogyrophana pseudomollusca, Peniophora lycii*, *P. pseudoversicolor*, *P. rufomarginata, P. violaceolivida, Phanerochaete magnoliae* and *Tomentella viridula*) belonging to 6 orders i.e. *Agaricales*, *Atheliales, Boletales, Polyporales*, *Russulales* and *Thelephorales* have been provided. All of these are new records for Himachal Pradesh and *Ceraceomyces serpens*, *Granulobasidium vellereum*, *Leucogyrophana pseudomollusca, Peniophora lycii*, *P. pseudoversicolor*, *P. rufomarginata, Phanerochaete magnoliae* and *Tomentella viridula* new records for India.

26. TWO ASCOMYCETOUS FUNGI FROM MAHARASHTRA

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In the course of a mycological survey of Maharashtra, two ascomycetous fungi were collected viz., *Bagnisiella indica* Vaidya and Naik and *Daldinia concentrica* (Bolt. ex Fr.) Ces. & de Not. These were growing saprophytically on dead stems of *Tamarindus indica* Linn. and the bark of *Azadirachta indica* (L.) Adr. Juss., respectively. Both these specimens have been examined and deposited at Ajrekar Mycological Harbarium, Agharkar Research Institute, Pune (India). The description of these species is provided.

27. SEASONAL VARIATION OF INDOOR AEROMYCOFLORA OF COLLEGE LIBRARIES

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Library is a basic source of cellulosic substrate for proliferation of diverse group of fungal organisms provided ambient climate of temperature and humidity. Among the airborne microorganisms fungi spread air spores at high rate from different sources. This study was undertaken to calculate the variety and quantity of airborne fungi every month for one year i.e. during the year March 2010 to February 2011 to report the aeromycoflora from five different college libraries of Wardha city. During this period of research, total 66 fungal species belonging to 32 genera of fungi were isolated from indoor environment of five college libraries by culture plate exposure method were representatives of the four major groups i.e. *Zygomycota, Ascomycota,* Mitosporic fungi and Mycelia sterilia and the unidenfied fungi were kept in unidentified group. Mitosporic fungi dominated the total colonies recorded followed by *Zygomycota* and *Ascomycota*. *Aspergillus* was dominated with higher colony count as well as greater species number. *Aspergillus niger* followed by *Aspergillus fumigatus* were found to be the most dominant fungi in the indoor aerospora. Diversity of fungal organisms on cellulosic material in library concerns to changing indoor environment.

28. *XYLARIA CHILAI* SP. NOV. FROM ZARI TEHSIL, DISTRICT YAVATMAL (MAHARASHTRA) INDIA

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Present paper deals with the description of *Xylaria chilai* sp. nov. from Zari tehsil District Yavatmal. The study area is a dominated by deciduous vegetation. Among the different tree species, Teak is most commonly associated with diverse group of saprobic fungi. During the mycological survey many specimens of wood inhabiting fungi were collected by the authors. Among these the interesting Ascomycetous genus *Xylaria* was studied in detail. One of the *Xylaria* specimen could not be assigned to any of the known species and is described as *Xylaria chilai* sp. nov. The holotype of this species is deposited in Ajrekar Mycological Herbarium (AMH 10247).

29. ISOLATION AND IDENTIFICATION OF PAINT DEGRADING FUNGI ON MONUMENTS OF MUMBAI (MS)

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Paint is a pigmented liquid that forms a thin layer coated to any object. It is used to provide protection, color and texture. Paints primarily consist of pigments, binders, solvents, and other volatile organic compounds. When degraded by a fungus, paint sets these components free to the environment which are toxic to the living beings. Fungal saprobes from paint were collected aseptically from different monuments of Mumbai by the Cotton Swab method and were cultured in Martin Rose Bengal Agar Media. The fungi isolated from the painted wall surface's deterioration belong to nine different species. The most prevalent genera include *Aspergillus, Fusarium, Curvularia, Mucor, Alternaria, Penicillium,* and *Colletotrichum*. It is observed that *Aspergillus* sp. was primarily responsible for paint degradation. Scanning electron micrographs clearly showed the adherence and fungal growth on paint flakes and the distorted surface. The current studies represent the significant finding of paint biodegradation by the isolated fungi.

30. STUDIES ON GENUS *AMANITA* FROM MIXED FORESTS OF JAMMU, INDIA: ONE NEW RECORD AND THREE REGIONAL RECORDS

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The family *Amanitaceae* is one of the most important and species-rich families of *Basidiomycota*. It is well known to both scientific and mycological community, probably due to the presence of most fascinating species which include both edible as well as deadly poisonous mushrooms. The most dominated genus, *Amanita* is characterized by two enveloping veils i.e. universal veil and partial veil during young stage. *Amanita* species alone are responsible for approximately 90% of the

fatalities resulting from mushroom poisoning. Till 2020, 71 species of *Amanitaceae* were reported from India, out of which 65 species belong to genus *Amanita*. From Jammu and Kashmir, only 3 species of *Amanita* have been recorded so far. During recent explorations in some mixed forests of Jammu, seasonal collections of *Amanita* species were made and out of them four species were worked out morpho-taxonomically, and were identified as *Amanita orsonii, A. Griseofolia, A. orientifulva* and *A. pakistanica*. Macroscopic characters were noted in the field from fresh basidiomata and collected samples were dried within wooden drier. Microscopic characters were observed with compound microscope from dry materials mounted in 5% KOH, 1% Phloxine and 1% Congo red. A detailed morphological and microscopic examinationwith one new record for India and three new regional records to the macro-fungal diversity of Jammu provinceare discussed.

31. ISOLATION, IDENTIFICATION AND ANALYSIS OF SECONDARY METABOLITES OF *FUSARIUM GLOBOSUM* FROM *COCCINIA GRANDIS* OF MALABAR REGIONS OF KERALA

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Coccinia grandis Wight & Arn. is one of the important perennial, herbaceous climber of family *Cucurbitaceae*. It is commonly known as Ivy gourd and used as vegetable. The present studies aimed to isolate and identify the fungi associated with both vegetable and the soil sample of the sampling area to determine the fungi involved in the spoilage of vegetable. Pathogenicity test was also carried out to confirm the fungal pathogens. Qualitative analysis of secondary metabolites was studied using standard methods, quantitative analysis were investigated using spectrophotometric methods. Total antioxidant activity, reducing power assay and DPPH activity was carried out using secondary metabolites produced by *Fusarium oxysporum*. Ethyl acetate and methanol were used for extraction. Results of the study showed that fungi viz., *Fusarium oxysporum* and *Aspergillus niger* were isolated from the vegetable and *Cladosporium* sp. and *Aspergillus niger* were isolated from soil sample and confirmed that *Fusarium oxysporum* and *Aspergillus niger* were thes oil borne fungi responsible for the spoilage of the vegetable. Pathogenicity test showed that *Aspergillus niger* had the highest decay diameter in the healthy vegetable while *Fusarium oxysporum* had the lowest decay diameter. Qualitative and quantitative study of secondary metabolites showed positive results in *Fusarium oxysporum*. The antioxidant activity was high in methanolic extract (33.16±0.045, 8.17±0.035, 0.37±0.0025) compared to ethyl acetate extract (30.12). This investigation reveals that the metabolites produced by *Fusarium oxysporum* can be a potential source of novel natural bioactive and antioxidants compounds.

32. MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF GENUS *AGARICUS* IN KERALA STATE

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The saprophytic genus *Agaricus* is a large genus of mushrooms with a cosmopolitan distribution. More than four hundred species are known worldwide and are of great interest as many species have high nutritional and medicinal value. Yet the extent of its diversity remains poorly known, especially in

subtropical and tropical areas including India and so far only 127 taxa were known from this vast country. The taxonomy of genus *Agaricus* and species level identification remain chaotic and problematic due to overlapping and limited number of taxonomically relevant phenotypic characters. Recent advances in molecular techniques however helped to resolve this issues to certain extend and various molecular markers are being used in unravelling species level complexities. As a part of our ongoing monographic study on the genus *Agaricus* of Kerala State, 150 specimens belonging to genus *Agaricus* were collected from different forest localities of the state during the two year period 2019-2021. Detailed macro-morphological and molecular studies of these specimens resulted in the identification of 17 species. It includes five new species, seven new records to India and two edible species. The ITS sequences generated from the tropical species is important from a phylogenetic perspective of the taxonomy of *Agaricus*. Morpho- and molecular details of these 17 species will be discussed in the present paper.

33. A NEW SPECIES OF *CLAVULINOPSIS* FROM LOWER GANGETIC PLAIN OF WEST BENGAL, INDIA

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The Genus *Clavulinopsis* belongs to the family *Clavariaceae* and order *Agaricales*; and are popularly known as coral fungi. This group has been exploited well so far but yet there are opportunities to improve the taxonomic diversity. Clavarioid fungi are always being the point of attraction for taxonomists due to their unique morphology of the fruiting bodies and majority of them show saprophytic association. Recent investigations suggested that there are 9 different families under coral fungi, and surprisingly 67 taxonomically known species are recognised in the genus *Clavulinopsis*. A new species of *Clavulinopsis,* has been recorded from lower Gangetic plain of West Bengal, India in recent days and the present paper is about the macroscopic and microscopic description, phylogeny of the new species. This species shows some unparallel features like bright yellow fruiting body, tetrasporic basidia (14.92-21.81 × 3.16- 5.74 µm in size), hyaline spores (5.74-8.61 × 5.74-8.89µm) that are globose to subglobose in shape with distinct apical pore, and each of the basidium contain clamp connection at their base. A phylogenetic representation of almost 45 accepted species along with the new one is also provided. This paper can be a contributed to the distribution, documentation and richness of an ecosystem of macro-fungi in lower Gangetic plane.

34. BIODIVERSITY OF FUNGUS ISOLATED FROM ACHANAKMAR-AMARKANTAK BIOSPHERE RESERVE AND THEIR ANTIMICROBIAL PROPERTIES

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Fungi are one of the most hyper diverse phyla and presently more than 1.25 lakh fungi are reported from across the globe. Moreover, it is estimated that at least 15 lakh fungi are yet to be described.

Despite their importance in ecosystem functioning as well as industries in the production of enzymes, metabolites, etc., they have been neglected. Hence, there is a need to map the diversity of fungi from various habitats of India and also accomplish its conservation. The Achanakmar-Amarkantak is a biosphere reserve and its region cover states of Chhattisgarh and Madhya Pradesh. The prosperous diversity of the region has not been surveyed yet in terms of its fungal wealth and holds a lot of potential as the region is undisturbed since long time. In the present investigation, a total of 228 fungi are isolated so far and deposited at NCCS-NCMR. Out of these, 21 probable novel fungi which have low similarity with the type sequences of available database in NCBI are taken up for complete characterization by doing multi locus sequence analysis (MLSA). Sequencing and BLASTn search of ITS showed that the isolates belong to genera *Diaporthe, Marasmiellus, Marasmius, Gymnophilus, Nemania, Chamaeota, Penicillium* and *Albifimbria*. Moreover, 160 cultures have been screened for their antagonistic activity against eight standard pathogens. Among these nearly 14 cultures showed antagonistic properties against pathogen. In the present study we present results about their diversity and bioactivity.

35. INTERESTING SPECIES BELONGING TO GENUS *LACTARIUS*

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Lactarius Pers. is a widely distributed genus which shows ectomycorrhizal relationship with broadleaf and coniferous trees and is characterized by the presence of latex. Microscopically, all members of the genus *Lactarius* have basidiospores showing amyloidy, ornamentation, sphaerocytes in the trama and pseudocystidia in the hymenium. Being ectomycorrhizal, they play a critical ecological role in terrestrial ecosystems through symbiotic association with higher plants. Many species from India have been named after their North American and European lookalikes and based only on their macromorphological similarity. The Union Territory of Jammu and Kashmir is rich in macrofungal diversity due to unique climate, rough topography and subtropical to temperate kind of forests. Till now, only 12 species of *Lactarius* have been reported from Jammu and Kashmir (J&K) but they have been identified solely based on macromorphological characteristics and comparisons. In the present investigation, some interesting species of *Lactarius* growing in the forests of J&K*were collected and* taxonomically characterized morphologically (macro and micro) and molecularly. These species were identified as *Lactarius sinozonarius*, *L. abieticola*, *L. pleuromacrocystidiatus*, and *L. controversus*. Survey of literature reveals that two of them (*L. abieticola*, *L. pleuromacrocystidiatus*) constitute new records for the macrofungal diversity of J&K while one species of *L. sinozonarius* constitute the new record to the mycobiota of India. Morpho-taxonomic details along with phylogenetic estimation of these *Lactarius* species will be highlighted in the present communication.

36. FUNGAL DIVERSITY IN THE FORESTS OF DAKSHIN DINAJPUR, WEST BENGAL

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Tropical regions are considered to be the optimum place for rich fungal diversity as the optimum growth conditions for the proliferation of different kinds of fungi is supported by rich plant diversity. In this study, forests of Dakshin Dinajpur district of West Bengal were selected to observe the diversity of

macro fungi. A total of 18 forests of 3 blocks were regularly visited for 3 years to explore the diversity and distribution of different types of macro fungi. Occurrence of different fungi throughout the year, association of fungi with forest vegetation, edaphic and climatic factors affecting the growth of macro fungi were carefully recorded. Most of the macrofungi grow abundantly during rainy to autumn season, whereas diversity reaches its peak during mid-July to end-August. Altogether 20 different genera (*Dacryopinax, Phallus, Daldinia ,Pycnoporus, Xylaria, Rosellinia., Stemonitis, Auricularia, Marasmius, Polyporus, Gymnopus, Pisolithus, Lentinus, Marasmiellus, Trametes, Ganoderma, Agaricus, Schizophyllum, Lycopedron, Sutorius)* were collected from the study area belonging to the families *Marasmiaceae, Dacrymycetaceae, Phallaceae, Polyporaceae, Xylariaceae, Auriculariaceae, Agaricaceae, Stemonitidaceae Ganodermataceae, Omphalotaceae, Sclerodermataceae, Schizophyllaceae, Boletaceae* and *Hypoxylaceae*. The most abundant genera found were *Pycnoporus, Pisolithus, Xylaria, Polyporus* and *Lentinus*. Interestingly the growth of *Marasmius* sp. and *Gymnopus* sp. were restricted inside the premises of Danga forest of Balurghat block only. Habitat study (leaf litter, dead wood, tree trunk), morphological study, hyphal and spore study were carried out for each species. The collected macro fungi were identified based on macroscopic characteristics like attachment, cap size, colour, gills, shape, surface texture and moisture, stem size, presence and absence of partial or universal veil etc.

37. DIVERSITY OF RESUPINATE, NON-POROID AGARICOMYCETOUS FUNGI (FAMILY *MERULIACEAE*) FROM DISTRICT MANDI, HIMACHAL PRADESH

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The family *Meruliaceae* belongs to the order *Polyporales*. The members of this family are having either crust like non-poroid or polyporoid hymenophore and, grow appressed to the substratum, or are more or less effused. Basidiocarps of these fungi have variation in colors from whitish to some shades of grey to yellow to more bright shades of orange, red, brown and blue. The fruitbody vary from loose to almost horny hard when dry and may consist of two general types of hyphae. The holobasidia are normally tetra sterigmate. Spore size, form and ornamentation also vary from species to species. Earlier only *Phlebia livida* of this family is reported from district Mandi. The present studies describe 10 taxa belonging to 2 genera of this family from the study area.

38. FOUR NOVEL FUNGAL SPECIES REPORTED FROM UTTARAKHAND, INDIA

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During a regular collection trip of Valley of Flowers, National park, Uttarakhand in June-November (2018-19), four new interesting member of fungi were encountered. In this paper two powdery mildews viz., *Podosphaera filipendulensis* sp. nov. on *Filipendula vestita* (Wall. ex G. Don) Maxim. (*Rosaceae*) and *Podosphaera thermopsidicola* sp. nov. on *Thermopsis barbata* Benth.

(*Fabaceae*) along with two rust fungi *Puccinia polygoni* sp. nov. on *Bistorta vivipara* (L.) Delarbre and *Nyssopsora toonae* on *Toona sinensis* (Juss.) M. Roem. are reported from the above region. The phylogeny of these four species has been inferred from partial nuclear ribosomal 28S large subunit (LSU) and internal transcribed spacer (ITS) rDNA sequence data.

39. MORPHOLOGY AND PHYLOGENY OF THREE NOVEL TAXA OF *COLLETOTRICHUM* AND *TERATORAMULARIA* FROM UTTAR PRADESH

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Three new interesting asexual foliicolous species, *Colletotrichum alzibia*, on young pods of *Albizia lebbeck, Colletotrichum tulsi* from living leaf of *Ocimum tenuiflorum*, and *Teratoramularia rumicis* on *Rumex crispus*, are described and illustrated. These species are compared with closely related species and the phylogeny of these species has been inferred from 28S nrRNA gene (LSU) and internal transcribed spacer regions 5.8S nrRNA gene (ITS) of the nrDNA operon. The phylogeny of *Colletotrichum tulsi* shows close resemblance with *C. yulongense* and *C. Gloeosporioides*. However, *C. gloeosporioides* differs in having longer and aseptate conidia and *C. yulongense* in having longer setae and smaller conidia. Morphologically, *C. alzibia* differ from *C. lebbeck* in having large sized and septate conidiogenous cell and comparatively larger, semicircular and tapering end of conidia. *C. fusiforme* also differs in having smaller conidiomata and larger conidia. *Teratoramularia rumicis* is compared with closely related species of *Teratoramularia.* It differs *T. rumicicola* due to having shorter and septate conidiophores; more separation, longer and thicker ramoconidia with more apical hila, shorter intercalary and terminal conidia and absence of type II brown conidia *and* species of *Ramularioid* complex along with dematiaceous cercosporoid forms reported on the same host genus and family.

40. MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF FOUR NEW MACROFUNGAL RECORDS FROM INDIA

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The reports of novel macrofungal records and species from India have added new dimensions to the field of fungal research worldwide. Various explorations of mycobiota in Kashmir Himalaya were undertaken keeping in view the diverse topographical features, varied phenological occurrences and distinctive ecosystem attributes. Over 50 specimens spanning the major areas of temperate forests were studied and out of these, four taxa *viz*., *Abstoma* sp. (*Agaricaceae*), *Hydnum vesterholtii* (*Hydnaceae*), *Inosperma rhodiolum* (*Inocybaceae*), *Pluteus salicinus* (*Plutaceae*) are described here. These were identified using morphological and molecular data. nrITS was used for phylogenetic analyses. Critical literature survey established that the present investigated species are first reports from India. Detailed morphological descriptions, photo-illustrations and distribution data of these species are provided in the present communication along with phylogenetic analyses.

41. CROSS MORPHO-ANATOMICAL STRUCTURAL ANALYSIS OF EARTHSTARS (*AGARICOMYCETES*) USING- INTEGRATIVE TAXONOMIC APPROACH

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The gasteroid genera *Geastrum* and *Astraeus* are popularly known as "earthstar" due to star-like appearance of exoperidium rays, have always been subject of great interest. They are hypogaeic, sub-hypogaeic or epigaeic in origin. The fruitbodies of earthstars and its allies have persistent endoperidium, which covers the hymenophore (gleba), and spores are realeased passivly by bellows mechanism through one or more apical mouth. They usually, grows on a diverse range of habitat such as decaying wood, leaf litter, mossy blocks, termite mould, sand dunes, and bare soil. These earthstars are placed in *Phallomycetidae* (*Geastrales*) and *Agaricomycetidae* (*Boletales*) clades of Agaricomycetous fungi. Expeditions to Sal forest of Jharkhand, India between June 2019 - July 2020 resulted into collection of three noteworthy earthstar species - *Geastrum* sp. (Geastraceae), *Astraeus asiaticus* and *A. odoratus* (*Asteraceae*). The earthstars are superficially similar but distinct in terms of morphological, anatomical and phylogenetic traits. This work is mainly concerned with the identification and cross morpho-anatomical structural analysis of earthstars growing in this region. Identification was carried out based on integrative taxonomic approach. The cross morpho-anatomical studies revealed, distinguishable combination of characters such as non-delimited mouth; nature of hygroscopic rays; trait of the exoperidium and endoperidium layers; spore and capillitium size and ornamentation; crystalline matter; basidiomata size and colour. Scanning electron microscopy analysis suggested varied size and distinct ornamentation of spore.

42. DIVERSITY OF GENUS *HYPHODERMA* IN DISTRICT SHIMLA (HIMACHAL PRADESH)

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Genus *Hyphoderma* is characterized by resupinate, effused, adnate and often ceraceous basidiocarps. The hymenial surface varies from smooth, tuberculate to grandinoid and ranges from some shades of white to yellow to gray to orange. Microscopically the genus is typical in having monomitic hyphal system with nodose-septate, thin- to thick-walled generative hyphae. The basal hyphae are oriented parallel to the substrate and are loosely interwoven where as subhymenial hyphae are vertical and compact. Cystidia may be present or absent. Basidia are generally clavate to subclavate, constricted or sinuous, 4- sterigmate and are with a basal clamp. Basidiospores vary from ellipsoid to cylindrical to allantoids. These are smooth, thin-walled, usually with oily contents, inamyloid and acyanophilous. The present paper provides an account of 6 species of genus *Hyphoderma* based on collections made from district Shimla (Himachal Pradesh). These are identified as *H. anthracophilum*, *H. definatum*, *H. hjorstamii*, *H. hallenbergii*, *H. incrustitissima* and *H. incrustatum*. All the six species are new records for the study area. *H. definatum*, *H. hjorstamii*, *H. incrustitissima* are new records for the state of Himachal

Pradesh and *H. anthracophilum*, *H. incrustatum* are new records for India. Among the six species, *H. hallenbergii* is a published new species.

43. FAMILY *HYMENOCHAETACEAE* IN HIMACHAL PRADESH: INTERESTING POLYPORES AND EVALUATION OF SOME SELECTED TAXA FOR ANTIOXIDATIVE POTENTIAL

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Poroid genera of family *Hymenochaetaceae* (*Hymenochaetales*, *Agaricomycetes*, *Basidiomycota*) are characteristic in having annual to perennial, resupinate to effused to reflexed to pileate (sessile to stipitate), xanthochroic basidiocarps, simple septate hyphae, presence/absence of setae as well as setal hyphae, two to four sterigmate basidia and thin to thickwalled basidiospores. An account of 51 species spread over 4 genera collected from different localities of Himachal Pradesh during the years 2013-2017 has been provided. It will be worth mentioning here that of all, *Phellinus himalaycus*, *P. indicus*, *P. papilatus* and *P. peculiarus* are being described as new to science while 10 species namely *Coltricia focicola*, *Inonotus mikadoi*, *Phellinus chryseus*, *P. garuhapensis*, *P. himalayensis*, *P. mori*, *P. neocallimorphus*, *P. punctatiformis*, *P. tremulae* and *P. tuberculosus* are being described for the first time from India. As many as 6 species (Phellinus badius, P. conchatus, *P. ferreus*, *P. glaucescens*, *P. membranaceus* and *P. nigricans*) are new to the study area. Investigations have been undertaken to evaluate the antioxidative potential of five species (*Coltricia cinnamomea*, *Inonotus cuticularis*, *Phellinus pectinatus*, *P. peculiarus* sp. nov. and *Porodaedalea pini*). Of the three different solvents (ethanol, methanol and water) used, maximum TAE (Tannic acid equivalents) has been observed in hot water extracts in all the five selected species. The maximum TAE of up to 24.75±0.89 mg/g of the powder has been observed in extracts of genus *Phellinus* followed by *Inonotus* and *Porodaedalea* (20.79±1.02 and 12.42±0.92 mg/g of the powder respectively). The hydroxyl radical scavenging activity, superoxide radical scavenging activity and DPPH radical scavenging activity have been observed to be the highest in *P. pectinatus* (94.05±0.61, 90.8±1.44 and 76.2±0.7 respectively) followed by *P. peculiarus* sp. nov. (92.8±1.29, 89.9±1.53 and 75.97±1.05 respectively), *I. cuticularis* (91±1.15, 89.5±1.09 and 75±1.07 respectively), P. pini (90±1.52, 88.9±0.57 and 74.92±0.50 respectively) and lowest in case of *C. cinnamomea* (23.64±1.02 %, 21.4±0.6 % and 15.2±0.95 % respectively). The mass spectra analysis of HW extract of the four species revealed the presence of compounds belonging to various classes of polyphenols of Phelligridin C and D, phloretin, hispidulin, foetisultide D, hhishispolon and hypolomine B most prevalent.

44. MORPHO-ANATOMICAL AND MOLECULAR CHARACTERIZATION OF SPECIES OF *RUSSULA* (*RUSSULACEAE*) FROM NARKANDA, INDIA.

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The forests of Narkanda- the present area of investigation for exploring the diversity of lamellate mushrooms reveals that the agaric mycoflora is dominated by genera like *Russula*, *Lactarius*, *Amanita*, *Laccaria* and *Entoloma* etc. It is the integrated morphological and anatomical characters which lead to the correct and authentic identification of the taxa and the molecular studies are supportive in

differentiating the thin line of identification at the species level. Thus, in the present paper based on morpho-anatomical characters of various *Russula* species have been taken into consideration along with the molecular taxonomy and identified as *Russula amethystina* Quél., *R. cuprea* Krombh., *R. globispora* (J. Blum) Bon, *R. laeta* F.H. Møller & Jul. Schäff. and *R. pauriensis* A. Ghosh, K. Das & Buyck var. *caulocystidii* var. nov. *R. cuprea*, *R. globispora*, *R. laeta* and *R. pauriensis* var. *caulocystidii* var. nov. are reported for the first time in India whereas *R. amethystina* is rerecorded from India.

45. ADDITIONS TO THE POLYPOROID FUNGI OF PUNJAB

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Polyporoid fungi is an artificial group of wood decaying fungi placed in *Agaricomycetes* of *Basidiomycota*. These are characteristic in having annual to perennial, resupinate to effused-reflexed to pileate (sessile/stipitate) basidiocarps with gymnocarpic hymenium which is lining the tubes that open via pores. The pilei are variable in shape and may be solitary, imbricate, or in groups. The abhymenial surface varies from smooth to warted, zonate to azonate, glabrous to tomentose, concentrically sulcate to irregular sulcate. The poroid hymenophores are with round to cyclic to angular to radially elongated to irregular to daedaleoid to lamellate pores. Polypores show remarkable variation with respects to micromorphological features such as hyphal system, ancillary structures, basidia and basidiosporers. These are responsible for different types of rots of both gymnospermous and angiospermous wood. Punjab, a state situated in north western India, has quite favourable environmental conditions, particularly during the rainy months, for the growth of these fungi. The review of literature revealed an account of 86 polypore taxa from different parts of Punjab. Exhaustive fungal forays were conducted in various districts of the study area. On the basis of both macro and microscopic structures 8 taxa (***Ganoderma ahmadii, Ganoderma brownie, Ganoderma cochlear,*** *Ganoderma dahlii*, *Ganoderma tsunodae*, ***Phylloporia pulla, Pycnoporus sanguineus, Pycnoporus cinnabarinus***) new to Punjab are described and illustrated. Of these, *Ganoderma dahlia* and *G. tsunodae*, are new records from India as well.

46. MYCOFLORISTIC STUDIES OF WOOD ROTTING CORTICIOID AND POROID FUNGI IN DISTRICT KULLU (HIMACHAL PRADESH)

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The corticioid and poroid fungi (*Agaricomycetes*, *Basidiomycota*) are characteristic in having annual to perennial, resupinate to effused-reflexed to pileate, sessile to stipitate basidiocarps. The hymenium is exposed, organised either in the form of a sheet on the susbstrate (corticioid fungi) or is lining the tubes (poroid fungi) that open through pore. These fungi are mainly responsible for wood decay and few of them are forest pathogens. Kullu district, situated between 31° 25' north to 32°35' north latitude and 76°9' east to 77°9' east longitude, covers an area of 5,503 km^2 with an altitudinal range of 1,100 m to 4,300 m above mean sea level. Of the total geographical area, 10.64% (586 km^2) is covered by very dense forest, 14.26% (785 km^2) by moderate dense forest and 10.68% (588 km^2) by open forests. The vegetation of district Kullu may broadly be classified into montane subtropical forests, montane temperate forests, west himalayan sub-alpine birch/fir forests and alpine scrubs. In present paper an account of eight taxa of these fungi, on the basis of fungal forays conducted during 201618 has been

provided. Of these, *Botryohypochnus verrucisporus* Burds. & Gilb., *Corticium meridioroseum* Boidin & Lanq., *Fomitiporella cavicola* (*Kotl. & Pouzar*) T. Wagner & M. Fisch., *Odonticium flabelliradiatum* (J. Erikss. & Hjortstam) Zmitr., *Rhizoctonia amygdalispora (*Hauerslev, P. Roberts & Å. Strid) Oberw., R. Bauer, Garnica & R. Kirschner. *Tomentella alutaceoumbrina* (Bers.), *Tomentellopsis echinospora* (Ellis) Hjortstam *and Trechispora clancularis* (Park.-Rhodes) K.H. Larss. It is pertinent to mention here that all these eight species *are* being described for the first time from India.

47. SOME NOTEWORTHY ADDITIONS TO FAMILY *POLYPORACEAE* AGARICOMYCETOUS FUNGI FROM DISTRICT SIRMAUR (HIMACHAL PRADESH)

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Family is characterized by resupinate, effused, reflexed to pileate, sessile to stipitate basidiocarps with gymnocarpic, unilateral hymenium lining the pores, color varying from whitish to some shades of yellow, grey, brown, violet, blue or red, hyphal system monomitic, dimitic or trimitic, cystidia present or absent, setae absent, basidiospores cylindrical to allantoid, usually thin-walled, subhyaline, smooth, not stained in Melzer's reagent. District Sirmaur is one of the 12 districts of Himachal Pradesh spanning from 77°01'12" to 77°49'40" East Longitude and up to 30°22'30" to 31°01'20" North Latitude, with annual average rainfall of 1405 mm. Maximum average temperature is 30°C, minimum average temperature is -2°C and relative humidity is around 80%. An account of 6 species (*Diplomitoporus allantosporus*, *D. flavescens*, *D. overholtsii*, *Earliella scabrosa*, *Hexagonia hirta* and *Pycnoporus cinnabarinus*) of family *Polyporaceae* (order-*Polyporales*, class-*Agaricomycetes*, subphylum-*Agaricomycotina* and phylum-*Basidiomycota*) has been provided on the basis of specimens collected from district Sirmaur. All the six species are being described for the first time from the state of Himachal Pradesh and all the three species of genus *Diplomitoporus* are also first reports from India.

48. NEW RECORDS OF GENUS *MARASMIUS* FR. OF SECTION *SICCI* FROM INDIA

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Genus *Marasmius* is one of the most prominent tropical leaf litter binding and decomposing genera with a worldwide distribution. All of the members of this genus are known to possess small to medium sized, non-fleshy and marscescent fruit bodies and are potent decomposers. Present work includes the macromorphological, anatomical details and field photographs of the six species of genus *Marasmius* falling under section *Sicci.* They are characterized by non- institious and non- collariate stipes along with a hymeniform epicutis having siccus type broom cells. *Marasmius dennisii* Singer*, M. fulvoferrugineus* Gilliam, *M. hinnuleus* Berk. & M. A. Curtis, *M. hypophaeus* Berk. & M.A. Curtis, *M. musicola* Murrill and *M. nogalesii* Singer described in the paper are new records from India.

49. DIVERSITY OF FAMILY *STROPHARIACEAE* SINGER & SMITH FROM NORTH KASHMIR, INDIA

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Jammu and Kashmir, the paradise on earth is one of the largest states of India which is located in the extreme North of the country, it comprises of the mighty Himalayas decorated with snow capped mountains, green grasslands which are rich in flora and fauna. It has diverse climatic zones ranging from sub-tropical to temperate, alpine and cold arid regions. Nature has gifted this region especially North Kashmir with large number of fleshy fungi, majority of which are still unexplored. Being rich and unexplored in fungal diversity the present area was selected for undertaking the studies on the diversity of agarics. During the course of intensive field research in the forests of the North Kashmir a number of collections of wild macrofungi were made and worked out for their morphoanatomical details. In the present paper an account of seven species belonging to the family *Strophariaceae* under the order *Agaricales* spread over four genera namely, *Gymnopilus, Agrocybe, Psilocybe* and *Protostropharia* are being discussed along with their field photographs, microphotographs and Camera Lucida drawings. It is pertinent to mention here that as many as three taxa *viz. Gymnopilus decipiens, Agrocybe ochracea* and *Psilocybe baeocystis* are being described as new to India. As many as three species *viz. Gymnopilus crocias, G. fuscosquamulosus* and *G. junonius* are the first time records for the North India while as Protostropharia semiglobata are being reported for the first time from the study area.

50. STUDY OF FUNGAL DIVERSITY FROM LAND PLANTS OF SAGAR (M.P.)

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Sagar district is located in the north-central part of the state of Madhya Pradesh. The region is rich in plant wealth as well as in fungal diversity. During the survey the authors across a large number of fungi occurring in different seasons. The study of the fungal diversity exhibited as many as 28 fungal forms but most encountered dominant fungi belong to *Cladosporium*, *Alternaria*, and *Asterina*.

SECTION-B

Fungal Physiology, Biotechnology and Applications

1. LACCCASE MEDIATED HYDROLYSIS OF STARCH OBTAINED FROM *COLOCASIA ESCULENTA*: AN ENVIRONMENTAL SUSTAINABLE METHOD

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Fungi are an important source for the production of the industrial enzymes. Laccase is an important industrial enzyme belonging to the family of blue multi-copper oxidases that are capable of oxidizing as well as degrading several compounds. The study is aimed to isolate laccase from *Aspergillus niger* grown in an optimized production medium. The crude enzyme was further purified by ammonium salt precipitation and dialysis. The crude and partially purified enzyme was used for production of glucose by hydrolyzing starch obtained from *Colocasia esculenta* corm. Enzymatic hydrolysis of starch obtained from *Colocasia* was found to yield higher concentration of glucose in comparison to the conventional acid hydrolysis method at a much lower temperature. Following enzymatic hydrolysis using the crude enzyme (5%v/v) 1gm of *Colocasia* starch yielded 29.1 mg of glucose as compared to 25.3 mg obtained through the conventional acid hydrolysis method. The maximum glucose yield was found in case of dialysed enzyme (31.4mg/gm). The hydrolysis efficiency followed the sequence- dialysed enzyme > salt precipitated enzyme > crude enzyme> acid. The study revealed the importance of laccase enzyme obtained from *Aspergillus niger* in the efficient conversion of starch to glucose. The present study highlights the importance of fungal laccases as an environmental sustainable method for obtaining glucose from plant biomass which could be further used for several applications.

2. IMPACT OF SEED BORNE FUNGI ON SEED QUALITY OF CEREALS

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Cereals are normally grown, harvested, preserved and stored at the livestock farm. Barley and oats are more commonly used as feed cereals but wheat and maize are also important. Nearly seventy percent of the total production of Food grains in India is retained at farm level where the unscientific and faulty storage conditions enhance the chance of fungal attack and thereby mycotoxin production. Toxins are very important extra cellular poisonous metabolites produced by seed borne fungi. They play an important role in abnormalities in seed physiology and necrosis in plant parts. Therefore, studies were carried out for toxin production in different dominating seed borne fungi and its effect against seed germination, shoot length, root length and seed discoloration of maize wheat and jowar seeds. Maximum seed germination was reduced due to toxin (c.f.) produced by *Aspergillus flavus, A. niger* and *Curvularia lunata* in all cereals. *Aspergillus niger, Helminthosporium, Alternaria alternata* showed more discoloration of seeds.

3. MICROBIAL DEGRADATION OF PESTICIDE RESIDUES

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Pesticides are widely used to prevent and control the diseases and pests of a crop, but at the same time, pesticide residues have brought serious harm to humans' health and the environment. It is an important subject to study microbial degradation of pesticides in the soil environment. The soil fungi like *Aspergillus niger* and *Penicillium* sp. are used to degrade the pesticides like Carbofuran 3% CG (Sumo), Dimethoate 30% EC (Tafgor), and Cypermethrin 25% EC (Raider). After 42 days, it was observed that *Aspergillus niger* degrade 74%, 68%, and 70%; *Penicillium* sp. degrade 71.8%, 62%, and 68.9% of the pesticides. *Aspergillus niger* is the most effective degraging of the available pesticides.

4. ISOLATION AND QUALITATIVE ANALYSIS OF PHOSPHATE SOLUBILIZING FUNGI: AN ECOFREINDLY APPROACH

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Phosphorus is an essential macro-nutrient, playing a key role in the development and yield of crop plants. An adequate supply of phosphorus in the early stages of plant growth is important for laying down the primordia for the reproductive parts of plants. In soil Phosphorus is abundant, in both organic and inorganic forms but its availability is restricted because precipitated forms cannot be absorbed by plants. Soil contains organic phosphorus that can be used by plants only if it is mineralized. P- content in average soil is about 0.05 % (w/w), but only 0.1% of total P is available to plant because of poor solubility and its fixation in soil. About 75-90% of added P is precipitated by metal-carbon complexes, and soon becomes fixed in soil. Excessive use of fertilizers day by day also affects the soil health and thus environmental concerns have led to the search for sustainable way of P nutrition to the crops. Use of phosphate solubilizing fungi (PSF) as best eco-friendly means for P nutrition of crop is important and, a wider diversity of filamentous fungi is required to be screened. Based on this view, soil samples were collected from Western Ghats of Maharashtra. More than fifty groups of fungi were isolated for screening of phosphate solubilization and were authenticated based on morphotaxonomic study. Upon screening of all the fungal isolates on Pikovskaya agar medium, total 38 fungal isolates have shown the phosphate solubilization potential. Phosphate solubilization potential of these fungal isolates have been compared by calculating solubilization index (SI). The solubilization index of the fungal isolates ranged from 1.02 to 2.18 after five days of incubation at 25°C. Among tested 38 isolates, 22 isolates have shown the very good phosphate solubilization potential (SI = > 1.5). Among all, *A. niger* was most efficient with a SI of 2.18. This suggests that all these potential fungi can be useful as eco-friendly biofertilizers in agriculture to improve the soil health and crop productivity.

5. EPIGENETIC MODIFICATION TO IMPROVE METABOLITE PRODUCTION IN ENDOPHYTE CULTURES

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Fungi have been valued for their ability to produce novel metabolites of pharmaceutical importance. Fungal endophytes can produce several host-derived metabolites *in vitro*. However, when grown in axenic cultures, the fungal endophytes lose their ability to produce desired metabolites upon repeated sub-culturing. This process of attenuation prevents their exploitation as long-term, eukaryotic source of novel and plant-derived metabolites in large scale fermenters. We here by show that epigenetic modifiers such as 5-azacytidine can effectively overcome the attenuation in axenic cultures. *Diaporthe perseae* isolated as an endophyte from *Gloriosasuperba* was shown to produce colchicine. However, the culture showed attenuation of colchicine production upon repeated sub-culturing. We treated the cultures with DNA methylation inhibitor 5-azacytidine which improved the yield 15-fold. We also show that global methylation levels were also reduced in 5-azacytidine treated cultures indicating the role of DNA methylation in attenuation. However, treatment with valproic acid could not reverse the attenuation process in attenuated culture. Further, whole genome sequencing of the fungal endophyte was performed and annotation of the sequences showed high similarity for sequences associated with genetic clusters involved incolchicine synthetic pathway. *In silico* analysis using KEGG Mapper tool was used to predict the possible biosynthetic pathway leading to colchicine biosynthesis in endophytic fungi.

6. EXPLOITING MULTIFARIOUS ABILITY OF *CANDIDA TROPICALIS* AS PLANT GROWTH ENHANCER.

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More than 25.53 million tonnes of chemical fertilizers are used in India to increase the yield of crop plants. Despite their efficiency in promoting crop yields, such fertilizers have proved to be hazardous for soil health as well as for the well being of human and animal populations. Applying microbial inoculants helps to reduce the use of chemical pesticides, hence represent promising agricultural approaches that can play a vital role in crop protection, growth promotion or biological disease control, and sustained soil fertility. There has been significant interest in exploiting microorganisms having multifarious abilities such as asphytohormone production, mineral solubilization, N_2-fixation, pesticide degradation etc. for the purpose of more sustainable crop production.Presence of the above-mentioned traits underlines and emphasizes the agronomic and environmental significance of such microbes. The potential of microbes to simultaneously detoxify pollutants while enhancing plant growthis well recognized. Much of this research has been focused on the use of particular bacterial species or mycorrhizal fungi, the potential to use other microbial species, including yeasts, has received less attention. The present study investigates the ability of *Candida tropicalis*, isolated from pesticide-contaminated farm soil, to promote plant growth to sustain crop production and food security.

7. ASSESSMENT OF ELEMENTS IN SOME *GANODERMA* SPECIES AND THEIR POTENTIAL CONTRIBUTION TO DIETARY INTAKES

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In recent years with increased interest in a healthy lifestyle and disease prevention, there has been a vast and rapidly growing consumer demand for functional foods with high nutritional and medicinal value. *Ganoderma* is a wood-degrading mushroom that has been perceived as functional food and the its amazing beneficial health effects has been archived in ancient scripts. Monitoring of element levels in mushrooms collected from the natural environment provides basic information in terms of safety, regulation, and nutrition. The present study gives a comprehensive evaluation of elements in *Ganoderma applanatum*, *G. brownii*, *G. lucidum*, and *G. philippii* collected from different forest localities of Uttarakhand, India. These mushrooms showed high content of proteins (9.2912.4%) and carbohydrates (75.580.3%) and low amount of fats (1.622.87%), but ash (6.148.32%) and fibre (4.928.07%) were present in significant quantities. Element concentrations were determined by wavelength dispersive X-ray fluorescence spectrometry. Calcium (540019,250 mg/kg) and potassium (26025601 mg/kg) were the predominant elements in the mushroom species. The mushroom samples provided significant percentage contribution to reference recommended dietary intakes (RDIs) of essential elements such as calcium (27.096.3%), copper (58.295.8%), and manganese (37.362.3%), for adult males and females; and iron (35.397.1% for males and 28.678.6% for females), magnesium (7.0611.5% for males and 7.7412.6% for females), and zinc (6.3519.8% for males and7.6523.7% for females). The studied mushrooms pose no health risks as toxic metals such as aluminium and lead were present below the legislated provisional tolerable intake values. Nutritional quality index (NQI) values revealed that mushrooms are densely rich in calcium, copper, iron, magnesium, manganese, and zinc.

8. BIODEGRADATION OF POLETHYLENE (LDPE) BY FUNGI

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Since 1950s, the rate of plastic production grown faster than that of any other material. Plastics are versatile, hygienic, light weight, flexible and highly durable. It accounts for the largest usage of plastics worldwide and is used in numerous packaging applications including containers, bottles, drums, trays, boxes, cups and vending packaging baby products and protective packaging. Lack of degradation, the closing of landfill sites and water bodies, land pollution problems have led to concern about plastics. Degradation of plastics may be by physical or chemical change in polymer as a result of environmental factors, such as light, heat, moisture, chemical conditions or biological activity. Biological activity is the process in which microorganisms like the fungi, bacteria etc. degrade the polymers. In the present study biodegradation of the LDPE, soil sample was collected from the dumpsite of Raichur City and isolated as a result seven fungal isolates were obtained. Out of these isolates *Aspergillus* sp. were detected for degradation by the dry weight method, morphological observations and changes by SEM, FTIR, AFM & XRD analysis.

9. SCREENING AND APPLICATION OF ENDOPHYTIC FUNGI EXHIBITING TOLERANCE TO HIGH SALT CONCENTRATION FOR USE AS A BIO-INOCULANT IN RICE CULTIVATION

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Anthropogenic activities have caused severe damage to the environment such that meeting society's present food needs in a sustainable manner has become difficult. Abiotic stress is one of the leading causes of crop yield loss. The abiotic stress factors when occur in combination have the most detrimental impact on the plants. The rapid urbanisation and global hunger has lead to increase in the demand of food supply. Rice being the most widely consumed staple food has always been the subject for yield improvement in order to meet the growing demand. The prevailing methods such as use of hybrid seeds, improving crop fertilizers etc. helped in yield improvement but there is a need of exploring a sustainable source for yield improvement. The diverse ecological niche of endophytic fungi has been of keen interest due to its symbiotic relationship with the host plant. These fungi have co-existed with the plants since ancient times and have shown potential in conferring stress tolerance to the host plants. In this study, endophytic fungi from irrigation fed rice variety PUSA 44 (prevalently grown in Punjab) were isolated and subjected to salinity stress. A total of 120 endophytic fungi from different parts of rice plant were isolated. These isolates were screened at different concentrations of NaCl ranging from 0.5 mM to 1.5 mM and compared against a control with absence of NaCl. The cultures exhibiting more than 70% growth on 1.5 mM NaCl as compared to control were further tested at 2 mM NaCl. The potent cultures exhibiting more than 80% growth on 2 mM NaCl as compared to control were taken up for further studies and to be used as a bio-inoculant for educing water uptake of rice.

10. BIODEGRADATION OF FEATHERS BY KERATINOPHILIC FUNGI FOR SUSTAINABLE AGRICULTURE AND ENVIRONMENT

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Keratin biomass among the toughest biological materials known and constitutes the bulk of epidermal appendages such as hair, nails, claws, turtle scutes, horns, beaks and extremely resistant to physical, chemical and biological agents. Feathers are biological waste generated in large amount by local poultry processing industry which is treated either by steam or chemicals to produce feather meal. Majority of untreated forms are disposed as landfill. Keratins are hard to degrade due to these disulphide bonds formed between cysteine amino acids. Biodegradation of feathers by keratinophilic fungi is found to be an efficient and cost effective method for bioconversion of waste into nutritionally rich biofertilizers. Keratinophilic fungus support better degradation of feather in soil due to their keratinase producing ability. Keratinase are serine protease can breaks disulphide bonding in keratin protein. FTIR analysis confirms the breaking of disulphide bond by action of *Chrysosporium indicum* and *C. tropicum*, *Alternaria tenuissima*. Feathers were degraded in soil and used as fertilizer for growth enhancement of plants. Enhanced decomposing of organic form increases availability of N and P. Feather compost are rich in nutritional quality due to high content of proteins and amino acids are released due in submerged state as well in solid state fermentation. These fungi could be a major role player in pollution control of leather industry because all waste of leather treatment contains keratinous material. This method of

feather waste application will not only helpful in eco-friendly growth promotion of plants but also helpful in controlling environmental pollution occurs due to production of tones of feather waste daily globally.

11. *IN SILICO* ANALYSIS OF FUNGAL GENOMES AND DISCOVERY OF ALR MAGNESIUM TRANSPORTER HOMOLOGUES IN BASIDIOMYCETOUS FUNGI WITH VARIANT MOTIF XXN

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Studies from baker's yeast and other model filamentous fungi reveal that presence of CorA super family magnesium transporter with GMN motif. They are sub grouped into ALR, MNR and MRS2 which are localized to plasma membrane, vacuoles and mitochondrial membrane, respectively. But fungi are highly diverse group organisms that are known to thrive on dissimilar niches with spectrum of magnesium levels so we are intrigued to uncover novel magnesium assimilation modes to satisfy cellular and molecular demands. Genomics approach was chosen and various bioinformatics tools (PSI BALST, SMART, MEME, GLAM2, TMHMM, Clustal Omega, PHYML, I-TASSER, PyMOL Plugin ALIGN, DUET) were used to analyze fungal genomes. About 600 protein sequences with tentative CorA super family features are catalogued from 200 fungal species. MSA and Motif analysis results indicated that genomes of Sordariomycetous fungi contain proteins with two transmembrane helies, CorA domain at the carboxy terminus with GQN in addition to the protein models CorA features with GMN. We also discovered one more new motif GAN in hypothetical proteins of *Trichoderma* species. The protein sequences with GQN and GAN are predicted to be localized in plasma membrane and mitochondrial membrane, respectively. Where as in Basiodiomycetous fungi, analyzed each genome encodes two protein models with GMN and one with SMN or SLN. The WoLF PSORT prediction studies indicated that GMN containing proteins are localized to vacuoles and mitochondrial membrane contrastingly SMN or SLN are to be decorated in plasmamembrane. Mutational analysis carried out by DUET server reveals that substitution of S at G and Q, A or L at M position in GMN of motif stabilizing the mutation. Structural superposition of the crystal structure of CorA (GMN motif) with a homology model of hypothetical CorA with GQN, GAN, SMN, SLN confirms as variant motifs. Fungi Gene expression omnibus repository examination confirms the expression of corresponding genes of that protein IDs with GQN, GAN, SMN and SLN. In summary Basidiomycetous fungi may be utilizing ALR homologues transporters with SMN/SLN motif for uptake of magnesium from the environment. Some fungal CorA transporter motif (GQN, GAN, SMN, SLN) has been modified from their prototype motif GMN so its effect onsubstrate affinity, structure and function will be interesting to study

12. FIBRINOLYTIC ENZYME FROM *ARMILLARIA MELLEA*

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A novel fibrinolytic enzyme from *Armillaria mellea* was purified and partially characterized for the first time, which was designated *A. mellia* fibrinolytic enzyme. This extracellular enzyme from *A. mellea* was isolated by ammonium sulphate fraction, and purified to electrophoretic homogeneity using gel filtration chromatography. The apparent molecular mass of the purified enzyme was estimated to be 28.3 kDa by SDS-PAGE. The optimum pH and temperature for the enzyme activity were pH 6.2 and 24

°C, respectively. In the presence of metal ions such as Mg^{2+} and Fe^{2+} ions the activity of the enzyme increased, whereas EDTA and Cu^{2+} ion inhibited the enzyme activity. Interestingly the N-terminal amino acid sequences of the enzyme is extremely similar to those of the trypsin proteinases from insects, and has no significant homology with those of the fibrinolytic enzyme from other medicinal mushroom. In conclusion, *A. mellea* produces a strong fibrinolytic enzyme may be considered as a new source for thrombolytic agents.

13. ANTIFUNGAL ACTIVITY OF ORGANIC SOLVENT EXTRACTS OF PLANTS ON *CURVULARIA LUNATA* [WAKKER] BOEDIJN A CROSS-KINGDOM PATHOGEN

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In the present investigation plants from the Puducherry region were screened for antifungal activity towards *Curvularia lunata* a cross kingdom pathogen. Twenty plants belonging to 15 families were assessed *in vitro* for antifungal activity using poisoned food technique and PDA. Leaf extracts of the test plants were made (3 days) in benzene, chloroform, ethyl acetate, acetone and ethanol of increasing polarity and used for the assay. All plants inhibited radial growth of *Curvularia lunata* and the inhibitory activity varied from plant to plant and solvent to solvent. Out of the five solvents tested benzene and acetone extracts were found to be inferior to other three solvents. Benzene extract of only one plant (*Coccoloba uvifera*) and acetone extracts of two plants (*Acacia dealbata* and *Barringtonia asiatica*) produced 100% inhibition. Ethyl acetate extracts of four plants and ethanol extracts of nine plants completely inhibited growth of the test fungus. Maximum number of plants produced 100% inhibition in chloroform extract. Chloroform extract of eleven plants produced 100% inhibition of *Curvularia lunata*. Overall around 90 percent of plants used in this study evinced strong antifungal activity against *Curvularia lunata*. However the inhibitory potential of the plants extracts was found to be inferior to the commercial fungicide bavistin. From these results it can be concluded that more than one solvent should be included in the screening programs and benzene is not a good solvent for this kind of work. Further work should focus to isolate the active principle in the plant extracts for controlling plant diseases and for treating human sufferings due to *Aspergillus niger* infections. The results of this study provides strong impetus and that the plants in and around Puducherry region should be screened systematically, which may bring to light many novel compounds with new modes action and with less side effects. The present investigation provides the data-base of plant species in the Puducherry region that can be used to identify potential novel bioactive compounds for pharmacological and agricultural applications.

14. EDIBILITY AND ECONOMIC UTILITY OF DARK SPORED MUSHROOMS

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Mushrooms have a long history of use in food and folk medicines. Mushrooms are amongst the most popular, nonconventional food accepted the world over and have higher consumer preferences due to their unique flavour and texture, low calories, high fibres and protein content, presence of essential

amino acids, vitamins and minerals. In view of the multifarious importance of mushrooms during the present study, attempt was made to gather information about their ethnomycological and sociobiological aspects from the local informants of the area from where the collections were picked up and also from literature. Out of the total taxa examined, 21% can be catagorized as edible, 5% hallucinogenic, 7% poisonous and 3% with medicinal properties. For majority (64%) of the taxa, no such categorization is possible because of the paucity of information as it was neither available with the local informants nor in the literature. The field data gathered during the survey between 2008-2012, 20 taxa out of the total 95 taxa examined possess excellent culinary credentials because of which they were categorized amongst the edible species. This information is primarily based upon literature as there is hardly any report of these being consumed in Punjab by the native people except for *Agaricus bitorquis* which is a known good edible fungus and commercially grown. *Coprinus sterquilinus, Agaricus blazei* and *Parasola plicatilis* are of medicinal value. *Agaricus campestris* var. *campestris* is reported to be edible and used for the treatment of ulcers, and bed sores.

15. INFLUENCE OF DISSOLVED OXYGEN CONCENTRATION ON THE PRODUCTION OF SUPEROXIDE DISMUTASE IN WILD TYPE *SACCHAROMYCES MELLIS*

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SOD activity is one of the major defense mechanisms against oxidative stress for all the aerobic organisms and industrial production of this enzyme is very essential. The effect of 2 different levels of dissolved oxygen (Uncontrolled DO and DO at 20%) on SOD production were evaluated. Increasing enzyme activity in *Saccharomyces mellis* cells cultivated under both conditions was detected in the early exponential phase and an active synthesis was observed during a period of intensive oxygen consumption. Moreover, the time courses of SOD production show 2 maxima. 1st maxima are up to 48 hours. 2nd maxima are from 48 hours to 96 hours. The results demonstrated that the O_2 level had a significant influence on SOD activity. Under high DO conditions higher levels of SOD were produced at 1st and 2nd maxima, reaching activities of about 112 and 124 U (mg protein)-1 respectively. The number of isoforms did not change under hyperoxic conditions when *S. mellis* was exposed to an atmosphere of 20% O_2. There was no significant change in Cu, Zn SOD activity, whereas Mn SOD expression increased 10-12-fold by elevated DO. Hence, it appears that Mn-SOD is the primary defense in *S. mellis* cells against oxygen toxicity. The presence of 59 ng-atom copper and 52 ng-atom zinc (mg enzyme)-1 in the purified *S. mellis* Cu, Zn SOD was confirmed by atomic absorption spectrometry

16. NUTRITIONAL ANALYSIS, ANTIOXIDANT AND ANTIMICROBIAL PROPERTIES OF A NEW EDIBLE MUSHROOM *RUSSULA LAKHANPALII* FROM GARHWAL HIMALAYAS

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Mushrooms are rich source of proteins, minerals, polysaccharides, unsaturated fatty acids and crude fibers. They have excellent antioxidant properties and also show good antimicrobial activity. Mushroom samples for this study were collected from Phedkhal (District- Pauri Garhwal), and bacterial

strains were procured from MTCC, CSIR- Institute of Microbial Technology, Chandigarh. Methanolic mushroom extract was tested against five pathogenic bacteria *Klebisella pneumoniae* (MTCC 4030), *Micrococcus luteus* (MTCC 1809) and *Staphylococcus aureus* (MTCC 1144), *E. coli* (MTCC 68) and *Streptococcus pneumoniae* (MTCC 655). After analysation of samples for various nutritional attributes, dried mushroom samples were found to contain 17.7% ash, 10% crude fiber, 134.46 mg protein, 30.9 mg carbohydrate and 2495 mg/dl lipid. The methanolic extract extracts showed 73.06% DPPH inhibition with 100 µg/mL concentration and scavenging activity was dose dependent. The methanolic extract of *Russula lakhanpalii* showed maximum zone of inhibition (18.8±1.04 mm) against *Klebisella pneumoniae* and minimum (12.16±0.76 mm) against *E. coli.* Based on the experimental data, *R. lakhanpalii* showed its efficacy as antioxidant agent for effective protection from free radicals. In addition, the results of nutrition analysis and antimicrobial activity highlight its nutritional value and antibacterial properties.

17. IMMUNE BOOSTING EFFECT OF TRADITIONALLY APPRAISED WILD EDIBLE MUSHROOMS

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Immune boosting has become a buzzword during COVID-19 crisis and activating body defence mechanism through healthy diet/functional food formula is among the top priorities. In this context, researchers have decoded that macrofungal derived β-glucans could be crucial weapon to charge up our immune system in the fight to stay well where some of the products are already in practical use. Consequently, West Bengal, India facilitates natural growth of many unique mushrooms that have long been included in tribal cuisine as health promoting foods. However the specimens remain neglected in city people due to lack of awareness and propaganda confining the traditional practice only in forest areas. Fortuitously, our team was able to collect two such members with the help of inhabiting tribal people where one species emerged as a novel taxon after thorough characterization. Further, crude polysaccharides were isolated from both the collected specimens using conventional hot water process. Physico-chemical characterization enumerated that the fractions were enriched with carbohydrate conjugated with small amount of proteins where the backbone of polymers were organized in triple helix conformation. Detailed analysis using sophisticated instruments depicted glucose as the principal component mainly presented in β-glycosidic bond. Interestingly both the samples verified excellent immune stimulation activities on RAW 264.7 murine macrophages evident by induced cell proliferation and phagocytic uptake in a time dependent manner. Moreover, when the monocytes were incubated with polysaccharides caused considerable augmentation in nitric oxide and reactive oxygen species generation along with production of a number of filopodia/lamellipodia representing definite sign for macrophage stimulation. Insight into molecular mechanism with the help of RT-PCR revealed that the treatment resulted alleviated level of TLR-2, TLR-4, COX-2, NF-κB, TNF-α, iNOS, IFN-$_\gamma$ and IκB-α expressions indicating their mechanism of action via TLR coordinated NF-κB pathway. Taken together, the studied mushrooms could definitely be utilized to develop powerful biological response modifier justifying their ethnic use as health promoting food.

18. SHIKONIN INHIBITS GROWTH OF *ASPERGILLUS TERREUS* VIA OVERPRODUCTION OF REACTIVE OXYGEN SPECIES

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In immunocompromised patients, *Aspergillus terreus* is an emerging pathogen. It accounts for 5.2% of mould infections worldwide. Because of the intrinsic resistance to amphotericin B (AMB) and the acquisition of resistance to azoles, the options of antifungal therapy are very limited. Therefore, the current situation demands alternative approaches to combat with resistance. The purpose of our study was to assess the inhibitory effect of shikonin (SHK) against *A. terreus*. The drug susceptibility assay was performed for *A. terreus* isolate (NCCPF860035) using MTT assay with standard drugs (AMB) and SHK to calculate MIC50 value. Reactive oxygen species (ROS) estimation in SHK-treated *A. terreus* were done using florescence microscopy. Further, qRT-PCR was performed for selected genes involved in ROS homogenesis and cell wall integrity (*cat, sod, NADH-Ub-OxRdtase, sdh, gel, rho-I, hexb spm1, Hsp70, Hsp90, cal-ATPase, calcineurin, cmd*). Shikonin efficiently inhibits the proliferation of *A. terreus* at MIC50;2 µg/mL compared to AMB (MIC50; 3.8 µg/mL). High ROS generation was observed after SHK treatment in *A. terreus*. Additionally, scanning electron microscopy showed that SHK affects normal germination process and hyphal morphology. The important genes involved in ROS homeostasis, calcium signaling and cell wall showed differential expression. Genes encoding *cat* showed downregulation while *sod, NADH-Ub-OxRdtase* and *sdh* showed upregulation. Also, *gel, rho-I, hexb* and *spm1* were upregulated while *Hsp70, Hsp90, cal-ATPase* and *calcineurin* showed down regulation under SHK exposure. Thus, SHK may induce ROS generation and interfere with cell wall integrity which contributes to its inhibitory action against *A. terreus*. Our results indicated that SHK could be an effective molecule against drug-resistant *A. terreus*. During its anti-*Aspergillus* action, ROS and cell wall integrity are critical. These results demonstrate the potential for antifungal targets of ROS and cell wall linked pathways.

19. GREEN SYNTHESIS OF COPPER NANOPARTICLES FROM ENDOPHYTIC FUNGI *COLLETOTRICHUM SPP.* ISOLATED FROM *TINOSPORA CORDIFOLIA* L. (GULVEL) LEAF

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Nanobiotechnology is a fascinating branch of science that, encompass synthesis of materials at its nanoscale (approx.1-100 nm) using biological resources such as plants, and microorganisms like bacteria, algae, fungi, yeast, etc. Despite various chemical and physical methods, biological methods are environment-friendly, economic, and carried out at ambient temperature and pressure. As copper serves as an essential micronutrient for plants as well as demonstrated the fungicidal activity in the agriculture crop field, has generated keen interest in the field. Therefore, in the present study, the synthesis of copper nanoparticles (CuNPs) was carried out by endophytic fungal species of *Colletotrichum* that was isolated from the leaf explants of *Tinospora cordifolia* L. (Gulvel). The fungal extract along with the ascorbic acid

(1%), which acts as a capping and reducing agent and precursor salt solution of $CuSO_4.5H_2O$ (100 mM) was used in the synthesis of CuNPs. The synthesized CuNPs were characterized by UV-Visible spectroscopic analysis showed an absorbance at 600 nm. Nanoparticles tracking and analysis revealed an average size ranging from 10-40 nm with a distribution of 2.18×10^8 particles/ml. FTIR analysis indicates the protein capping of CuNPs from the fungal extract. X-ray diffraction analysis of CuNPs demonstrated the presence of particles of 20 nm in size with the "*fcc*" structure. Zeta potential measurement was found to be -23.2 with zeta deviation 6.00 mV. *In vitro* antifungal evaluation of myco-synthesised CuNPs was observed on the crop pathogenic fungi, which showed the significant activity compared than that of control. CuNPs showed the antifungal agent and also known to promote growth in the crop plants, which may lead to development of nano-based agro-products like nano-fungicides, nano-fertilizers, etc.

20. EVALUATION OF PHYSICAL PARAMETERS FOR THE DOMESTICATION OF *LENTINUS TIGRINUS*

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Genus *Lentinus* is cosmopolitan lignicolous agarics possessing lignolytic activities it falls under family *Polyporaceae* under order *Polyporales.* It is a known genus with many potential edible taxa. Thus it is well represented by known edible species like *L. sajor-caju, L. squarrosulus, L. connatus, L. torulosus, L. cladopus, L. lepideus, L. tuber-regium, L. crinitus, L. polychorus, L. strigosus, L. kauffmanii* and *L. edodes* (presently known as *Lentinula edodes*). From amongst, L. *sajor-caju* and *L. edodes* are commercially cultivated at large scale as a known technology has been developed. The present study aims at domesticating other taxa of *Lentinus* which is collected from the wild by the local people of Kashmir for cooking, this taxa was collected and identified as *Lentinus tigrinus* using classical taxonomy, pure cultures of this species were raised and confirmed through molecular taxonomy. The evaluations of physical parameters reveals Yeast Extract Agar (YEA) as best solid medium while Yeast Glucose Media (YGM) as best liquid medium which were selected for further studies Whereas the optimum temperature for solid medium was 35º ± 2ºC while for liquid medium 30º ± 2ºC gave best vegetative growth and optimum pH for both solid and liquid media was 4.5 pH. Mycelial growth was observed in light and dark conditions and best results were observed under dark exposure. Studies on evaluation of incubation period gave the result of 11 days for optimum growth of *Lentinus tigrinus*. Further studies on the spawn preparation gave the best result on 30 minutes boiled wheat grains in 11 days.
Keywords:

21. ASSOCIATION OF AFLATOXIGENIC FUNGI AND AFLATOXINS CONTAMINATION IN SOME SPICES OF BIHAR

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Aflatoxin is a potent mycotoxin mainly produced by *Aspergillus flavus* and *Aspergillus parasiticus present* in a wide range of consumable substrate including various types of food and feed. Aflatoxin is well known for its hepatotoxic, nephrotoxic, teratogenic and carcinogenic effect. Aflatoxin B_1 has been classified as Grade 1 carcinogen by International Agency of Cancer Research, Lyon (France). Spices are important ingredient of our food since ancient time of civilization. Spices are used in Indian

cooking to provide distinct flavour, aroma and colouring food. Some spices such as turmeric, black pepper, fenugreek, fennel, cinnamon and cloves are well known for their therapeutic use in different medical therapy. In the present study different spices such as red chilli, turmeric, black pepper, fenugreek, fennel, cinnamon and cloves were examined for their association with aflatoxigenic fungi. *Aspergillus flavus* and *Aspergillus niger* were the most dominant species present in all types of spices. Black pepper had the highest incidence of *A. Flavus* (46.3%) followed by red chilli (31.6%). The amount of aflatoxin B_1 present ranges from 210 µg/kg to 930 µg/kg. Cinnamon and clove are resistant to aflatoxigenic fungi and aflatoxin were not detected in these two spices. Altogether 230 samples of spices comprising red chill, black pepper, turmeric, fenugreek, coriander, cumin, clove, fennel, green cardamom and black cardamom were collected from different parts of Bihar and were analyzed for natural incidence of aflatoxin. All spices were found to be naturally contaminated with aflatoxin except clove. Natural incidence of aflatoxin was highest in black pepper samples. 74% samples were positive to aflatoxin and the amount detect was 630 µg/kg. Clove was the safest spice among all examine spices. No aflatoxin was detected from cloves sample. Presence of aflatoxin in spices is a matter of great concern as it directly affect the human health.

22. MICROBIAL APPROACH IN DEGRADATION OF POLYETHYLENE

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Plastics' accumulation in the environment raises significant concerns causing long-term environmental, economic, and waste management problems. The present research aimed to investigate polyethylene's biodegradability under controlled laboratory experiments using selective fungal isolated from the soil; *Aspergillus niger, Penicillium* and *Trichoderma, Rhizopus, Fusarium*. Predominant fungal strains *Aspergillus niger* was selected for polyethylene degradation. Effect of fungi on the degradation of commercial polythene bags of low-density polyethylene (LDPE) notices over four weeks in laboratory conditions. Biodegradation was measured in terms of mean weight loss, which was nearly 8 to 12% after four weeks.

23. VARIATION IN *CURVULARIA* ISOLATES FOR THE PRODUCTION OF AMYLASE

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Curvularia species are important plant pathogens associated with over 60 genera. An array of enzymes and toxins are produced from such necrotrophic fungi. Pathogenicity or virulence is directly proportional to the concentration and type of enzymes produced. Different species/strains may have various potential to produce required enzymes for pathogenesis. Hence, determination of enzymes production by *Curvularia* is essential to show virulence of the organisms. The present work describes ability of amylase production in 14 isolates of *Curvularia* obtained from maize by enzyme plate assay. Modified Czapek's Dox agar medium was used by substituting starch for sucrose as sole carbon source. The agar plates were inoculated separately and incubated for three consecutive days (24h, 48h, 72h) in separate sets. Starch hydrolysis was detected by using 3% iodine solution after regular intervals. Enzyme index (EI) is represented as the ratio of zone of hydrolysis and colony diameter. At 24h of incubation EI varied from 1.00 to 3.77 indicating varied extent of amylase production in different isolates. However,

not much variation in EI values were noticed among *Curvularia* isolates at 48h and 72h of incubation. Hydrolysis of starch by producing amylase in *Curvularia* isolates was evident in this assay. Biochemical variation in terms of enzyme production potential can be assessed using the plate assay.

24. HETEROLOGOUS EXPRESSION AND STRUCTURAL INSIGHTS OF CELLOBIOHYDROLASE OF THE THERMOPHILIC MOLD *MYCELIOPHTHORA THERMOPHILA* (MtCbh) FOR LIGNOCELLULOSE BIOCONVERSION TO ETHANOL

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Cellulases are the third largest hydrolytic industrial enzymes with a considerable potential in bioethanol production. They are classified into three classes: a) endoglucanase, b) exoglucanase/ cellobiohydrolase and c) β-glucosidase. Lignocellulosic biomass is a renewable energy source consisting mainly of cellulose, hemicellulose and lignin. Cellulases cleave the β-1,4-glycosidic linkages of cellulose into monomeric glucose units, which can further be fermented to bioethanol. The three enzymes act synergistically on cellulose bioconversion. In this investigation, the codon optimized gene that encodes cellobiohydrolase (MtCbh) of a thermophilic mould *Myceliophthora thermophila* was heterologously expressed in *Escherichia coli* in an inducible manner by isopropyl β-D-1 thiogalactopyranoside (IPTG). The experimental variables have been optimized for maximizing enzyme production and activity of recombinant MtCbh. The optimum pH and temperature of the rMtCbh have been determined. The expressed protein was purified to homogeneity using His-Tag (affinity) chromatography. SDS-PAGE analysis confirmed rMtCbh to be a ~42 kDa protein. Structural characterization and physico-chemical analysis of MtCbh has been carried out using various *in-silico* approaches. The 3D structure of MtCbh was derived using homology modeling approach. The protein model of MtBgl3c was validated using bioinformatics servers. The ion binding and N-glycosylation sites have been predicted. MtCbh is stable in broad pH and temperature ranges, thus making it an efficient enzyme for lignocellulose bioconversion.

25. BIOPROSPECTING OF FUNGI ISOLATED FROM FAMLONGLHO WILDLIFE SANCTUARY, SIKKIM

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Phylum *Eumycota* (true fungi) contains diverse group of organisms. There are more than 1,25,000 species known today in the phylum *Eumycota* and represent one of the largest group of living organism on the planet Earth. They act as symbiotic, saprophytes or parasites and play a prominent role in ecosystem functioning thus helping in the survival of many other species. The present study include various groups of fungi (pathogenic fungi, keratinolytic fungi, endophytic fungi, soil fungi, etc.) that were isolated from the wildlife sanctuary by Government Sikkim College, Sikkim and sent to National

Centre for Microbial Resource (NCMR), NCCS, Pune. Till date we have analyzed 260 fungi using molecular methods, isolated from various niches of Fambong Lho Wildlife Sanctuary. For molecular identification, we did sequencing of internal transcribed spacer region (ITS) and D1/D2 domain of large subunit and all cultures were deposited at NCMR-NCCS, Pune. Bioprospecting of 250 fungi for production of different industrially important enzyme like amylase, laccase, cellulase and pectinase is being done. Out of these 16, 25, 12 and 19 fungi showed 3 star (3-5 cm dia) activity for amylase, laccase, cellulose and pectinase respectively. Genera which shows 3 star activity for laccase enzyme belong to *Pestalotiopsis, Fusarium, Psatharella* and *Trichoderma*. The fungi which shows 3 star activity for amylase belong to *Diporthe, Aspergillus, Penicillium* and *Colletotrichum* genera. Cellulase enzyme activity was shown by *Fusarium* and *Alternaria*. *Trichoderma* and *Aspergillus* showed 3 star activity for pectinase activity.

26. ANTIFUNGAL ACTIVITY OF THE PIGMENTS PRODUCED BY *ASPERGILLUS NIDULANS*

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Fungi are known to produce diverse group of secondary metabolites including pigments. These pigments are used for colouring food, cosmetics, textile and pharmaceutical products. Biological activity shown by pigments may have significance for broadening their applications. In the present study both cellular and secretory pigments produced by *Aspergillus nidulans* was tested for their antifungal activity by conidial germination assay, bioautography and disc diffusion assay against selected fungi. The results showed that the crude secretory pigment of *Aspergillus nidulans* showed inhibition activity on *Cladosporium* sp. and *Curvularia* sp. in spore germination assay. In the bioautography, the secretory pigment showed inhibition activity against *Alternaria* sp., *Cladosporium* sp., and *Curvularia* sp.; whereas the crude cellular pigment showed inhibition activity only against *Curvularia* sp. The disc diffusion assay showed that the crude cellular pigment slightly inhibited *Candida albicans* MCC 1151 whereas the crude secretory pigment showed inhibition against both *Candida albicans* MCC 1151 and *Cryptococcus* sp. MCC1408. The results clearly demonstrated the antifungal activity of *Aspergillus nidulans* pigments. Interestingly, differences in the antifungal activity between cellular and secretory pigment compounds is also evident. Separated pigment fractions in Thin layer chromatography (TLC) also indicated the presence of antifungal fractions. The results are promising for the use of fungal pigments with antifungal activity in food and pharmaceutical industry.

27. PREBIOTIC AND ANTI-CANCER PROPERTIES OFFRUCTO-OLIGOSACCHARIDES GENERATED BY *ASPERGILLUS TAMARII* FRUCTOSYLTRANSFERASE

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Owing to health and dietary concerns, prebiotic oligosaccharides are gaining increasing attention in modern times. Prebiotic fructooligosaccharide (FOS) synthesis using fructosyltransferase (FTase) catalysis is a promising approach. Present study demonstrates production of prebiotic FOS under optimized conditions using mycelial fructosyltransferase and its health promoting effects. Partially

purified *Aspergillus tamarii* mycelial FTase was used as biocatalyst for FOS generation. FOS was analyzed by TLC and HPLC and purified using gel filtration matrix Bio-Gel P-2. Purified FOS have been utilized as growth promoter of *Lactobacillus*. Short chain fatty acids (SCFA) generated from FOS fermentation were determined by ^{1}H-NMR. Purified FOS were examined for anti-cancer potential against colon cancer cell lines HT-29 and relative gene expression of Caspase 3, Caspase 9 and Bax genes involved in apoptotic signaling pathways have been investigated. Bio-Gel P-2 was successfully utilized for FOS purification FOS supplementation showed significant increase in growth of *Lactobacillus* by production of SCFA resulting in pH lowering. FOS treatment resulted in an induction in HT-29 cell death. Real-time qPCR analysis concluded a significant increase in Caspase 3, Caspase 9 and Bax gene expressions. This study provides an insight into the role of apoptotic genes in anti-cancer potential of FOS.

28. EFFECTS OF BIO-INOCULANTS ON THE GROWTH AND PHOSPHORUS UPTAKE OF *RHIZOPHORA MUCRONATA* LAM

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Bio-inoculants consist of a consortium of different types of microbes, which are capable of converting nutritionally essential elements from unavailable to available form through natural processes. In the present study, the interactive effects of Arbuscular mycorrhizal (AM) fungi and phosphate solubilizing bacteria (PSB) on the growth and P uptake of *R. mucronata* was evaluated. An experiment comprising of eight treatments of single and dual inoculation involving AM fungal species *Rhizophagus intraradices, Acaulospora dilatata,* and PSB *Bacillus halotolerans* were used to inoculate the propagules of *R. mucronata*. Our study revealed positive effects of dual inoculation with AM fungi and PSB in the growth promotion of *R. mucronata*. Various parameters *viz.,*AM fungal colonization, plant growth, biomass, leaf pigments, and P contents were analyzed. Percent AM fungal root colonization in AM inoculated plants ranged from 43.75 to 91.45% with the highest value observed under treatment 8 (*R. intraradices* + *A. dilatata* + PSB). Treatment 7 (*R. intraradices* + *A. dilatata*) significantly promoted plant height. However, *R. intraradices* inoculum in combination with PSB showed a better impact on all the growth parameters. Above ground and below ground plant biomass was higher in treatment 7 and treatment 8, respectively. Chlorophyll and carotenoids content was significantly higher in treatment 8. A dual inoculation of *R. intraradices* and *B. halotolerans* (treatment 5) and combined inoculation of all the three bio-inoculants (treatment 8) resulted in increased uptake of P. The total P content in treatment 5 and treatment 8 reached a maximum of 14.6 and 14.7µg/g, respectively. The use of such a microbial consortium may be a promising strategy to increase plant growth and biomass in environmental restoration programs.

29. DOMESTICATION OF WILD EDIBLE AGARIC: *MACROCYBE GIGANTEA*

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Mushroom hunting from the wild is known from ancient times and native people of the world have the knowledge of differentiating the edible mushrooms from poisonous ones. The present study focuses on *Macrocybe gigantea* which was collected and selected from amongst a number of agarics

collected from the wild. This taxon has the potential as it has very robust, fleshy fruit bodies growing in caespitose clusters and is collected by the local people for its known edibility. The study aims at domesticating this mushroom and to release a protocol for its growing under artificial conditions. Thus, the preliminary studies on the physical and biochemical parameters were conducted. The pure culture was raised from the wild freshly collected carpophores, later Malt Extract Agar and Glucose Peptone media were selected as the best solid and liquid media for the vegetative growth of the fungus, 30 ± 2°C and pH of 5.0 gives best vegetative growth, whereas Glucose proved to be the best carbon source and Yeast Extract as Nitrogen source. Out of the various concentrations of different trace elements, vitamins and growth regulators, maximum vegetative growth was observed in basal medium supplemented with Mg (10 ppm), Vitamin C (50 ppm) and Indole Butyric acid (40 ppm). The grains of the common cereal crops of Punjab like Wheat, Maize, Jowar and Bajra were tried for spawn preparation of *M. gigantea* and Wheat grains boiled for 30 minutes were selected. Various substrates like wheat straw, rice straw, rice husk and saw dust were evaluated for mycelial growth out of which wheat straw showed maximum growth.

30. CRUDE OIL HYDROCARBON-DEGRADING FUNGI ISOLATED FROM MARINE ENVIRONMENTS AS POTENTIAL BIOREMEDIATION AGENTS

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Oil spill resulting from petrochemical related activities has become a serious environmental threat over the last century. Crude oil is a complex mixture of hydrocarbons like alkanes, naphthenes and polycyclic aromatic hydrocarbons (PAHs). These hydrocarbons upon spilling spread horizontally onto soil and partition into groundwater, thus contaminating large volumes of soil and groundwater. Some of the crude oil associated hydrocarbons are known to be highly toxic to humans and animals due to their carcinogenic and mutagenic effects. Currently adopted mechanical and chemical methods used to remove hydrocarbon contaminants are expensive and do not completely destroy the pollutants. Therefore, researchers are now focused on eco-friendly and efficient techniques such as bioremediation which is a cost-effective technology and results in complete mineralization of the pollutants. The present study demonstrates the degradation of crude oil, alkanes and PAHs therein using ten fungal cultures isolated from marine environments. The selected ten fungal isolates degraded the long-chain n-alkanes more effectively as compared to short-chain n-alkanes. Furthermore, of the ten isolates studied, Mangrove fungus #NIOSN-M126 identified as *Penicillium citrinum*, was found to be highly efficient in biodegradation of crude oil, reducing the total crude oil content by 77% and the individual n-alkane fraction and PAH fraction by an average of 95.37% and 62% respectively. NIOSN-T4 identified as *Fusarium equiseti* showed maximum PAH degradation efficiency of 73% and proved to be highly efficient in reducing high molecular weight PAHs by 70% and low molecular weight PAHs by 84%. The bioremediation by-products obtained did not prove to be toxic when tested against artemia larvae indicating that these isolates could be used as potential bioremediation agents. Microorganisms possess an untapped potential for various applications in biotechnology and the current study demonstrated the potential of marine fungi for use in bioremediation of xenobiotic hydrocarbons in the environment.

31. PURIFICATION AND CHARACTERIZATION OF FUNGAL ENDOINULINASE FOR THE PREPARATION OF FRUCTOOLIGOSACCHARIDES FROM INULIN

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A three-step purification technique (iso-propanol precipitation, ion-exchange and size-exclusion chromatography) was used for the purification of an endoinulinase from the culture broth of *Aspergillus tritici* BGPUP6. The specific activity of purified endoinulinase was found to be 57.86 IU/mg with a purification fold and recovery yield of 11.97 and 3.07%, respectively. Low K_m (1.02 mM) and high V_{max} (19.60 mM/min·mg), K_{cat} (1.3×10^{-3}/min) and V_{max}/K_m ratio (19.21/min·mg) of purified endoinulinase for inulin than stachyose depicts its higher affinity towards inulin. Purified enzyme was found to be stable in the pH range 4.0-7.0 with an optimal pH 5.5. The optimal temperature of purified biocatalyst was 55 ºC with thermostability in the range 50-70 ºC. D-value and Z-value for endoinulinase at 55 ºC was found to be 100.08 h and 11.62 ºC, respectively. Thermodynamics inactivation parameters (ΔG, ΔH and ΔS) of endoinulinase show its wide range thermal stability. Endoinulinase activity was enhanced by $CaCl_2$ and $MnSO_4$. Further, statistical optimization of hydrolytic conditions for the preparation of fructooligosaccharides (FOSs) from inulin using purified fungal endoinulinase was carried out in a batch system. Maximum FOSs yield 99.19% was obtained, under the optimized hydrolytic conditions i.e. inulin concentration (7.3%), enzyme load (65 IU), hydrolysis time (13 h) and agitation (100 rpm). The closeness of value of co-efficient of determination (R^2) to 1, low percentage error (<5%), good agreement between model's predicted and experimental values, high adequate precision (>4%) and F value (11634.32), and low Lack of fit (0.60) of the designed quadratic model authenticates its fitness. TLC chromatographic and densitometry studies confirmed the synthesis of short-chain FOSs. FOSs preparation contained 33.85% GF2 (kestose), 24.50% GF3 (nystose), 7.26% GF4 (fructofuranosylnystose) and 33.58% FOSs of DP5-9

32. EVALUATION OF LACCASE BY AUTOCHTHONOUS WHITE ROT FUNGUS *GANODERMA* SP. UNDER SOLID-STATE FERMENTATION FOR VARIOUS APPLICATIONS IN TEXTILE INDUSTRY

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White Rot fungi are well known for producing degradatory enzymes especially the laccases with tremendous industrial potential but till date the group has not been explored uniformly for this potential. The available literature reports the work only on few well known established white rot genera. The diversity of climatic conditions present in the Chandigarh capital region has made it a natural habitat of large number of *Ganoderma* species with enormous potential of producing different enzymes which may find a number of industrial applications if explored and screened properly. The demand of potential laccases to be used in industry especially in textile has increased due to their multifaceted uses in a variety of processes employed in textile industry. Therefore, keeping all these things in mind, the present study was undertaken to explore various autochthonous white-rot fungi for their laccase producing potential and evaluating the application of potential enzyme (laccase) in textile wet processes to reduce the environmental pollution. In present study, *Ganoderma sp.* was isolated from Lower Shivalik Hills of Chandigarh Capital Region which produced high titre of laccase enzyme. Laccase was found to be active

in the temperature and pH range which was suitable for their application in textile wet processes in the industry. Physico-chemical conditions were standardized for the over production of enzyme in solid state fermentation by using classical and statistical methods. Significant results were achieved by employing the enzyme in textile wet processes i.e dye reduction, bleaching, detoxification of textile waste water. Therefore this fungal enzyme is highly suitable for envirosafe alternatives to chemical processes for developing a cleaner and economical process in textile industry to reduce the burden on environment.

33. ISOLATION AND MOLECULAR CHARACTERIZATION OF KERATIN DEGRADING FUNGI FROM AQUATIC HABITATS OF HARYANA

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Keratinophilic fungi can be found in all most all kinds of ecological habitat. They play a vital role in degrading the keratin based waste which is otherwise very difficult to degrade due to the presence of di-sulphide bonds which makes them one of the toughest proteins to degrade. The keratin based waste like chicken feathers, human hair, nails, wool, horns, beaks, hides, etc. pose a major landfill problem and area of concern in solid waste management. Keratin degrading fungi can play an important role in this regard thus, they are receiving significant attention. The present paper deals with the isolation of these fungi from aquatic habitat of Haryana in which a lot of keratinous waste is present. Twenty soil samples were collected from aquatic soil of different localities of Haryana. Out of these 20 samples, 18 were found to possess the potential for keratin degradation. Thus, by hair baiting method 27 keratinophilic fungi were isolated from these samples. On identification of the fungi they were found to fall under genera like *Aspergillus, Chrysosporium, Ctenomyces, Microsporum, Nannizzia* and *Trichophyton*. The screening was done on skimmed milk agar plates and clearing zone thus formed were observed. Selected isolates were further confirmed through molecular characterization. *Chrysosporium indicum, Trichophyton longifusum* and *Microsporum incurvatum* were selected for further study. Keratinolytic fungi produced clearing zone on the skimmed milk agar plates. Of these it was observed that *Chrysosporium indicum* produced 5 mm clearing zone in 12 days which was comparatively more than in the other two selected fungi. Thus, *Chrysosporium indicum* was selected for keratinase production and feather degradation studies.

34. BIODEGRADATION OF MALATHION USING CUTINASE FROM A SOIL ISOLATE OF *FUSARIUM* SP.

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Malathion, an organophosphate insecticide, has been extensively used for control of household and agricultural pests. A major amount of malathion and its remains present in the environment are rapidly absorbed by humans through all routes including the gastrointestinal tract, skin, mucous membranes, and lungs. From animal testing, the toxic effect of malathion has been shown to affect the central nervous system of invertebrates, immune system of higher vertebrate wildlife, and adrenal glands, liver and blood of fish. Malathion also causes detectable mutations and as per IARC, malathion is a probable carcinogen. Cutinases are hydrolytic enzymes that catalyze the cleavage of ester bonds that

make them highly potential industrial biocatalyst. In recent years, the cutinases have been exploited for many biotechnological applications. In the present investigation, different soil isolates of fungi were screened for cutinase activity and the isolate showing maximum activity was selected and identified as *Fusarium* sp. on the basis of cultural and microscopic studies.The temperature and pH optima of enzyme was found to be 50°C and 6.0, respectively. GC/MS results revealed that application of crude cutinase on Malathion for 3 days resulted in 53% reduction of malathion. Current study describes cutinase as an attractive alternative for the bioremediation of malathion contaminated soil residues.

35. DOCKING ANALYSIS OF GALLIC ACID AND HEXANOIC ACID WITH POLYKETIDE SYNTHASE, A COMPUTATIONAL APPROACH TO CONTEMPLATE GALLIC ACID - MEDIATED AFLATOXIN BIOSYNTHESIS INHIBITION IN *ASPERGILLUS FLAVUS*

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Aspergillus flavus is the major opportunistic contaminant known to produce aflatoxin in food crops . Food contamination via aflatoxin is an *en effet* nutriment safety concern for agricultural yields. In order to identify and develop novel anti-aflatoxigenic agents, a study on phytochemicals as anti-aflatoxigenic agents has accrued remarkable importance including Gallic acid. The previously conducted experimental studies on Gallic acid suggested it as potential Inhibitor. Therefore, to understand the molecular mechanism behind inhibition of aflatoxin biosynthesis by phytochemicals , a computational interactive study with Polyketide Synthase A (PksA) of *Aspergillus flavus* was conducted. The protein sequence of PksA from *A. flavus* was obtained from UniProt database to perform homology modeling. Further, The 3D structure of PksA comprising of seven structural domains were modeled using SWISS-MODEL server and systematic Docking studies were performed using Autodock tools-1.5.6. Docking energies of the ligands Gallic acid and Hexanoic acid (as precursor) were compared with each of the domains of PksA enzyme. Binding energy for Gallic acid was found less than Hexanoic acid. LigPlot analysis showed the formation of seven hydrogen bonds in Gallic acid in comparison to three hydrogen bonds in Hexanoic acid. During an interaction with acyl transferase domain, both Gallic acid and Hexanoic acid showed H-bond formation at Glu36, Arg8, Thr11 positions. Out of seven domains, both Gallic acid and Hexanoic acid showed the maximum inhibition with Thioesterase domain. The dynamics of protein-ligand complex formation for every domain was investigated through MD simulations. Phytochemicals showed stable binding with active site of Polyketide Synthase A (PksA) indicated by steady RMSD of protein backbone atoms and potential energy profiles. Overall results revealed that Gallic acid exhibited the highest level of binding potential with PksA domain in comparison to Hexanoic acid; thus, Gallic acid feasibly inhibits, by virtue of competitively binding to the seven domains of Polyketide Synthase, a critical enzyme of aflatoxin biosynthetic pathway. Further, we suggest other key enzymes can be explored using this aflatoxin biosynthetic pathway. Our study may find its application in phytochemicals based anti-aflatoxigenic agents .

36. ANTIOXIDANT POTENTIAL OF EXOPOLYSACCHARIDE BASED NANOEMULSION DERIVED FROM *GANODERMA* SP.

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The synthetic antioxidants have been long associated with adverse health effects and there is a high demand from the consumers for food products containing naturally derived alternatives. Fruits, whole grains, vegetables, spices and herbs are considered to be a good natural source containing appreciable amounts of antioxidants. However, mushrooms particularly the genus *Ganoderma* has been widely studied in the past few decades for its antioxidant effect. The basidiocarp, mycelia and spores of *Ganoderma* sp. contain approximately 400 different bioactive compounds, which mainly include triterpenoids, polysaccharides, nucleotides, sterols, steroids, fatty acids, proteins/peptides and trace elements which have been reported to have a number of pharmacological effects. Amongst these bioactive compounds exopolysaccharide is considered as a major group. However, the major problem for application of polysaccharides in food and healthcare field is their low solubility and easy degradation, which result in difficulties for maintaining their biological activity. In order to overcome this problem nanoemulsion formulations are sought after which have a potential in resolving the solubility and stability problem of these bioactive polysaccharides. The present study aims at the development of effective exopolysaccharide based nanoemulsions in order to enhance the stability of the polysaccharide and in turn its antioxidant potential.

37. HARNESSING THE POTENTIAL OF FUNGI ISOLATED FROM OIL CONTAMINATED SITE TOWARDS EFFICIENT HYDROCARBON DEGRADATION

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Due to unique properties and vast array of application, identification of new biosurfactant producing microbes is in great demand. They are environmental friendly, biodegradable, less toxic and non-hazardous. Sample collected from oil contaminated site composed of 100mL diesel and 5mL aliquot from the sample was used to obtain desirable microbes by providing harsh environment as oil contaminated site for breaking down of hydrocarbons. Isolation of fungal strain from enrichment culture has been facilitated by use of plating sample on BH media. Strains were examined for morphological identification. Seven different strains of fungi were isolated are *Aspergillus, Penicillium, Scopulariopsis* and unknown strains. These were used for primary screening to check the biosurfactant producing activities with the help of drop collapse assay, oil spreading and emulsification activity test. Cultures showed positive result toward screening test. Fungi possess extracellular enzymes and their mycellia provide deeper penetration and larger surface area for absorption and have ability to clean up the contaminated environment. The result indicates that these fungal strain might be candidates for the bioremediation of the hydrocarbon contaminated site.

SECTION-C

Mycorrhiza and Endophytes

1. DIVERSITY OF VAM SPORES FROM INDUSTRIAL BELTS OF MIDC, DOMBIVLI

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Arbuscular mycorrhizae are the obligate symbionts, forming natural, beneficial relationship from almost all lower to higher plants. About 80% of plants are colonized by AM fungi which belong to *Glomeromycota* and members of family *Endogonaceae*. In soil microorganisms, AM fungi are commonly studied because of their capacity to develop plant strength under toxic and inappropriate conditions. The current paper deals with the exclusive survey of fifteen industrial sites selected from MIDC, Dombivli (East). The sites were investigated to study diversity of AM fungi with respect to rhizosphere soil analysis for subsequent spore density and identification upto species level. The standard method like 'Wet sieving and decanting' was used to analyze VAM spores. The spores were identified based on morphological characters. The spore density was highest for *Glomus* species. Spores of *Acaulospora* species and *Gigaspora* species were also observed. The observed species were also detected in root colonization analysis, using standard 'Ink-vinegar staining' method. *Glomus* was observed to be dominant genus, among arbuscularmycorrhizal (AM) fungi.

2. ARBUSCULAR MYCORRHIZAL FUNGAL DIVERSITY IN *VIGNA UNGUICULATA* FROM AGRICULTURAL FIELDS OF GOA

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A study to assess the arbuscular mycorrhizal (AM) fungal diversity in *Vigna unguiculata* growing in fallow rice fields in Goa was undertaken. The agricultural soil analysis study confirms that soils are generally acidic. The soil texture of the study sites indicated that they are sandy-loamy with an average pre-dominance of sand. Twenty-two AM fungal species were recorded from 18 sites. In all seven genera *viz., Gigaspora* (4), *Glomus* (4), *Scutellospora* (1), *Funneliformis* (2), *Accaulospora* (8), *Rhizophagus* (1), and *Racocetra* (2) belonging to Phylum Glomeromycota were recorded. The root colonization ranged from 78 to 97%, while the spore density ranges from 9 to 45 spores per 100g of rhizosphere soil. AM species richness ranged from 6 to 14 at the different study sites. The edaphic factors of the soil indicated that macronutrients, micronutrients, organic carbon, root colonization, and spore density of AM fungi varied significantly in different agricultural fields. *Gigaspora decipiens* was the most dominant AM fungal species recorded at all the study sites. Simpson's and Shanon-Wiener's Diversity indices of AM fungi were highest at the Deulwada Harmal site.

3. STUDIES ON MYCORHIZAL ASSOCIATIONS IN SOME ECONOMICALLY IMPORTANT ORCHIDS

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The plants under study namely Orchids, known for their myriad of shapes, colors and size embody an order of aristocracy among flowering plants, justifying their position as amongst top

floriculturally important flowering plants in international market. The numerical strength has been assessed at 25316. Nearly 73% species are epiphytic which are distributed in tropical and subtropical climates. The presence of fungi in orchid roots was first reported by Heinrick Friedrich Link in 1840 with the graphic evidence of *Goodyera procera,* protocorm section. Albert Bernhard Frank first point the term 'mycorrhiza' in 1885 to describe the root-fungus combination. He hypothesized that mycorrhiza represent a pervasive mutualistic symbiosis in which fungus and host nutritionally rely on each other; the fungus extracts nutrients from both mineral soil and humus; translocates them to the host plant and the fungus gets support in return. The most important and perceptive observation of the role of fungus in orchid seed germination in which both fungus and host are benefited by each other was made by Noel Bernard in 1899. Presently, work based on mycorhizal association in some orchids with emphasis on extent of infusion, fate of fungal partner, isolation and identification of fungi partner. Orchid species under study namely *Cymbidium pendulum, Aerdies multiflora*, *Rhynchostylis retusa* and *Vanda cristata* had been collected from their natural habitat and used. It was observed that the fungal partner had entered into the cortex and found to belong *Rhizoctonia* like organism based upon the structure of hyphae when stained with cotton blue. MS and PDA followed by Mitra media found to be more perfect for growth and extraction of fungus. Upon comparison of colony characteristics the fungus found to be like *Rhizoctoni* like species. Fungal entry is through roots, mediated through the thin walled 'passage' cells. The fungal endophytes were identified as anamorphs of *Rhizoctonia* species, based on their morphological (bi- to multinucleate condition, fungal clamps, mycelial loops, and formation of 'moniliods') and growth characteristics on different media. PDA is found to be most suitable for isolation generally.

4. EXTRACELLULAR ENZYME PRODUCTION FROM FUNGAL ENDOPHYTES IN ROOTS OF *WRIGHTIA TINCTORIA*

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Endophytic microorganisms are those which inhabit healthy living tissues of the host for all or some part of their life cycle without causing apparent harmful symptoms. Many groups of microorganisms such as fungi, bacteria or actinomycetes have been found in endophytic association with plants. These endophytes play very important and crucial role in many fields as industrial, agricultural and medicinal such as production of antibiotics, anticancer agents and other bioactive molecules. During the present investigation, endophytes were isolated for the first time from the symptomless roots of *Wrightia tinctoria* and were screened for their ability to produce protease, amylase, cellulase and lipase enzymes. It is interesting to note that, each of endophytic fungi such as *Trichoderma harzianum*, *Fusarium oxysporum*, *Aspergillus niger*, *Curvularia lunata*, *Colletotrichum falcatum*, *Alternaria alternate, Phomopsis* isolates showed wide range of enzyme activity. Specifically *Fusarium oxyporum* and *Aspergillus niger* were able to produce maximum amylase, lipase and cellulase. While, production of Protease was not detected by any endophytic fungi.

5. DIVERSITY OF ENDOPHYTIC FUNGI ON MEDICINAL PLANT VITEX NEGUNDO L.

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Endophytes are microorganism present in living tissue of plants establishing mutual relationship without any apparent symptoms of disease. These endophytes protect their host from infectious agents and adverse conditions by secreting bioactive secondary metabolites. In the present research work total 12 endophytic fungal isolates were recovered from leaves and petiole of *Vitex negundo* L., which is very important medicinal plant. The isolates belong to Coelomycetous, hypomycetous fungi and mycelia sterilia. *Alternaria alternata* was reported as dominant among all the isolates.

6. FUNGAL ENDOPHYTES OF SUGARCANE AND THEIR BIOACTIVE POTENTIAL

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Endophytes are considered plant mutualists as they receive nutrition and protection from the host plants while the host plant may benefit from enhanced competitive ability. Evidence suggests that plants infected with endophytic fungi have distinguishable advantage against stress (biotic and abiotic) over non-endophytic counterparts. The association of endophytes from various groups of plants including medicinal plants, mangroves, tropical forest trees and grasses have been done, but studies on the endophytes of crop plants are gaining interest in the recent past. Therefore, the present investigation was aimed to study the endophytes present in sugarcane (*Saccharum officinarum*) grown in Puducherry. Fungal endophytes belonging to the genera *Alternaria, Cladosporium, Colletotrichum, Curvularia, Drechslera, Fusarium* and *Nigrospora* were isolated. Eleven sterile forms were also recorded. Some of the fungal endophytes including *Alternaria* sp., and *Fusarium* sp. showed activity against pathogenic bacteria when tested *in vitro*.

7. ENDOPHYTIC FUNGAL DIVERSITY FROM SELECTED MEDICINAL PLANTS OF SATHYAMANGALAM, TAMILNADU

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Present study reveals the endophytic fungal diversity found in selected medicinal plants from Sathyamangalam, Tamil Nadu, India. The medicinal plants studied are *Argemone mexicana, Capparis grandiflora, Pachystachys lutea, Solanum jasminoides and Ziziphus oenophila.* Modified methodology of surface sterilization was used to isolate endophytic fungi. Diversity of endophytic fungi from medicinal plants was analysed using methods of descriptive and inferential statistics. Colonization frequency, species abundance, Jaccard similarity coefficient, and biodiversity indices were calculated.

Some endophytic fungi species were common in all of the investigated plant species. These are *Phyllosticta* sp., *Pestalotiopsis* sp., and *Phoma* sp. On the other hand, *Didymella glomerata, Acremonium* sp., and sterile form (green) appear to be host specific. 15% of the endophytic fungi species that were found in leaves of *Ziziphus oenophila* were found in shoots of the same host as well. An infection degree of 100% was recorded because of the high abundance of dominant species (*Phoma* sp., *Phyllosticta* sp., Sterile forms of black, white and grey colonies) that can be found in the investigated region. Gleason reciprocal index was higher in leaves of *A. mexicana* (0.0704) and internode of *C. grandiflora* (0.0714). Gleason richness index was highest in the shoots of *P. lutea* (3.3403) followed by leaves of *A. mexicana* (3.3231). *Phoma* sp. and *Alternaria alternata* showed an equal potential to sustain their position similar with other species. Typically the observed abundance patterns of endophytic fungi varied not only between host plants but also between investigated sections from the same host plant. But we have observed a few exceptions: In *Argemone mexicana*, for instance, sterile form white showed the same abundance level in the internode region as well as in the shoot, a sterile form grey was most abundant in leaves as well as in shoots.

8. CAMPTOTHECIN, AN ANTICANCER DRUG IN AN ENDOPHYTIC FUNGUS *PESTALOTIOPSIS MICROSPORA* MH458929 FROM ETHNO PHARMACOLOGICALLY IMPORTANT MEDICIAL PLANT *CORDIA DICHOTOMA* G. FORST: ISOLATION, SCREENING AND *IN SILICO* TOXICITY

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Cordia dichotoma G. Forst was studied for its ethnopharmacological importance from different ranges of Sathyamangalam Tiger Reserve Forest (STRF), Tamil Nadu. Fungus was isolated from the leaves of *C. dichotoma* collected from Kottada - Mavallam beat of Hasannur range of STRF. DEKM07 medium was used as the screening medium for the presence of CPT. CPT was analyzed by UV-Vis spectrophotometry, thin layer chromatography (TLC), High Performance Liquid Chromatography (HPLC), Fourier Transform Infrared (FTIR) spectroscopy and Electron spray ionization-Mass spectrometry (ESI-MS). The compounds identified by ESI-MS from the fungal extract were studied for their *in silico* toxicity against *Daphnia magna, Tetrahymena pyriformis, Pimephales promelas* and Rat (oral). Further, the bioaccumulation factor, developmental toxicity and mutagenicity were studied by Quantitative Structure-Activity Relationship model Toxicity Estimation Software Tool. The CPT yield of 0.691 mg/L was produced by the fungus *P. Microspora* MH458929. CPT derivatives were identified at m/z of 334.66, 349.10, 363.08, 381.24, 384.75, 389.41 and 415.27 through ESI-MS. *In silico* toxicity evaluation revealed that the compounds were of Category D, and hence, considered as non-toxic to higher organisms. However, the compounds showed high toxicity for lower organisms, with the toxicity order *D. magna*>*T. pyriformis*>*P. promelas*> Rat (Oral). This is the first initiative to isolate the CPT producing endophytic fungus *P. microspora* of *C. dichotoma* plant from STRF. Further *in vitro* and *in vivo* studies are recommended, for the utilization of CPT derivatives obtained from *P. Microspora* in pharmaceutical industries to reduce the market demand at certain extent.

9. PRODUCTION OF CAMPTOTHECIN FROM NOVEL ENDOPHYTIC FUNGAL STRAIN *PHYLLOSTICTA ELONGATA (MH458897)*: PROCESS OPTIMIZATION AND ITS ANTICANCER ACTIVITY STUDIES

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Camptothecin (CPT) gained much attention among the researchers because of its effective anticancer activity. In the present study, a novel endophytic fungal strain *Phyllosticta elongata* (MH458897) was isolated from the Western Ghats region of Sathyamangalam Tiger Reserve and evaluated for the production of CPT in DEKM07 medium and the CPT was quantified at initial screening was 0.694 mg/L. CPT was extracted and characterized using High Performance Liquid Chromatography, FTIR, and Electrospray ionization-Mass spectrometry. Optimization of DEKM07 mediumconstituents such as Potato extract (peeled and diced) 250.0 g L^{-1}, Dextrose 20.0 g L^{-1}, Peptone 10.0 g L^{-1},$MgSO_4.7H_2O$ 0.5 g L^{-1}; pH 5.6and incubation time was carried using Response Surface Methodology to maximize the CPT yield. The maximum yield of CPT (0.747 mg/L) was produced at optimized factors of dextrose 50 g/L, peptone 5.708 g/L, magnesium sulphate 0.593 g/L, and incubation time 14 days. *In-vitro* MTT assay revealed that the CPT derivatives were cytotoxic to A-549 lung cancer cell lines (IC_{50} 58.28 µg/mL) as compared to the (IC_{50} 51.08 µg/mL) standard CPT. CPT producing strain *P. elongata* from *Cipadessa baccifera* has the potential of CPT biosynthesis, and could be an effective anticancer biometabolite.

10. ENDOPHYTIC FUNGUS *DIAPORTHE CAATINGAENSIS* Mt192326 FROM *BUCHANANIA AXILLARIS*: AN INDICATOR TO PRODUCE BIOCONTROL AGENTS IN PLANT PROTECTION

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The study aims at the isolation, screening and *antibacterial* evaluation of Camptothecin and its derivatives, an anticancer molecule from endophytic fungus *Diaporthe caatingaensis* MT192326 of the medicinal plant, *Buchanania axillaris.* Plant parts were collected from Sathyamangalam Tiger Reserve forest, Tamil Nadu. The fungus was isolated using DEKM07 medium was used as the screening medium for the presence of CPT. The strain with the highest yield of CPT was identified at the molecular level by 18S rDNA sequencing. CPT was isolated and analysed by UV-Vis spectrophotometry, Thin layer chromatography, High Performance Liquid Chromatography, Fourier Transform Infrared spectroscopy and Electronspray ionization-mass spectrometry. The compounds identified by ESI-MS from the fungal extract were studied for their *antibacterial assays* against procured *MTCC bacterial pathogens*. The maximum yield of 0.681 mg/L of CPT was produced by the fungus *D. caatingaensis.* CPT derivatives were identified at m/z of 305, 348 and 389 through ESI-MS analysis. Antibacterial studies revealed that the compounds of endophytic fungal extract was studied for antibacterial activities of disc diffusion assay, exhibits the growth inhibition range of 15-22mm in nutrient agar plate medium. The Minimum Inhibitory Concentration revealed the antibacterial potential at lower concentration 12.5-25µg/mL with all bacteria studied. The partially purified biometabolites involved in the antibacterial activity with lesser than positive streptomycin (3.125) concentration due to partial purification and mixture of compounds present in extract. This is the first initiative to screen, isolate and analyze the *antibacterial assays* of CPT

and derivatives from endophytic fungus *D. caatingaensis* of ethnopharmacologically important *B. axillaris* plant from STRF.

11. DIVERSITY OF ENDOPHYTIC FUNGI FROM WILD MEDICINAL PLANTS

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Endophytic fungi are microbes that colonize living internal tissues of plants without causing any harm to host. Endophytic fungi are ubiquitous in most plant species growing in natural environment. The association between fungal endophytes and host plants may be symbiotic or antagonistic or slightly pathogenic in nature. Major impact of endophytes is observed on ecology, distribution and physiology along with immunity of plants. One to several endophytes can be isolated from a single plant by selecting suitable isolation protocol. In present study two wild medicinal plants *Hemidesmus indicus* and *Adathoda vasica* Linn were collected and examine to study the diversity of endophytic fungi in different seasons. Plant parts were collected in three different seasons for isolation of fungi. Total fifteen fungi were isolated from the host. Variation in colonization frequency and occurrence was observed. Highest rate colonization was recorded in monsoon as compare to other season. A few endophytes harbor the host only in particular season and vanished in next season. Isolated endophytic fungi were screened for antibacterial test against three pathogenic bacteria i.e. *Escherichia coli* (MTCC 1698), *Staphylococcus aureus* (MTCC 2639) and *Pseudomonas aeruginosa* (MTCC 6458) taken from IMTECH, Chandigarh, India. Endophytes exhibited great antibacterial activity against tested microbes. Antibacterial potential was determined by measuring zone of inhibition.

12. ISOLATION AND CHARACTERIZATION OF FUNGAL ENDOPHYTES FROM SALT ADAPTED VARIETIES (KRL-210, KRL-213 AND KRL-219) OF *TRITICUM AESTIVUM* L.

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Plant growth promoting fungi (PGPFs) generate a variety of non-pathogenic fungi that provide a variety of benefits to their host plants. For this study, seed samples of salt adapted wheat genotypes (KRL-219, KRL-210 and KRL-213) were obtained from the Central Soil Salinity Research Institute (CSSRI). Lucknow, were optimized with different (0 mM, 50 mM, 100mM, 150mM, 200mM, 250mM and 300mM) salinity doses and half maximal growth was found at 200mM. Further experiments were carried out using 100mM, 150mM and 200mM NaCl doses. Percentage of seed germination and radicle growth were measured after 72 hours of salinity exposure. Percentage reduction in radicle growth under stress over their respective control was calculated for each of 3 genotypes. Fungal endophytes were isolated from root, shoot and leaf of all three genotypes. The percent reduction in radicle length of KRL-210, KRL-219 and KRL-213 in treated sample with 200mM NaCl was 50%, 63.54% and 51.54% respectively compared to the control. A total of 65 endophytic fungi were isolated using culture-dependent approach

and screened for salinity stress tolerance by inoculating the endophytic fungi on PDA plates amended with different concentrations (200mM, 400mM, 600mM, 800mM and 1000mM) of NaCl along with control. Mycelial growth of all endophytic fungi decreased with increase in NaCl levels in media. Out of 65 fungal endophytes 15 salt tolerant fungi and were screened for plant growth promoting traits, extracellular enzymatic activities, carbohydrate utilization test and antimicrobial activity. Out of 15 screened fungi, 5 fungal endophytes gave all these test. Our future study will focus on the salt tolerant PGP fungal endophytes from the salt adapted wheat genotypes help plant to survive under salt stress.

13. ABIOTIC STRESS TOLERANT ENDOPHYTIC FUNGI FROM WHEAT (*TRITICUM AESTIVUM*)

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In India, wheat is one of the three major cereals having more than 93 million tonnes production annually. In the 21st century, drastic change in the climate is posing a global challenge in terms of food security. In recent years, greater attention has been paid to the problems that are directly associated with changed climate, which has increased uncertainty with respect to food production. Uncontrolled expansion in human population is directly enhancing the stress on agriculture. Currently, use of beneficial endophytic microbes is a naturally alternative method appears to be a plausible substitute which is comparatively cheap, effective and environment friendly. Plant growth promoting endophytes (PGPEs) act as bioinoculants or eco-friendly microbes that enhance the capacity of plant to uptake the nutrients from the soil. In our study, different parts of wheat variety PBW 725 were collected after the interval of 15 days from the day of sowing till flowering stage. The 145 isolates obtained in the study were then subjected to production in potato dextrose broth and potato dextrose agar for screening under drought stress mimic by Polyethylene glycol MW 6000. Out of 145 endophytic fungi, 10 isolates showed the potential to survive against drastic conditions of drought. Two abiotic stresses were chosen, namely salinity (0.5M-2M) and high temperature (15-45°C), for screening of 10 potent endophytic fungi. Further, these endophytic fungi were screened for biological activity in terms of total phenolic content, total flavanoid content and in-vitro antioxidant activity. The culture isolate #6TAKR-1a and #8TAKS-3a possess good scavenging activity of above 90%. The isolates #5TAKL-3a and #6TAKR-1a showed the highest TFC (642.72 and 223.63 µg/mL) and TPC (396.8 and 1171.2µg/mL). Classical and molecular tools (ITS sequencing) are used to identify these 10 potent endophytic fungi.

14. DIVERSITY OF ARBUSCULAR MYCORRHIZAL FUNGI IN THE RHIZOSPHERE OF GRASSES FROM MELGHAT FOREST, INDIA

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Grasses are considered to be an important integral part of forest ecosystem and are of great benefit for growth and nutrient acquisition to nearby plants by establishing Arbuscular Mycorrhizal Fungal (AMF) network. So far, enough attention has not been paid by researchers to investigate mycorrhizal association especially with grasses. The present study deals with the diversity and

distribution of AM fungi in rhizosphere soil of grasses from Melghat forest. The rhizosphere soil samples were analysed for AMF spore isolation by wet sieving and decanting technique followed by identification and ecological studies. The findings revealed Isolation Frequency (IF) of grasses ranged between 4.76% to 14.29% in phase I, and 11.11% to 22.22% in phase II. Isolation and identification of AMF spores were carried out to evaluate the AMF diversity. IF of AMF species ranged between 4.76% to 66.67% and 11.11 to 77.78% in phase I and II respectively. The highest IF was found in *Acaulospora scrobiculata* Trappe and *Acaulospora delicata* C. Walker, C.M. Pfeiff. & Bloss. The Relative Abundance (RA) for grass species of phase I was in between 1.43% to 4.29%, and in phase II 2.27% to 6.82%. Amongst identified species of AMF the RA was from 0.22 % to 18.02%, and 0.21% to 57.51% respectively in phase I and II. The site wise species richness (D) was also noted from the study of both the phases. It was found to be 0.14 to 1.15; 0.3 to 1.36 for grasses and likewise 0 to 2.88, and 0.2 to 2.4 for AMF species. It is the first report depicting abundant rhizosphere biodiversity of AM fungi from the study area associated with grasses. Considering the potential application of AM fungi it seems that more attention has to be paid in future to explore predominant AM fungi for mass inoculation and maintenance of ecosystem in Melghat forest.

15. THE POTENTIAL OF ARBUSCULAR MYCORRHIZAL FUNGI FOR THE CULTIVATION OF IMPORTANT MEDICINAL HERB *PICRORRHIZA KURROA*

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Picrorrhiza kurroa Royle is an important medicinal herb of Ayurveda. It belongs to family *Scrophulariaceae*. In India, it is mainly found in Himachal Pradesh and Jammu and Kashmir. Modern clinical studies have confirmed the efficacy of this plant for the treatment of jaundice and liver disease. The rhizome is used as medicinally important part of the plant. Roots contain two bitter glycosides-picrorhizin and kutkin. It grows on high altitude and prefers moist places to grow. It cannot be propagated easily and suffers heavy mortality during rains. Its vegetative propagation can be done through stolons. Its market price is very high and due to this people used to collect the plant from wild conditions. This medicinal herb population is decreasing day by day and ultimately it came under the list of endangered medicinal herbs. Therefore, there is urgent need of its conservation. Keeping this in view, present research investigation was undertaken to assess the effect of arbuscular mycorrhizal (AM) fungi on the growth and nutrient uptake of *Picrorrhiza kurroa.* Two AM fungi i.e., *Glomus mosseae* and *Acaulospora laevis* alone and in combination with two different substrates i.e., vermicompost and farmyard manure were inoculated to the seedlings of *Picrorrhiza kurroa*. Different growth parameters like seedling survival rate, height of plant, number of branches, number of leaves, root and shoot fresh and dry weight, root length, AM spore count/10g of soil, percent mycorrhizal root colonization were observed after 60 days of inoculation. Soil parameters like pH, EC, OC, N, P, K was also analysed in all the inoculated plants and compared with control plants. A significant increase was found in all mycorrhizal plants over control plants. Root P content was more than shoot P content in all treatments. The present study indicates that *G. mosseae* and *A. laevis*are the best strains of VAM symbionts when mixed together with vermicompost as substrate for inoculating the *P. kurroa* to get higher yield of biomass.

16. ENDOPHYTIC FUNGI ISOLATED FROM *AZADIRACHTA INDICA* EXHIBITS LOVASTATIN PRODUCTION

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Fungal endophytes are the fungi that resides in the plant and majority of which are isolated from higher plants. Endophytes are rich source of secondary metabolites that exhibit various bioactivities studied by researchers. *Azadirachta indica* commonly name as Neem tree is a tropical evergreen tree of medicinal importance. Lovastatin is one such fungal secondary metabolite with hypocholesterolemic action and has high drug value. Lovastatin is not yet explored from endophytes of *A. indica*. In this research work endophytes were isolated from various parts of as *A. indica* like stem, leaves, petiole and bark. Using solid state fermentation, fungal endophytes were screened for lovastatin production by TLC, UV and HPLC. Antifungal activity of lovastatin extracted from selected endophytic fungi on the growth of *Sacchromyces cerevisiae* was studied. Most of the fungal isolates were isolated from leaves. Total 28 isolated endophytes were confirmed for lovastatin production in varying quantities. Six fungi were characterized at molecular level for identification. These six endophytic genera are *Pleurostoma, Pseudofusicoccum, Preussia, Wickerhamomyces, Xylaria* and *Fusarium*, and were found to be first time reported from *A. indica*. Studies revealed that endophytes show significant amount of lovastatin production. *Preussia isabellae* and *Pleurostoma ootheca* were found to be a potential source for lovastatin metabolite with antifungal activity. The study confirms for the first time that endophytes associated with *A.indica* show lovastatin production.

17. CHARACTERIZATION OF BIOACTIVE COMPOUNDS ISOLATED FROM MANGROVE ENDOPHYTIC FUNGI AND ITS POTENTIAL ACTIVITY AGAINST A549 LUNG CANCER CELL LINE

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In the present study, the mangrove endophytic fungi were screened for anti-cancer activity. Five endophytic fungi were isolated and identified based on their morphology and spore characters. Ethyl acetate was found to be the most suitable solvent system for the extraction of secondary metabolites. The crude fungal extracts were screened for cytotoxic activity against lung cancer cell line A549 by using MTT assay. The results indicate the inhibitory activity of the endophytic extracts against the human lung cancer cell line (A549). The highest inhibitory activity was recorded in MEn89 (*Cladosporium* sp.) and MEn87 (*Alternaria alternata*) with the IC_{50} value of 2.672 and 3.012 g/mL, respectively. However, MEn85 (*Nigrospora* sp.) reported the lowest inhibitory percentage compared to other fungal extracts. The bio-compatibility assay was also performed on the selected fungal extracts by using the Normal Mouse Fibroblast cell line (L929). The bio-compatibility assay revealed that the crude fungal extract did not show any lethality on normal cells with viability percentage ranging from 70 to 100%. The GC-MS analysis of the extracts revealed the presence of diverse groups of secondary metabolites having potential biological activities.

18. EFFECT OF *RHIZOPHAGUS INTRARADICES* ON THE CHEMICAL PROFILE OF *OCIMUM TENUIFLORUM* ESSENTIAL OIL

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The effect of *Rhizophagus intraradices* colonization on the chemical profile of *Ocimum tenuiflorum* L. essential oil was determined. Two high yielding genotypes of *O. Tenuiflorum* were taken into consideration for the study. Essential oil was extracted by hydro-distillation using Clevenger's apparatus and characterization of the components/composition was done by Gas Chromatography-Mass Spectrophotometry. Essential oil of *O. tenuiflorum* is a concentrated heterogenous mixture of terpenoid and phenylpropanoid derivatives. The composition of EOs varied between the two genotypes. While 23 compounds were identified from EOs of non-mycorrhizal plants of genotype A, 37 compounds were identified from B genotype. Influence of *R. intraradices* colonization on the composition of EOs was evident as the number of compounds identified reduced to 21 and 34, respectively in genotype A and B. Thirteen compounds were common in all the treatments, cumulatively contributing to 95.8% and 97.4% of the total EO concentration of NM genotype A and B, respectively and 96.76% and 97.86%, respectively of the total EO concentration of M genotype A and B. While the overall the terpenoid composition was positively influenced by AM colonization in both the genotypes, phenylpropanoid composition declined. Nevertheless, eugenol (a phenylpropanoid, highly valued for its pharmaceutical value) concentration increased by 15.66% and 12.18% in genotype A and B, respectively. Other medicinally important terpenoids such as β-elemene and β-caryophyllene increased by 13.88% and 12.80% in genotype A, respectively and 5.87% and 57.51% in genotype B, respectively. *R. Intraradices* concomitantly increased EO production and individual concentration of the highly sought-after compounds, biomass, and nutrient concentration, thereby improving the overall biological activity of *O. tenuiflorum.* Therefore, the results of the study represent the potential of AMF in promoting growth of this important medicinal shrub, at a time when natural ways of growing such crops are coveted in the herbal industry.

19. DIVERSITY OF FUNGAL ENDOPHYTES FROM MEDICINAL PLANTS OF EASTERN HIMALAYAN REGION, SIKKIM, INDIA

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Endophytic fungus generally belongs to *Ascomycota* phylum of the large kingdom of Fungi. They spend their whole or part of their lifecycle colonizing inside the healthy host plant tissue without causing any apparent symptoms of disease. Various plant hormones like indoleacetic acid, several valuable bioactive compounds like terpenoids and alkaloids, important extracellular enzymes like cellulose and pectinase, have been isolated successfully from the endophytic fungi. Hence they are an essential source of several functional compounds which make them significant for the studies. The Eastern Himalayan regions of India are reservoir of such efficient endophytes, while the current study focuses on the State Sikkim, one of the major biodiversity hotspot on the continent. The medicinal plants from North Eastern areas of the country are used for treating several diseases like cancer, malaria, etc. Endophytic fungi isolated from these medicinal plants may also offer natural products useful to combat

several diseases. The present study briefs about the fungal diversity of endophytic fungi acquired from the medicinal plants. In the present study, the endophytic fungi were isolated from the medicinal plants of the Sikkim. Isolated cultures were identified using molecular techniques (seuecning of ITS and LSU regions) and deposited at National Centre for Microbial Resource (NCMR), NCCS, Pune. We are also screening them for antimicrobial activities as a part of the bioprospecting of these fungi.

20. BIOFABRICATION AND CHARACTERIZATION OF FLUORESCENT NANOSTRUCTURES DERIVED FROM ENDOPHYTIC FUNGUS FOR SENSING, BIOIMAGING AND BIOTIC STRESS

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In the current work, we have synthesised and characterised novel nanoparticles derived from endophytic fungus *Aspergillus* sp. isolated from the healthy symptomless tissue as a function of temperature via hydrothermal process. In our knowledge, this is the first study which shows a systematic growth of fluorescent nanoparticles with the increase of temperature up to 200°C by using fungal biomass only in water. Above 200°C, we observed the formation of fluorescent carbon dots. NPs and Cds were characterised by various experimental techniques like ultraviolet visible (UV- Vis) spectrophotometer, Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Photoluminescence (PL). We observed that 283nm UV peak intensity increases with temperature ranging from 60°C till 200°C and peak disappears at 220°C. Similarly, fluorescence intensity also increases with temperature and shows blue shift. Further, we have investigated the effect of Carbon dots and NPs on the plant growth promotion on *Brassica nigra*with induced plant pathogenic resistance. Robust fluorescence property of CQDs has been also utilized as a tool to detect the adulterant in food and for the bio-imaging of melanoma skin cancer cell.

21. ISOLATION AND IDENTIFICATION FROM ENDOPHYTIC FUNGI ISOLATED ASSOCIATED WITH LEAVES OF *ANISOMELOUS INDICA* L. AN IMPORTANT MEDICINAL PLANT

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Microorganisms that are ubiquitously associated with the plant tissues and possess no harmful effects are referred to as endophytes. A large number of endophytic fungi have been isolated from various parts of different medicinal plants. These endophytic fungi have a great ability to synthesize novel secondary metabolites which have advantageous effects on plant growth, development and protection from phytopathogens. At the same time, these secondary metabolites from endophytic fungi play a great role in the pharmaceutical industry. With this background, the present study was carried out in order to isolate, identify and screen for bioactive metabolites from endophytic fungi associated with medicinal plant *Anisomelous indica* L. The plants were collected from the campus of University of North Bengal, West Bengal, India. The endophytes assemblages were initially identified using morphological characters as observed through visual and microscopic characters such as colon morphology, colony color, hyphae, asexual and sexual spore, reproductive bodies, and an arrangement of conidia. All the

endophytes are grown in three different media such as potato dextrose agar (PDA), malt extract agar (MEA), and potato carrot agar (PCA) to evaluate mycelial growth differences and pigmentation variations. Results suggested that PDA seemed to be a better medium for the isolation of endophytic fungi from *Anisomelous indica* as compared to the other media. Extraction for bioactive compounds has been done from endophytic fungi and subsequent study is underway for their antibacterial, antifungal, and antioxidant ability.

22. ISOLATION AND CHARACTERIZATION OF FUNGAL ENDOPHYTES FROM SALT ADAPTED VARIETIES (KRL-210, KRL-213 AND KRL-219) OF *TRITICUM AESTIVUM* L.

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Plant growth promoting fungi (PGPFs) generate a variety of non-pathogenic fungi that provide a variety of benefits to their host plants. For this study, seed samples of salt adapted wheat genotypes (KRL-219, KRL-210 and KRL-213) were obtained from the Central Soil Salinity Research Institute (CSSRI). Lucknow, were optimized with different (50 mM, 100 mM, 150 mM, 200 mM, 250 mM and 300 mM) salinity doses and half maximal growth was found at 200 mM. Further experiments were carried out using 100 mM, 150 mM and 200 mM NaCl doses. Percentage of seed germination and radicle growth were measured after 72 hours of salinity exposure. Percentage reduction in radicle growth under stress over their respective control was calculated for each of 3 genotypes. Fungal endophytes were isolated from root, shoot and leaf of all three genotypes. The percent reduction in radicle length of KRL-210, KRL-219 and KRL-213 in treated sample with 200mM NaCl was 50%, 63.54% and 51.54% respectively compared to the control. A total of 65 endophytic fungi were isolated using culture-dependent approach and screened for salinity stress tolerance by inoculating the endophytic fungi on PDA plates amended with different concentrations (200 mM, 400 mM, 600 mM, 800 mM and 1000 mM) of NaCl along with control. Mycelial growth of all endophytic fungi decreased with increase in NaCl levels in media. 15 salt tolerant fungus were found out of 65 fungal endophytes that screened for plant growth promoting traits, extracellular enzymatic activities, carbohydrate utilization test and antimicrobial activity. Out of 15 salt tolerant fungus, 5 fungal endophytes gave all these test. Our future study will focus on the salt tolerant PGP fungal endophytes from the salt adapted wheat genotypes help plant to survive under salt stress.

23. PLANT GROWTH PROMOTING POTENTIAL OF CULTURABLE ROOT-ASSOCIATED FUNGAL ENDOPHYTES FROM HIMALAYAN SILVER BIRCH

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The heterogenous group of fungi colonizing within the host plant tissue without causing any apparent adverse effects, considered as fungal endophytes. Fungal endophytes associated with high altitudinal medicinal plants have various plant growth promoting potential through various mechanisms however the functional and ecological aspect of these endophytes still unexplored. Temperature is a well known attribute to affect the nutrient availability in plant species in high elevation region subsequently affecting the growth and survival of the species. It is hypothesized that microbial endophytes might have potential to support the growth of the plant species in extreme condition. Therefore, the present study aimed to assess the plant growth promoting activity of root- associated fungal endophytes isolated from treeline species *Betula utilis* D. Don, commonly known as Himalaya Silver Birch from sub-alpine zone of Indian Himalayan region (IHR). The microscopic observation of stained root confirmed the presence of mycorrhizal fungi and dark septate endophytes. Total five culturable fungal endophytes were isolated from root samples *B. utilis*. Based on ITS region sequencing method the isolated fungal endophytes were identified as *Eurotium* sp. 1, *Penicillium citrinum*, *Eurotium* sp. 2, *Pezicula radicicola*, and *Paraconiothyrium archidendri*. These endophytes have ability to produce several extracellular enzymes including amylase, gelatinase, and xylanase. All isolated endophytes have potential to promote plant growth (PGP) activities including phosphorus solubilization, siderophore production, Indole acetic acid (IAA) and ACC deaminase production in three different temperature conditions. The endophytes also possess the antimicrobial activities against pathogenic bacteria and fungal phytopathogens. The plant growth promoting activity and phytopathogens inhibitory activity by these endophytes promising their potential in various biotechnological applications.

24. ENDOPHYTIC FUNGI:AN IMPLIED SOURCE OF BIOACTIVE COMPOUND

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Endophytic fungi are the group of fungi with is having by the symbiotic relationship with the host plant. The present study detailed with a review on the bioactive compounds by Endophytic fungi. Plants are the source of herbal remedies. Endophytes are the group of fungi and bacteria which are potential source of different bioactive compounds and secondary metabolites such as alkaloids, flavonoids, steroids, phenols, terpenoids and other compounds are well known studied for their biological activity. Numerous studies indicate that the endophytes play an important role in host production against predators and pathogen. This is a review on bioactive compound produced by the endophytic fungi. Numerous researchers from all over the world have identified the endophytic fungi of medicinal plants that show prominence activities against tumor and microbial pathogen.

25. ARBUSCULAR MYCORRHIZAL FUNGUL DIVERSITY IN MANGROVES ALONG SOUTH EAST COAST OF INDIA

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Mangroves are trees and shrubs that have adapted to life in a salt water environment. There are about 80 different species of mangrove trees and all of these trees grow in areas with low-oxygen soil, where slow-moving waters allow fine sediments to accumulate. Mangroves protect shorelines from damaging storm and hurricane winds, waves, and floods. They also help prevent erosion by stabilizing sediments with their tangled root systems and maintain water quality and filtering pollutants & trapping sediments originating from land. The unique feature of mangroves is that, unlike most marginal ecosystems, they are highly productive and dynamic. There are few reports revealed that mangroves were found to be associated with mycorrhizal fungi particularly Arbuscular Mycorrhizal (AM) fungi in India and other parts of the world. The present study aims to investigate the diversity status of AM fungi in association with four different mangrove plants such as *Avicennia marina, Avicennia officinalis, Rhizophora apiculata* and *Rhizophora mucronata*in two locations in Cuddalore and Mailaduthurai districts in Tamil Nadu, India. Soil physico-chemical properties were measured to determine their potential effects on the distribution of AM fungi. The results of the revealed that all the mangrove plants had AM fungal association with all the four mangrove plants but varying percent root colonization (55-86%) and soil spore population (176 to 350 spores/ 100 g soil). Among them, *R. Mucronata* had maximum of 350 spores per 100 g soil and *A. officinalis* had minimum of 176 spores per 100 g soil. Soil physico chemical analysis showed that high moisture and organic content, slightly acidic pH, (6.2- 6.5), low level of phosphorus (14.23- 17.25 kg/Ac), high level of nitrogen (51.2 54.5 kg/Ac). Data analysis revealed that P content and salinity in soil were the important factors influencing AM fungal association in mangroves in different study locations. It was also inferred that different AM fungal spores of four different genera *viz*., *Acaulospora, Gigaspora, Glomus* and *Scutellospora* were observed as first time records in mangrove of study area.

SECTION-D

Medical Mycology, Plant Diseases and management

1. STUDY OF POST HARVEST SPOILAGE OF FRUITS CAUSED BY FUNGI

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Fruits and vegetables are important nutritional commodities. However, a major chunk of the total produce is wasted due to losses during harvesting, storage and even during marketing. Postharvest decay of fruits and vegetables pose a serious threat by causing appproximately 25-30% losses. An increase in yield has been the main focus of most of the horticultural strategies. A very meager amount of efforts are put in to exercise for reduction of the postharvest losses. Lack of proper data base for planning suitable strategies for better utilization of horticultural commodities is a major challenge. Fruits due to their acidic nature, are more prone to fungal attacks. During the present investigations, various markets of Ferozepur, Punjab were surveyed during 2018-19 for collection of fruit samples. A total of 98 collections were made during the study period. Maximum incidence of post harvest spoilage was reported during the months from June to September, thus indicating the role of climatic conditions in the disease development. The collected samples were thoroughly investigated for their macroscopic as well as microscopic details. Ten different genera of fungi were reported on 15 fruit hosts. Genera like *Alternaria*, *Stemphylium, Gloeosporium* etc. were reported on more than one host. However, some genera were reported on some particular fruit host only. *Alternaria* was reported for maximum incidence followed by *Rhizopus* and *Penicillium,* while *Corynespora* and *Nigrospora* were reported in least number. Some of the fruits like Banana, Guava, Orange and Papaya showed symptoms of decay due to multiple pathogens. Pathogenicity was also tested using Culture method.

2. HISTOPATHOLOGICAL INVESTIGATION OF FUNGAL INFECTED *CLARIAS BATRACHUS* FISHES FROM WADALI LAKE, AMRAVATI, MAHARASHTRA

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Fungal diseases of fresh water fishes are known to be problematic disease. The aim of this study was to investigate the increasing aquatic fungal flora of the Wadali Lake and the percentage of infection of various species in fishes. Present investigations deal with the histopathological alterations induced due to the fungal infections in the *Clarias batrachus*, were dissected out from both control and infected fishes and rinsed in fresh water fish saline to remove the bloodstains and tissue debris. The tissues were further processed by standard methods. Pure cultures were made on sabouraud dextrose agar, glucose yeast agar and potato dextrose agar. Identification of various species was carried out on the basis of their vegetative and reproductive characters. The fungal species isolation was investigated from different parts of the body using the routine technique. *Saprolegnia parasitica* was isolated from all collected specimens. The sections were cut and stained with haematoxylin-eosin, processed further, cleaned and then observed under microscope. However, fungal parasitic infections were more in the skin, gills and muscles. Severely infected fishes showed necrosis of skin in dorsiventral and caudal region with hemorrhagic lesions. Histological observations of the infected fish liver showed; hemorrhage, blood congestion and necrotic cells. Histopathological studies of lesions in various tissues such as skin, gill, liver and kidney of all the infected fishes showed diffuse infiltration of broad, non-septate fungal hyphae and a large number of inflammatory cells through the lesion in *Saprolegnia* infected fishes. Although most of the fishes from the lake were found to be healthy, but under histopathological observations it was found that most of fishes were

affected by fungal parasites. Gill lamellae of infected fishes showed hypertrophy and hyperplasia. Degeneration of the infected gills affected respiration and eventually the fish died of suffocation. Most fish died due to osmotic or respiratory problems if the affected area of skin or gills was large.

3. ANTIFUNGAL ACTIVITY OF OIL NANOFORMULATIONS AGAINST THE PLANT PATHOGENIC AND SPOILAGE FUNGI *FUSARIUM GRAMINERUM* AND *ASPERGILLUS OCHRACEUS*

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Fusarium graminerum causes Fusarium head blight disease (FHB) in wheat, barley and chickpea leading to ~ 50% yield losses and also contaminates the food grain with harmful mycotoxins. Another mycotoxin producing fungus *Aspergillus ochraceus* adversely affects the quality and quantity of food grain causing 10% losses worldwide. Currently the azole antifungals used for the control of pathogenic and spoilage causing fungi faces the problem of resistance. There is a need for newer strategies for the control of harmful fungi. Citronella and garlic essential oils are natural aromatic volatile compounds of plants that can suppress growth of plant pathogenic and spoilage fungi to reduce disease development and spoilage. However, the active ingredients of these oils are volatile in nature and are extremely labile, reducing their effectivity on the field. Nanotechnology approach can offer solution for the slow sustained release of the active ingredient and its improved activity by encapsulation of the essential oils in nanoparticles. Polymeric nanoparticles encapsulating the essential oils were synthesised by ionic gelation method. The citronella oil nanoparticles were 130 nm having +23.6 mV charge and garlic oil nanoparticles were 139nm in size having +25.5 mV charge. The antifungal activity of citronella and garlic oil nanoformulations were evaluated against plant pathogenic fungi *Fusarium graminerum* and *Aspergillus ochraceus* microdilution method. Garlic oil nanoformulation had MIC 50 of $25*10^{-3}$ ul/mg for both on *Fusarium graminerum* and *Aspergillus ochraceus*. Whereas citronella oil nanoformulation had MIC 50 of 20*10-4 ul/mg for both on *Fusarium graminerum* and *Aspergillus ochraceus*. Further, data for seed protection by nanoformulation against wilt and fungal contamination will be presented.

4. PHYLLOSPHERIC INVESTIGATION OF BRINJAL AND STUDY THEIR SYMPTOMS OF THE DISEASES AND MORPHOLOGICAL CHARACTERS OF THE PATHOGEN

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In the present research work phyllosphere mycoflora of brinjal was undertaken to investigate different types of fungal mycoflora causing diseases to these economically important vegetable plants. During the investigation, an extensive survey of various aerial diseases of vegetables plants was carried out from July 2013 to December 2015. The leaf, stem and fruit samples of selected four vegetable plants were collected from various field of Amravati and Akola region at the intervals of 15 days starting from seedling to harvesting stage. The disease samples were collected in all the stages of plant i.e. seedling,

foliage, flowering and fruit-formation stage. The samples from plants were brought into laboratory in separate sterilized polythene bags for isolation of all possible phyllosphere mycoflora. The etiological study of the diseases was carried out in different climatic conditions i.e. rainy, winner and beginning of summer. The disease samples were collected from different localities of Amravati and Akola region. The infected plant parts which were collected different stages of disease development and all the samples were carefully preserved in the form of herbarium to study the etiology of diseases. The symptoms of diseases were studied in the beginning as well as severity of infection. Phyllosphere isolation were carried out by different methods such as serial dilution, leaf impression, leaf washing methods, etc. The different types of fungal pathogens were also isolated by cutting small fragments of aerial diseased parts of plants from junction of infected and healthy parts. Pathogenicity test was confirmed by Koch's postulate method and fungi showing positive pathogenesis were used for further investigation. In case where more than one fungal from was isolated from single disease spot, the pathogenicity of such fungi was confirmed separately. The potato dextrose agar (PDA) medium was used for isolation of the fungi. To maintain stock cultures regular sub culturing of isolated fungi were carried out. From the phyllosphere study it was concluded that mainly Deuteromycetean fungi were found to be associated with various parts viz. leaf, stem and fruit. The fungal isolated were identified with the help of available literature and stock cultures available in Research Center in Botany, Mangrulpir; Mycology and Plant Pathology Laboratory, B. B. Science College, Amravati; Dr. P.D. Krishi, Vidyapeeth, Akola and Symbiotic Multipurpose Institute's Agrigen Biotech Centre, Aurangabad.

5. NITRIC OXIDE: A SIGNAL MEDIATOR IN CHILLI-*ALTERNARIA ALTERNATA* INTERACTION

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Chilli is consumed as condiment as well as vegetable throughout the world. It is accepted as one of the most important cash crops of India. Different stresses are associated with limited production of chilies throughout the world. Among the biotic stresses *Alternaria alternata* is now a days emerging as major limiting factor of chilli production. This fungus can cause leaf spot and fruit rot diseases of chilli. In the present study, we have taken an attempt to understand differential defense responses in two chilli cultivars (tolerant and susceptible) against progression of this pathogen. Time course analysis of disease progression showed that the leaf spot symptoms were more prominent on the leaves of susceptible cultivar than the tolerant one. The different defense related enzymes showed higher activities in tolerant cultivars in response to pathogen progression. Total phenol and flavonoid also showed higher accumulation in tolerant cultivar than the susceptible cultivar. The signaling molecule nitric oxide (NO) also showed higher generation in tolerant cultivar against the pathogen progression. Semi quantitative RT-PCR analysis of different defense related genes showed differential regulation in their expression pattern at different time points of pathogenesis in both the cultivars. The tolerant cultivar also showed higher deposition of callose in response to *Alternaria* invasion. The tolerant cultivar showed less amount of lipid peroxidation. To confirm the participation of NO, different NO modulators were applied to the leaves and defense responses were recorded. Overall, from our results it can be stated that NO functions as important signaling molecule in this novel host pathogen interaction.

6. DIVERSITY OF SECRETED IN XYLEM GENES AND PHYLOGENETIC RELATIONSHIPS AMONG THE MEMBERS OF *FUSARIUM OXYSPORUM* SPECIES COMPLEX

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Fusarium oxysporum (*Fo*) is a species complex (FOSC) comprising of genetically heterogenous and anamorphic species that are the causal agents of vascular wilt diseases of agronomically important crops. The pathogen shows a broad host range infecting more than 150 plant species. Individual strains of the pathogen are host-specific. They are characterized into *formae speciales* and races depending on their ability to infect a particular host and cultivars of a host plant species, respectively. Pathogenic strains secrete small, cysteine-rich effectors, known as Six (Secreted In Xylem), into the xylem of infected host plants. These effectors interact with host regulators and interfere with defense responses. Till now, 14 *SIX* genes are identified in the genome of tomato-infecting pathogen *F. oxysporum* f. sp. *lycopersici*. The array of *SIX* genes varies significantly among members of FOSC. Thus, variation in *SIX* gene profile can be used to distinguish *formae speciales*, races, and non-pathogenic isolates. Phylogenetic studies on members of FOSC revealed that majority of *formae speciales* are polyphyletic in origin. FOSC lacks sexual reproduction; however, they witness horizontal transfer of *SIX* genes between strains contributing to the observed variation in *SIX* genes profile and polyphyletic origin. The diversity of *SIX* genes in *formae speciales* of FOSC and *Fusarium* spp. was investigated. The results showed that the profile of *SIX* genes among FOSC vary significantly, ranging from fourteen genes in *Fol* to only three in *formae speciales gladioli* and *ricini*. Phylogenetic relationships between *formae speciales* of FOSC and *Fusarium* spp. were also analyzed on the basis of *ITS, TEF-1α*, *β-tub.* The results supported the concept of polyphyletic origin of *formae speciales*.

7. COLONIZATION BY ARBUSCULAR MYCORRHIZA FUNGI REDUCES ARSENIC ACCUMULATION, IMPROVE GROWTH AND PROMOTE NUTRIENT ACQUISITION IN TRITICUM AESTIVUM L. GROWN IN ARSENIC CONTAMINATED SOIL

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Arsenic (As) contamination poses serious environmental threats due to its toxic nature. In India, large proportion of wheat growing area coincides with region comprising As-contaminated groundwater. A study was carried out to examine the influence of *Rhizophagus intraradices* colonization on the concentrations and distribution of nutrients in roots and grains of wheat plants subjected to As. Plants (mycorrhizal and non-mycorrhizal) were grown in soil contaminated with different levels of As (0, 25, and 50 mg As kg^{-1} soil) as sodium arsenate. Mycorrhizal plants displayed better growth than non-mycorrhizal plants at all As levels. Elemental analysis was done using ICPMS, CHNS, and spectrophotometric methods to study the acquisition and translocation of various macro and micro elements in wheat plants parts. Relative elemental content, heat map analysis, and principal component analysis suggest that high concentrations of As in soil depress the nutrient acquisition and lead to nutrient imbalance in plants. However, colonization by AM fungi, aided wheat plants to augment nutritional status in roots as well as in grains at all As levels by improving the translocation of macro and micro nutrients. Colonization by *R. intraradices increased* the ratio of essential elements to their homologous

nonessential elements such as P:As, Ca:Ba, Mg:Ba, and K:Na, yielding grains with higher nutritive value over non-colonized plants. Furthermore, *improved concentration of photosynthetic pigments and net photosynthesis also ensured enhanced grain biomass in mycorrhizal plants.*

8. ASTRAKURKUROL POTENTIATES APOPTOSIS, AUTOPHAGY AND ATTENUATES CELL MIGRATION, VIA FINE TUNING THE AKT SIGNALING IN HUMAN LUNG ADENOCARCINOMA CELLS (A549)

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Although comprehensive exertions have been made in late decades for treating advanced lung cancer with inclusive therapies but efficient anti-lung cancer therapeutics are statically inadequate in the clinics. Hence, compelling novel anti-lung cancer drugs are considerably desired. Herein, we investigated the antitumor activity of a terpenoid isolated from a gastromycetes. Mechanistic analysis disclosed that sensitizing effect of astrakurkurol is due to cell cycle arrest at G0/G1 phase, increased level of Fas, FADD, decreased ratio of Bax/Bcl-2, and increased cleaved form of caspase 9, 8 and 3. Apart from the induction of apoptosis, it was demonstrated for the first time that astrakurkurol induced an autophagic response as evidenced by the formation of acidic vesicular organelles (AVOs), autophagosomes, and the up-regulation of beclin-1, Atg7 and downregulation of p62. Apoptosis and autophagy can be sparked by the same stimuli, which was as evident from the astrakurkurol induced inactivation of PI3K/AKT signalling. The thorough scanning of the mechanism of crosstalk between apoptosis and autophagy is requisite for prosperous anticancer treatments. Apart from enhancing cytotoxicity and inducing apoptosis on A549 cells, astrakurkurol could curb migration and regress tumor size in *ex-ovo* xenograft model. These findings put forth astrakurkurol as a convincing natural anti-cancer agent, for exploring the lung cancer therapies and as a robust contender for further *in vitro* and *in vivo* investigations.

9. EFFICACY OF ENDOPHYTIC FUNGUS MEDIATED SILVER NANOPARTICLES AGAINST PLANT PATHOGENS AND MULTI-DRUG RESISTANT *E. COLI* STRAINS

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We report an eco-friendly, cost-effective novel method for mycosilver nanoparticles (AgNPs) synthesis by the green method using fungus cell filtrate. The fungus cell-filtrate acts as a reducing and capping agent for the silver ions. The biosynthesized mycosilver nanoparticles were characterized by Ultraviolet-visible Spectroscopy (UV-Vis), Fouriertransform infrared Spectroscopy (FTIR), Transmission Electron Microscopy (TEM) and Energy Dispersive Spectroscopy (EDAX) gave the composition of silver nanoparticles and showed the presence of metallic silver in the mycosilver nanoparticles. Mycosilver nanoparticles were mono dispersed and spherical in shape. The mycosilver nanoparticles were effective against multi-drug resistant *E.coli* strains and inhibited the formation of

biofilm. Thus, mycosilver nanoparticles could be used as antimicrobial resistance breakers to control the infectious diseases caused by multi drug resistant pathogens. The AgNPs showed good antibacterial activity against human pathogenic strains. A result of this study indicates that the AgNPs has remarkable potential antimicrobial property. It will be used in treating infectious diseases andalso use full in biomedical application. Further, the plant pathogenic fungi including *Fusarium graminearum, Fusarium udum, Rhizoctonia solani* and *Aspergillus niger* were treated with mycosilver nanoparticles to test the efficacy to control plant pathogens, and showed broad spectrum antifungal activity against the phytopathogens by inhibiting the radial growth.