Research Workers of DMR

Directorate of Mushroom Research

(*Indian Council of Agricultural Research*)

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PREFACE

Directorate of Mushroom Research was established as National Centre for Mushroom Research and Training in 1983 under the auspices of Indian Council of Agricultural Research (ICAR) for research and development on mushrooms in the country. Later on Centre was renamed as National Research Centre for Mushroom in 1996 and recently the Centre has been upgraded to the level of Directorate. The mandate of the Directorate is to conduct mission-oriented and innovative research on all aspects of mushrooms and act as the Centre of academic excellence and repository of mushroom germplasm and information. It coordinates network research on location specific problems of national importance to achieve higher production and productivity. It also promotes human resource development and transfer of technology and provides technical support to the mushroom industry, as well as rural masses for poverty alleviation. It has served the cause for which it was established and has emerged as a Centre of Excellence for mushroom research and development in the world. Besides developing and improving the cultivation technology of mushrooms, the Directorate has played key role in creating awareness and popularizing mushroom cultivation throughout the country. Since its inception, 25 scientists specializing in different disciplines viz., Genetics, Biotechnology, Plant Pathology, Biochemistry, Plant Physiology, Entomology, Extension, Engineering and Computer Application have worked at the Directorate. The present document is an effort to compile the significant contributions of all these workers in the past 25 years.

The information in this compilation has been provided by the scientists. At places where the information could not be obtained, the editors have culled out the information from the institute reports so that everyone who has contributed to the development of the Directorate finds a place in this compilation. We would like to acknowledge the contribution of all those who lead this organization since its inception i.e. 8th June, 1983. In the early years, the Centre functioned under the control of Dr. N.M. Nayar, Director, CPRI, Shimla with Dr. B.L. Dhar as Incharge of NCMRT (8th June, 1983-18th July, 1984). On 19th July, 1984 Dr. H.S. Sohi joined as Officer on Special Duty and subsequently was appointed as the first regular Director of this Centre followed by Dr. S.R. Sharma, Acting Director (1st March, 1990 to18th October, 1994; 1st April, 2002 to 30th July, 2002), Dr. R.N. Verma, Director (19th November, 1994 to 31st March, 2002) and Dr. R.P. Tewari (31st July, 2002 to 31st December, 2008). We would like to thank all the workers who have contributed to the development of this Directorate.

Director

AHLAWAT, OM PARKASH

Paddy straw mushroom breeding and cultivation, and recycling of spent mushroom substrate

Om Parkash Ahlawat obtained his M.Sc.in Microbiology in the year 1989 and Ph. D in 1993 from Ch. Charan Singh Haryana Agricultural University, Hisar. From 1991 to 1993 he worked as Sr. Research Fellow of Council of Scientific and Industrial Research (CSIR) at Deptt. of Microbiology, CCSHAU, Hisar. He joined Agricultural Research Service of Indian Council of Agricultural Research in the year 1993 at National Academy of Agricultural Research Management (NAARM), Hyderabad. Dr. Ahlawat joined National Research Centre for Mushroom, Solan in September, 1994 and served there till December, 1999. From January, 2000 to August, 2000 he was at Central Institute of Post Harvest Engineering & Technology, Abohar, Punjab as Sr. Scientist (Microbiology). He rejoined National Research Centre for Mushroom in August, 2000 as Senior Scientist, Biotechnology and since then he is working at this Centre. Presently he is Principal Scientist, Biotechnology at the Directorate.

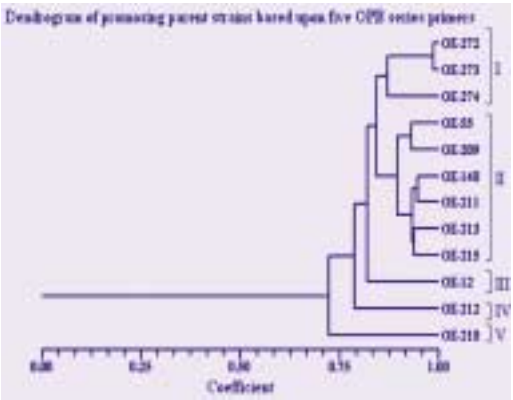
Description of Research

The main focus of Dr. Ahlawat's earlier research was to investigate the role of associative heterotrophic bacteria from mushroom compost and casing in fructification of mushrooms and in particular white button mushroom. He for the first time established the yield stimulatory role of phosphate solubilizing bacteria present in 'Phosphotika' biofertilizer, and *Bacillus megaterium, B. circulans*-I and *B. circulans*-II from compost on their mixing in ready to spawn compost. He also established the fruiting body stimulatory role of *Alcaligenes faecalis*, a common bacterium of cowdung and *B. megaterium* from mushroom compost on their mixing in ready-to-case casing material. During the same period the role of these bacteria in yield enhancement of *Agaricus bitorquis* and *Pleurotus* spp. was also investigated.

The mushroom spawn spoilage causing bacteria were also identified along with developing strategies for their management during healthy mushroom spawn preparation. Dr. Ahlawat also did work on post harvest management of button mushroom, which includes the spray of safer chemicals on mushroom beds during cropping and washing treatment after crop harvest for enhancing the quality and shelf life of the harvested mushrooms. For the work on post harvest management of button mushroom, the All India Food Preservers' Association bestowed Dr. Ahlawat with KU Patel Award 2000. He also has one patent to his credit.

Standardization of cultivation technology and strain improvement in paddy straw mushroom, *Volvariella volvacea* using molecular techniques: The

cultivation of paddy straw mushroom using paddy straw as substrate and following conventional techniques started in the year 1940 in India. Despite all strong features like a shortest cropping cycle of 20-25 days, unique aroma & texture, higher temperature requirement of 28-35°C and easy cultivation technique, this mushroom is fast loosing its place to other mushroom species. Because of the availability of raw material and easy to cultivate both outdoor as well as indoor, this mushroom has the potential to change the mushroom production scenario in the country. Over the last few years, the group



has perfected the indoor cultivation technology of this mushroom with yield potential of more than 35% (B.E.) by using cotton ginning mill waste. The newer

strains with high yielding potential, superior resistance to diseases and insect-pests and with superior shelf life have also been developed. The basic aspects like role of extracellular lignocellulolytic enzymes in mycelial colonization of the substrate and fructification, and role of proteinase, chitinase, N-acetyl-ß-glucosaminidase and polyphenol oxidase in post harvest storage of mushrooms under refrigerated and ambient temperature conditions have also been studied. The phylogenetic relationship between different parent strains and monosporous isolates using RAPD markers and ITS sequencing of 5.8S rRNA has also been studied. Tools have also been developed for identifying a superior yielding strain without going into the fruiting trials.

The group is further interested in understanding the molecular mechanisms involved in liquefaction of the mushroom fruiting bodies on their storage at refrigerated conditions and mushroom fructification.

Value addition to spent mushroom substrate (SMS): The production of every one kg of oyster and button mushroom generates about 3 and 5 kg of spent substrate, respectively. As per the present figure of nearly 1,20,000 tons of mushroom production per annum in the country, the country generates about 5,00,000 tons of SMS annually. The mushroom growers are disposing off this valuable organic waste indiscriminately without caring for its real value and harmful impact on the surrounding environment if not handled properly. Hence it is necessary to develop suitable recomposting techniques to convert it into an organic manure for raising organic food crops and to remediate the damaged/polluted soils. The group has developed novel techniques for its faster decomposition and use as manure for vegetables and cereals.

During its use as manure for vegetables and cereals, its multifacet roles like enhancement in fruit / grain yield, improvement in quality of the produce and lowering of diseases / insect – pests incidences have also been investigated. The group has also investigated the use of SMS as feeding material for vermicompost preparation. The group has also established the bioremediative role of SMS against pesticides and

fungicides commonly used in agriculture and heavy metals released through different industrial activities. For his continuous efforts in developing technologies for reuse of spent mushroom substrate for environment management activities, Dr. Ahlawat was bestowed with Scientist of the Year Award 2006 by National Environmental Science Academy. Currently the group is involved in developing technologies for using SMS in decolourization of colouring synthetic dyes.

Organic button mushroom production, casing and advanced compost production technology: Mushrooms are more preferred for fresh consumption and the pesticides used during crop raising do not get enough time for their natural decomposition. Considering the ill effects of these pesticides on human health, compost production and crop raising

protocols have been developed by the group for raising economically feasible organic button mushroom crop.

Among different key steps involved in button mushroom crop raising, compost preparation and casing are considered as the critical factors for raising a healthy button mushroom crop. The group has evaluated several compost formulations and composting methods and has come up with some of them for shortening the composting period and enhancing the button mushroom yield over the conventionally used formulations and composting methods. The different agro – industrial wastes have been analysed for their suitability as casing material and the group has recommended decomposed coirpith alone and in 1:1, v/v combination with 2 years old aerobically recomposted spent mushroom substrate as the best available casing material in the country. The group has also established the role of high temperature (45-52°C) fermentation of casing material in enhancing its quality as casing material. Currently efforts are on for improving the composting protocol for remediation of the ingredients borne pesticides and use of neem based organic N rich supplements for controlling diseases and insect – pests incidences during button mushroom cropping.

Selected Publications

1. Ahlawat, O.P., Gupta, Pardeep and Dhar, B.L. 2008. Profile of the extracellular lignocellulolytic enzymes as a tool to select the promising strains of *Volvariella volvacea* (Bull. ex Fr.) Sing. *Indian Journal of Microbiology,* 48: 289-296.

2. Ahlawat, O.P., Gupta, Pardeep, Shwet Kamal and Dhar, B.L. 2008. Development of molecular and biochemical markers for selecting a potential high yielding strain of paddy straw mushroom, *Volvariella volvacea*. *Journal of Plant Biochemistry and Biotechnology,* 17(1): 57-63.

3. Ahlawat, O.P., Sagar, M.P., Dev Raj, Indu Rani C., Gupta, Pardeep and Vijay, B. 2007. Effect of spent mushroom substrate on yield and quality of capsicum. *Indian Journal of Horticulture,* 64(4): 430-434.

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5. Ahlawat, O.P., Gupta, Pradeep, Dev Raj and Vijay, B. 2006. Dye decolorization potential of spent substrates from *Agaricus bisporus* and *Pleurotus* sp. - a laboratory study. *Mushroom Research,* 15(1): 75-82.

6. Singh, S.K., Vijay, B., Mediratta, V., Ahlawat, O.P. and Shwet Kamal. 2005. Molecular characterization of *Humicola grisea* isolates associated with *Agaricus bisporus* compost. *Current Science*, 89(10): 1745-1749.

7. Ahlawat, O.P., Ahlawat, K. and Dhar, B.L. 2005. Influence of lignocellulolytic enzymes on substrate colonization and yield in monosporous isolates and parent strains of *Volvariella volvacea* (Bull. Fr.) Sing. *Indian Journal of Microbiology,* 45(3): 205-210.

8. Ahlawat, O.P. and Vijay, B. 2004. Effect of casing material fermented with thermophilic fungi on yield of *Agaricus bisporus*. *Indian Journal of Microbiology,* 44(1): 31-35.

9. Ahlawat, O.P., Rai R.D. and Dadarwal K.R. 2002. Influence of bacteria from mushroom substrate/ casing soil on *Agaricus bisporus* strain $U_{3.}$ *Indian Journal of Microbiology,* 42 (3): 219-223.

10. Ahlawat, O.P and Rai, R.D. 1998. Use of ascorbic acid, Veradix and Vipul in *Agaricus bisporus* cultivation - effect on yield, quality and shelf life. *Mushroom Research,* 7(1): 19-24.

ARUMUGANATHAN, T.

Post harvest processing of mushrooms and low cost structures for mushroom cultivation

T. Arumuganathan obtained his M.E (Agricultural Processing) in 1999 and Ph.D (Agricultural Processing) in 2007 from Tamil Nadu Agricultural University, Coimbatore. He joined Agricultural Research Service of Indian Council of Agricultural Research (ICAR) at National Research Centre for Mushroom (NRCM), Solan in 2001 and continued at the Centre upto 20th Dec., 2008.

Description of Research

Dr. Arumuganathan started his scientific research career in 2000, as a Senior Research Fellow in a research project entitled "Controlled Atmosphere Storage of Paddy" funded by the ICAR, New Delhi at Agricultural Engineering College and Research Institute, TNAU, Trichy, Tamil Nadu. In this research project, he worked in the areas like determination of physical properties of paddy, Shelf life of paddy, airflow resistance characteristics of paddy and its constituents, carbon dioxide gas sorption characteristics of paddy and its byproducts, and mathematical modeling of carbon dioxide movement in grain bins. He joined NRCM, Solan in 2001 and worked on various aspects of Post harvest Technology of different mushrooms like button mushroom, oyster mushroom and milky mushroom. He was involved in the following at NRCM, Solan

Development of value added mushroom products: Drying technology of button and oyster mushroom by sun-drying, Cabinet air drying, Osmo-air drying, Freeze-drying, Fluidized-bed drying and Dehumidified air-cabinet drying methods were standardized and their quality characteristics were analyzed. Various value-added mushroom products viz., Mushroom Soup powder, Mushroom Biscuit, Mushroom Nuggets, Mushroom Chutney powder, Mushroom Murabba, Mushroom Candy and dried mushroom pickle were developed and its cost analysis was worked out.

Development of low cost mushroom growing structures: In the area of Mushroom farm design and application of electronics in mushroom cultivation, two low-cost mushroom houses namely bamboo-mud house and bamboo-paddy straw-polyhouse were constructed using locally available agricultural materials and cultivation of various mushroom in the developed structures were carried out. An evaporative-cooled mud house was introduced for cultivation of button mushroom and milky mushroom. Data on mushroom growers, mushroom research workers, consumption pattern of mushrooms in India were also collected and compiled.

Modified atmospheric packaging of mushrooms: Engineering properties of fresh button mushrooms were studied critically and based on the results a MAP technology named "Diffusion Channel Storage" was devised and was found suitable for prolonging the shelflife of button mushroom. The same technology is now under study for its suitability for other edible mushrooms.

Development of indigenous machinery for mushroom cultivation: A workshop was established in NRCM, Solan with the machines such as Lathe machine, Shaper, Sheet bending machine, Air blower, Painting gun, Air compressor, Power hacksaw, Bench drill machine, Hydraulic press, Lifting Jack, Hand grinder, Bench grinder, Arc welding machine and 10 KV Generator set. Using the facility, the indigenous prototype machines namely Compost turner, Compost conveyor and Substrate mixing drum were designed and developed for the mushroom industry A small gadget named "Mushroom Stipe Cutting machine" was also designed and developed for cutting the stem of button mushroom.

Selected Publications

1. Arumuganathan, T., Rai, R.D. and Hemakar, Anil Kumar. 2003. Preparation of pickle from Oyster mushroom (*Pleurotus florida*). *Processed food Industry*, 7(3): 21-23.

2. Arumuganathan, T., Rai, R.D., Hemakar, Anil Kumar and Kamal, S. 2006. Mushroom soup powder, nuggets, biscuits & pickles from the dried white button mushroom *(Agaricus bisporus)*. *Indian Journal of Mushrooms*, XXIV (1 & 2): 40-43.

3. Arumuganathan, T., Hemakar, Anil Kumar and Rai, R.D. 2004. Studies on drying characteristics and effect of pretreatments on the quality of sun-dried oyster mushroom, *Pleurotus florida*. *Mushroom Research*, 13(1): 35-38.

4. Arumuganathan, T., Hemakar, Anil Kumar and Rai, R.D. 2005. Studies on development of value added products from fresh white button mushroom *Agaricus bisporus*. *Mushroom Research,* 14(2): 84-87.

5. Arumuganathan, T., Rai, R.D., Indurani, C., Dhar, B.L. and Hemaka, Anil Kumar. 2004. Studies on rehydration characteristics of oyster mushroom (*Pleurotus florida*). *Mushroom Science*, XVI: 393-396.

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7. Arumuganathan, T., Rai, R.D. Chandrasekar, V. and Hemakar, Anil Kumar. 2003. Studies on canning of button mushroom, *Agaricus bisporus* for improved quality. *Mushroom Research,* 12(2): 117-120.

8. Arumuganathan, T., Kailappan, R. and Indurani, C. 2004. Production of activated carbon from Kiluvai (*Commiphora berryi* (Arn.) Engl.). *SAARC Journal of Agriculture*, 2: 235-242.

9. Dhar, B.L. and Arumuganathan. T. 2005. Low cost seasonal mushroom growing houses. *Mushrooms International,* 100: 7-10.

10. Arumuganathan. T., Manikantan, M.R., Rai, R.D., Ananadakumar, S. and Khare, V. 2009. Mathematical modelling of drying kinetics of milky mushroom in a fluidized bed drier. *Internation Agro Physics,* 23(1): 1-7.

DHAR, BEHARI LAL

Cultivation of *Agaricus bitorquis*, casing soil management and organic mushroom farming

Behari Lal Dhar completed his B.Sc.(Agri.) in 1964 from College of Agriculture, Sopore, (Kashmir), J&K University. He did his M.Sc in Mycology and Plant Pathology in 1976 from College of Agriculture, Solan (HP), HP University and completed his doctorate degree in Mycology and Plant Pathology in 1988 from Post Graduate School, IARI, (Pusa), New Delhi. Before joining Agricultural Research Service in1977 he served in different departments like HP Govt., Shimla / Solan from 1965-67, Deptt. of Agri., J&K Govt., Srinagar from 1967-1977. From 1977-1983 he served in Central Potato Research Station, ICAR, Jalandhar, Punjab as a scientist. He joined National Research Centre for Mushroom, Solan, HP in 1983- as a founder member of the Centre and served the Centre as Sr. Scientist and Principal Scientist till 2007. He was instrumental in the establishment of the National Research Centre on Mushroom and functioned as its first Scientist-Incharge for initial 2 years. He has been sharing the responsibility in various capacities at the Centre. In Dec. 2007, he was transferred to Division of Plant Pathology, IARI, New Delhi from where he retired as Principal Scientist in February, 2009. Dr Dhar was honoured by the International Society for Mushroom Science (UK) by selecting him as 'Mushroom Personality' in 1995. He has more than 180 publications to his credit.

Description of Research

He worked extensively on *Agaricus bitorquis* and developed complete package of technology for cultivation of this mushroom and released 2 high yielding varieties NCB-6 and NCB-13 for commercial cultivation in India. He also released one hybrid strain of *Agaricus bisporus* NCH-102 for the use by the seasonal mushroom growers in India.

Dr Dhar also worked on shortening of the composting period for button mushroom (*A. bisporus*) cultivation and use of non-conventional energy sources like, solar energy, for compost pasteurization. He isolated microflora from *Agaricus*

mushroom compost at various stages of its fermentation, and established the role of important micro-organisms in the composting process and correlated to yield of mushrooms. He contributed on post composting supplementation of compost with N-rich organic materials for yield increase, in both *A. bisporus* and *A. bitorquis*. Dr Dhar was also involved with the following activities:

Evaluation of casing materials suited to Indian conditions : Use of Mushroom Spent Compost, Coir Pith and Farm Yard Manure after water leaching for cultivation of button mushrooms with excellent yields.

Computer Application in Mushroom Cultivation: Application of electronics in mushroom cultivation process, at various stages of crop raising i.e. composting/ cropping. Collaborative project with CEERI, Pilani, Rajasthan. Control of growing room environment with use of remote sensing and computers.

Development of Mushroom Farm Design appropriate to Indian growing conditions. Preparation of Master Blue Print for development of infrastructure on mushrooms in various States of Indian union under Central Sector Scheme on Mushrooms, Govt. of India. Development of Techno Economic Feasibility Reports for the industry in private/public sector on cost under the consultancy programme.

Selected Publications

1. Ahlawat, O.P., Gupta, Pardeep and Dhar, B.L. 2008. Profile of the extracellular lignocellulolytic enzymes as a tool to select the promising strains of *Volvariella volvacea* (Bull. ex Fr.) Sing. *Indian Journal of Microbiology,* 48: 289-296.

2. Ahlawat, O.P., Gupta, Pardeep, Shwet Kamal and Dhar, B.L. 2008. Development of molecular and biochemical markers for selecting a potential high yielding strain of paddy straw mushroom, *Volvariella volvacea*. *Journal of Plant Biochemistry and Biotechnology,* 17(1): 57-63.

3. Dhar, B.L. and Arumuganathan. T. 2005. Low cost seasonal mushroom growing houses. *Mushrooms International.* 100: 7-10.

4. Dhar, B.L. and Verma, R.N. 1995. “Mushroom as Biotech tool for recycling of agro-products into useful protein rich food.” Natl. Seminar on Biotech. For Rural and Industrial Development, Gulberga Univ.

5. Dhar, B.L. and Verma, R.N. 1995. “Recycling of Agro-wastes for production of protein rich mushrooms”. Intl. Workshop Urban Agril. And Sust. Environment, Calcutta, 8-10 December, 1995.

6. Dhar, B.L., Ahlawat, O.P. and Gupta, Y. 2003. Evaluation of Agro-industrial wastes as casing materials in *Agaricus bisporus* cultivation. *Mushroom International* (UK), 92(1): 5-9

7. Dhar, B.L., Ahlawat, O.P., Dubay, J.K. and Amit Nath . 2004. Organic mushroom production in India, technology and residue assay. *Mushroom Science* XVI: 289-295 (Science and cultivation of edible and medicinal fungi, Romaine, C.P., Keil, C.B., Rinker, D.L. and Royse, D.J. eds, PennState, University Park, PA, USA)

8. Dhar, B.L., Ahlawat, O.P., Gupta, Pardeep and Dev Raj. 2006. Casing layer as related to mushroom yield and quality in *Agaricus bisporus* in India. *Mushroom Research*, 15(2): 111-117.

9. Dhar, B.L., Yadav, M.C. and Verma, R.N. 2000. Breeding in Tropical Agaricus (*Agaricus bitorquis*) for plains of India. National Symposium on Tropical Mycology in the 21st Century (8-10 February, 2001) Calcutta University, Calcutta.

10. Dhar, B.L.,Yadav, M.C., Verma, R.N. and Upadhyay, R.C. 1998. Strain Improvement in mushroom—a pre-requisite for raising production in the next century. Indian Phytopathological Society Annual Meeting, Lucknow 17-19 Feb. 1999.

GAUTAM, YOGESH

Electronic applications on mushroom cultivation

Yogesh Gautam obtained his Master of Computer Applications (MCA) from Himachal Pradesh University, Shimla, in 1993. He joined National Research Centre for Mushroom in January 1998. Prior to this, he served in Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan for 2 years and as Lecturer in Govt. Boys Senior Secondary School, Solan for three years. He has guided many MCA and BCA students in their Project work and is currently on the experts panel of the DOEACC (Department of Electronics and Accreditation of Computer Courses). He has done MBA with specialization in Marketing and is currently pursuing his Ph.D in Computer Sciences from Himachal Pradesh University.

Description of Research

The main focus of research of Yogesh Gautam was on generation of data on various aspects of mushrooms, and electronic applications on mushroom cultivation. He was part of the collaborative Project of NRCM and CEERI (Central Electrical and Electronics Research Institute), Pilani in which studies were carried out related to application of computers in mushroom cultivation. In the Project, the electronics part was developed by the CEERI and the mushroom house related part was of NRCM. The technology generated was submitted to the Ministry of Information Technology (MIT), the sponsors of the Project.

He compiled data on mushroom growers and mushroom research workers of India. He also compiled data on the mushroom production of India which gave the exact production figures of different States of India. The mushroom consumption and mushroom marketing studies carried out gave the trends of mushroom consumption and mushroom marketing in the region. Some research effort has been directed towards the trends of internet use among students, trainees and the factors which influence the use of computer by a farmer.

Selected Publications

1. Dhar, B.L., Verma,R.N.,Kapoor,P., Prasad, B. and Gautam, Y. 2002. Application of electronics in mushroom cultivation process. In "Recent Trends in Automation of Agriculture & Agro-based Industries" at Aurangabad. Feb 25-26.

2. Gautam, Y. 2005. Mushroom informatics on the NET- its importance in research, production and trade. In "*Frontiers in Mushroom Biotechnology*" (Eds. R.D. Rai, R.C. Upadhyay and S.R. Sharma), National Research Centre for Mushroom, Solan (HP), 2005. 360-364.

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9. Gautam, Y., Kumar, Satish and Dhar, B.L. 2005. Present status of computer applications in mushroom cultivation – a review. *Mushrooms International*, 99: 5-12.

10. Sagar, M.P. and Gautam, Y. 2002. Recent Approaches to Transfer of Mushroom Cultivation Technology. In "*Recent Advances in the Cultivation Technology of Edible Mushrooms*". NRCM, Solan HP India. pp 283-295.

GREWAL, PARWINDER SINGH

Mushroom Nematodes and their control

P.S. Grewal did his B.Sc. (Agri.) from Punjab Agricultural University Ludhiana in 1991, M.Sc. (Plant Path. - Nematology) from the same University. He did his Ph.D. in UK at I.H.R. West Sussex, University of London in 1990 wherein he worked on the use of insect parasitic nematodes for the biological control of mushroom fly pests. He joined ICAR through Agricultural Research Services in March, 1985 at NCMRT, Solan where he exclusively worked on mushroom nematodes and their control upto September, 1987.

Description of Research

Dr. Grewal established the relationship between the initial inoculum level of nematodes and the loss in mushroom yield. He concluded that an initial level of 20 larvae of *Aphelenchoides composticola* per bag (1 nematode/200g of compost) at the time of spawning has the potential to cause significant loss in mushroom yield. He also studied the toxicity of various plants namely *Eucalyptus hybrida* (Safeda), *Leucacena leucocephala* (subabul), *Populus deltoids* (Poplar) and *Tectena grandis* (Teak) and observed that the fresh leaves extract results in mortality of nematodes which increased with the time of exposure and concentration of the extract. A new and cheaper technique for rapid multiplication of *Arthrobotrys conoides*, a potential biocontrol agent against the mushroom nematodes, was given by him. Dr. Grewal tested the cultural metabolies of different fungi namely *A.conoides, Paecilomyces, Gliocladium deliquescens, Trichoderma viride* and *Trichothecium roseum* against *A.composticola* and reported that all the above mentioned fungi have nematicidal activity which was maintained even after autoclaving. He also studied the effect of different pesticides on the growth of *Agaricus bisporus* and *Pleurotus sajor-caju* and revealed that phorate inhibited the mycelial growth of both the edible fungi at 100-800 ppm whereas diazinon was toxic only to the latter at 10 to 80 ppm. Aldicarb, carbofuran, dichlorvos and phenamiphos did not show significant adverse effect on the growth of *P.sajor-caju*.

Dr. Grewal studied the sensitivity of *Auricularia* species, *Pleurotus* species and *Stropharia rugoso-annulata* to diazinon and bavistin. A wide variation in sensitivity was observed among both the species. Lower doses of both the pesticides stimulated growth in most of the edible species tested, whereas higher doses were inhibitory. All the three species of *Auricularia* showed no significant inhibition in mycelial growth up to 40 ppm of diazinon whereas, bavistin was toxic at 25 ppm and above. Diazinon was less toxic to all the eleven species of *Pleurotus* tested as compared to bavistin. Diazinon caused significant increase in growth of *P.sapidus* at 10-80 ppm whereas bavistin showed inhibition at 25 ppm and above. *S.rugoso-annulata* showed no significant inhibition at 20-80 ppm of diazinon whereas bavistin completely inhibited its growth at 100 ppm and above.

Selected Publications

1. Grewal, P.S. and Sohi, H.S. 1989. Effect of various fungal metabolities on *Aphelenchoides composticola* and its multiplication in some fungi. *Mush. Sci.,* 12(2): 813-820.

2. Grewal, P.S. 1989. Nematicidal effects of some plant extracts to *Aphelenchoides composticols* (Nematoda) infesting mushroom, *Agaricus bisporus*. *Rev. Nematol.,* 12: 317-322.

3. Grewal, P.S. 1989. Effects of leaf matter incorporation on *Aphelenchoides composticola* (Nematoda), mycofloral composition, mushroom compost quality and yield of *Agaricus bisporus*. *Ann. Appl. Biol.,* 115: 299-312.

4. Grewal, P.S. 1989. Pathogenic potential of *Aphelenchoides composticola* Franklin infesting white button mushroom, *Agaricus bisporus* (Lange) Singer. *Mush. Sci.*, 12(2): 821-830.

5. Grewal, P.S. and Sohi, H.S. 1988. A new and cheaper technique for rapid multiplication of *Arthrobotrys conoides* and its potential as a bio-nematicide in mushroom culture. *Curr. Sci.,* 57: 44-46.

6. Grewal, P.S. and Sohi, H.S. 1987. Studies on the effect of different pesticides on the growth of *Agaricus bisporus* (Lange) Singer and *Pleurotus sajr-caju* (Fr.) Singer. *Mush. J. Tropics,* 7: 25-29.

7. Grewal, P.S. and Sohi, H.S. 1987. Integrated control of pests and diseases in mushroom cultivation. In: Cultivating Edible Fungi. (eds. P.J. Wuest, D.J. Royse and R.B. Beelman), Elsevier Science Publishers, The Netherlands, pp. 667-677.

8. Grewal, P.S. and Sohi, H.S. 1987. Effect of incorporation of dried plant material on interaction among various competitor moulds and other fungi in the mushroom compost. *Indian Phytopath.,* 40: 276.

9. Grewal, P.S., Sohi, H.S. and Vijay, B. 1988. Cost-effective pre-treatment of chicken manure for controlling nematodes and fungal flora in synthetic compost used for the cultivation of *Agaricus bisporus* (Lange) Singer. *Indian J. Nematol.,* 18: 22-26.

10. Grewal, P.S., Upadhyay, R.C. and Sohi, H.S. 1988. Differential sensitivity of *Auricularia* species, *Pleurotus* species and *Stropharia rugoso-annulata* to diazinon and bavistin. *Mush. J. Tropics.,* 8: 23-29.

GUPTA, YASH

Casing and Crop Management in button mushroom

Yash Gupta obtained her M.Sc. Degree from HPKVV, Solan in 1982 and Ph.D. from YSPUHF, Solan in 1986. She joined ICAR services in November, 1984 at National Centre for Mushroom Research & Training now Directorate of Mushroom Research. She was transferred from NRCM to CPRI, Shimla in 2003. Dr. Gupta worked on casing and crop management in *Agaricus bisporus*, compost, composting, nutrition and microbiology of *A. bisporus* and crop improvement and management of *A. bitorquis*.

Description of Research

During her stay at NRCM she worked on various projects like Studies on *Morchella* species, Crop management in *Agaricus bisporus* and Casing management in *Agaricus bisporus*. She evaluated number of casing materials to find out the most suitable material and concluded that the compost, coir pith form a very good casing medium when used either alone or in combination with farm yard manure and spent compost. She also reported that FYM and loam soil in equal volumes or FYM, loam soil and spent compost as standard casing material. She also contributed immensely in the compost project along with Dr. Vijay and reported reduction in composting period from 28 days to 16-20 days for long method of composting. She also worked on compost supplementation and revealed that post-composting supplementation in upper layer of compost bed at spawning or at casing with deoiled soybean meal @ 2% significantly enhanced the yield of *A. bisporus*. Dr. Gupta also recorded that mixing spawn run compost with CACing two days after shredding gave considerable high yield in button mushroom. She also conducted detailed physiological studies on *Morchella* spp.

Selective Publications

1. Dhar, B.L., Ahlawat, O.P. and Gupta, Y. 2003. Evaluation of Agro-industrial wastes as casing materials in *Agaricus bisporus* cultivation. *Mushroom International* (UK), 92(1): 5-9 .

2. Gupta, Y. and Vijay, B. 1990. Studies on interaction between *Agaricus bisporus* and some weed fungi. *Indian J. Mycol. Pl. Pathol.,* 20 (1) : 99-100.

3. Gupta, Y. and Vijay, B. 1992. Post composting supplementation in *Agaricus bisporus* under seasonal growing conditions. *Mush. Res*., 1 (2): 115-117.

4. Gupta, Y. Vijay, B. and Sohi, H. S. 1989. Spawned casing effect on yield of *Agaricus bisporus. Indian J. Mycol. Pl. Pathol.,* 19 (2): 225-227.

5. Gupta, Y. and Vijay, B. 1990. Post Composting supplementation in *Agaricus bisporus* for yield increases. Paper presented at 15th *Annual conference of Soc. of MPP, Hyderabad,* Jan. 28-30, 1993.

6. Sohi, H.S., Vijay, B. and Gupta,Y. 1988. Studies on thermophilic fungi of compost of *Agaricus bisporus. Indian J. Mycol. Pl. Pathol.,* 18 (1) : 29.

7. Vijay, B. and Gupta, Y. 1992. Studies on fungal competitors of *Agaricus bisporus. Indian Phytopath*., 45 (2): 228-232.

8. Vijay, B. and Gupta, Y. 1992. Studies on manipulation of casing microflora on the yield of *Agaricus bisporus* (Lange.) Sing. *Mushroom Research*, 1 (1) : 61-63.

9. Vijay, B., Gupta, Y. and Upadhyay, R. C. 1988. Effect of casing thickness on yield of *Agaricus bisporus. Indian J. Mycol. Pl. Pathol.,* 18 (2) : 209-210.

10. Vijay, B. and Gupta, Y. 1994. Studies on Post composting supplementation in *Agaricus bisporus* under seasonal growing conditions. *Mush. Res*., 3(1): 49.

KUMAR, SATISH

Exploitation of indigenous microbes, plant products and pesticides for the management of pests and diseases of mushrooms

Satish Kumar obtained his M.Sc (1993) and PhD (Agricultural Entomology) in the year 1996 from Himachal Pradesh Krishi Vishva Vidyalaya, Palampur. He joined Agricultural Research Services of Indian Council of Agricultural Research and was posted at NRCM, Solan in 1996.

Description of research

The main focus of Dr Satish Kumar's research was integrated pests and disease management in mushrooms. He has designed and developed yellow colour light trap for monitoring and management of mushroom flies. The trap is very popular among the mushroom growers all over the mushroom growing states of India. He has reported many new pests associated with mushrooms. Presently his main focus is on estimation of pesticide residues in mushrooms and isolation and use of potential microbes and plant products for the management of pests and diseases. He has screened different strains of button mushroom, oyster mushroom and paddy straw mushroom against sciarid and phorid larvae. He has recorded many new pests of mushrooms and also worked on the role of mushroom flies in the transmission of fungal diseases and competitor moulds of mushrooms. He is the introduced decamethrin for the management of mushroom insect pests. He was member of team that standardized the cultivation technology of specialty mushrooms , management of insect pests and wet bubble disease. He has isolated and tested efficacy of 18 isolates of Bti against sciarid larvae wherein isolate Bti 132 was found to cause 100% mortality of larvae within 24 hours. Molecular characterization of each isolate has also been done. He has worked on the residues of malathion, decamethrin, diflubenzuron, carbendazim and mancozeb.At the same time he has analysed the residue level of carbendazim in mushrooms collected from different sources. He has also worked on the physiology and management of fungal diseases and competitor moulds of mushrooms. He screened of different strains of white button mushroom against wet bubble and determined thermal death points of different mushroom diseases and moulds. He has authoured two

technical bulletins viz., Insect, mites and nematode pests of mushrooms and Diseases and competitor moulds of mushrooms and their management.

Selected Publications

1. Kumar, S, and Sharma, S.R.2002. Persistence of carbendazim in oyster mushroom, *Pleurotus sajor-caju. Indian J. Mush.,* XX (1&2) : 19-20

2. Kumar, S. and Sharma ,S.R. 2002. Persistence of diflubenzuron and carbendazim in white button mushroom, *Agaricus bisporus. Mush. Res.*, 11(1): 15-17

3. Kumar, S., Sharma, S.R., Sharma, V.P. and Gautam, Y. 2004. *Lasioderma serricorne* Fabr.- a new pest of dried mushroom. *Mush. Res.*, 13(1):45

4. Kumar, S. and Sharma, V.P. 2006. Persistence of carbendazim and mancozeb on *A. bisporus. Ann. Plant Protection Science,* 14 (1): 266-267

5. Kumar, S. and Sharma, S.R. 1999. Yellow coloured light trap- a cheap method for management of mushroom flies. *Mush. Res.*, 8(2):57

6. Kumar, S. and Sharma, S.R. 1997. *Achorutes armatus* Nic. –a new pest of button mushroom. *Mush. Res.*, 6: 105-106.

7. Kumar, S. and Sharma, S.R. 1998. New and noteworthy pests and diseases of shiitake, *Lentinula edodes* in India. *Indian J. Mush.*, XVII No. 1 : 52-56

8. Kumar, S. and Sharma, S.R. 1998. Record of new mite fauna associated with mushrooms. *Mush. Res.,* 7(2): 93-98.

9. Kumar, S. and Sharma, S.R. 1998. Transmission of parasitic and competitor moulds of button mushroom through flies. *Mush. Res.*, 7(1) :25-28.

10. Kumar, S. and Sharma, S.R. 1998. *Serretia marcescens* Bizia- a potential biocontrol agent for beetles of oyster mushroom. *Mush. Res.*, 7(1): 49-50.

RAI, R.D.

Post harvest biochemistry and morphogenesis of mushrooms and cultivation of *Ganoderma lucidum*

R.D. Rai obtained his M Sc (Biochemistry) with gold medal from the University of Allahabad and Ph D (Biochemistry) from Central Drug Research Institute (CDRI) Lucknow. He joined the Indian Council of Agricultural Research (ICAR) in the first batch of the Agricultural Research Service (ARS) on 1st September 1976, at the then Central Staff College for Agriculture (now NAARM) at Hyderabad. He was recipient of the National Merit Scholarship During M Sc and CSIR JRF during Ph D. His Ph D thesis was on biochemical studies on amoebic meningo-encephalitis caused by *Acanthamoeba culbertsoni* in albino-mice. After training at Hyderabad, he joined Central Potato Research Institute (CPRI) and was posted at its regional station at Patna from 1976 to 1983. Dr Rai joined the National research Centre for Mushroom Solan in March 1984, where he served ad Senior Scientist till 1998 and then as Principal Scientist (Biochemistry) till July, 2009. he has been transferred to IARI, New Delhi in the Division of Biochemistry. He has served the Centre in many areas of scientific and administrative endeavor. He was founder Chief Editor, *Mushroom Research*—international journal of mushroom research and development from 1991-2004.

Description of Research

Dr RD Rai and his group at NRCM have endeavored to understand the molecular processes underlying the mycelial growth and fruiting of various mushrooms on lingo-cellulosic materials. Mushrooms are great degraders of various biopolymers-lignin, cellulose, hemicellulose, starch protein and nucleic acids, the aspect is very significant not only in production of mushrooms but also in recycling mechanisms in the forest ecosystems. Besides, post harvest physiology, biochemistry and technology are other areas, which his group has been concentrating upon. Morphogenesis in mushrooms is a very interesting area for any biochemist and attracted the attention of his group. He has been the principal investigator of medicinal mushrooms at NRCM Solan.

Fungal degradation of ligno-celluloses by mushrooms: He worked on production of various degradative enzymes produced by the mushrooms, especially by *Pleurotus* species during the growth on lingo-cellulosic agro wastes like cereal straws. *Pleurotus* species were found to produce full battery of enzymes—exocellulases, endocellulases cellobiase, xylanases, ligninases, Mn+ peroxidases and laccases for degradation of all major constituents of the agrowastes, namely cellulose, hemicellulose and lignin. Also that lignin degradation preceded the degradation of cellulose—Lignin degrading enzymes appeared and peaked earlier than cellulases. While lignin degradation dominated during the mycelial colonization, cellulose degradation was predominant during the fruiting of mushrooms. Establishment of mycelium was supported by utilization of easily assimilable soluble substances—sugars, amino acids and phenols. Peak activities of cellulases coincided with peak appearance of mushrooms, specially near the fruiting surface of the substrate block further supporting the role of celluloses during fruiting. Production of these enzymes, as affected by the forms and levels of cellulosic materials and nitrogen supplementation, were also studied. Nitrogen supplementation of the cereal straws greatly stimulated the production of degradative enzymes resulting in greater degradation and better mycelial colonization by the mushroom mycelium. Production of these enzymes by various microbes, beneficial as well antagonist, associated with button and oyster mushrooms, were investigated upon. Special attention was laid upon the thermophilic fungi (*Scytalidium thermophilum*, *Humicola* spp., *Chaetomiun thermophilum*) which play very important role in the degradative processes during the composting for the button mushroom. Most interesting aspect was the shift from degradation of starch and protein in the spawn on wheat grain to the degradation of lignocelluloses during mycelial colonization after the spawning which gives a measure of mushrooms as degraders.

Morphogenesis in mushrooms: Mushroom formation represents an interesting and worth investigating morphogenetic process in multi-cellular eukaryote systems where the mycelium transforms into a fruitbody with distinct structures and function-root, stem, cap with gills, basidiospores etc. Also as to what triggers the fruiting process and regulates periodic appearance(flushes) of mushrooms. A shift from glycolysis to HMP shunt was observed during the fruiting of the button mushroom. Generation of reducing powers in form of NADPH are of paramount importance for synthesis of mannitol—fungal alcohol. Accumulation of which triggers the fruiting. Synthesis of mannitol is accompanied by the degradation of cellulose giving the sugar precursor. Many folds increase in the acitivity of Glucose-6-phosphate dehydogenase were observed in pinheads than in mycelium of the button mushroom corroborating the activation h HMP shunt in the fruiting of the button mushroom but

surprisingly the process does nor seem to hold true in the fruiting of *Pleurotus*: G-6-PDH was almost undetectable in the pinheads. Different mechanisms might be operating in the fruiting of different mushrooms. Changes in the biochemical composition of the button mushroom during the development of pin heads into mature fruitbodis showed that there was conversion of the free amino acids into proteins.

Post harvest biochemistry of Mushrooms: Mushrooms have very short shelf life and post harvest biochemical changes were studied during the storage of button mushroom at the ambient as well as cold storage of mushrooms. There was drastic reduction in the contents of free phenols due to very high activities of polyphenol oxidase during the storage of mushrooms. Activated proteases led to reduction in the protein content resulting into higher levels of free amino acids. Activated ascorbic acid oxidase led to the conversion of ascorbic acid into dehydroascorbic acid in the button mushroom. Nutritional values of various mushrooms with respect to proximate composition were investigated upon. Owing to wide variations in the values reported for the protein and vitamin C content in mushrooms, various methods of quantitation of proteins and vitamin C were deployed to critically assess the contents of two very important nutritional constituents in the mushrooms-either Lowry's method or Nx4.38 factor were found to be the nearest to real values of true protein. Similarly due to very active polyphenol oxidase, 2,6 dichlorophenol- indophenol titrimetry was not suitable for estimation of vitamin C in mushrooms; colorimetry with dinitrophenol was more suitable method giving the real values of vitamin C in the button mushroom.

Medicinal mushrooms: First successful cultivation technology of medicinal mushroom Reishi (*Ganoderma lucidum*) was developed. The technology is at par with the best in the world—fully organic and yield levels above 25%BE. Dehydration and processing technology for ready to use micronized powder and extract were also standardized. *Ganoderma* strains were got characterized by molecular tools (ITS sequencing and RAPD). Productioin of extracellular enzymes by *G. lucidum* as affected by the wheat bran supplementation were also investigated. Isolation procedures for polysachharides, and triterpenes from the fruit bodies of *Ganoderma lucidum* were standardized.

Selected Publications

1. Rai, R D. and Saxena, S. 1987. Effect of storage temperature on vitamin C content of the mushroom (*Agaricus bisporus*). *Curr. Sci.,* 57: 434-435.

2. Rai, R D., Vijay, B. and Saxena, S. 1990. Production of extracellular enzymes by the mesophilic fungi of mushroom compost. *Indian Phytopath.*, 43:542-546.

3. Rai, R D., Saxena, S., Upadhyay, R.C. and Sohi, H.S. 1988. Comparative nutritional value of various *Pleurotus* species grown under identical conditions. *Mushroom Journal for the Tropics*, 8: 93-98.

4. Rai, R.D. and Vijay, B. 1992. Effect of Carbendazim on mycelial growth and extracellular enzymes of *Pleruotus sajor-caju* and *Trichoderma viride*. *Indian Phytopath.*, 45: 207-212.

5. Rai, R.D. and Saxena, S. 1989. Biochemical changes during post-harvest storage of mushroom (*Agaricus bisporus*). *Curr. Sci.,* 58: 508-510.

6. Rai, R.D. and Saxena, S. 1989. Suitability of method of estimation for critical assessment of vitamin C. in mushrooms. *Mushroom J. Tropics*, 9: 43-46.

7. Rai, R.D. and Saxena, S. 1992. Effect of pretreatments on biodegradation of wheat straw by *Pleurotus sajor-caju* (Fr.) Sing. *Mushroom Res.*, 1: 131-133.

8. Rai, R.D. and Verma, S.C. 1990. Ascorbic acid during storage of canned potatoes. *Indian Food Packer,* 44(5): 68-71.

9. Saxena, S. and Rai.R.D. 1988. Storage of button mushrooms (*Agaricus bisporus*) - the effect of temperature, perforation of packs and pretreatment with potassium metabisulphite. *Mushroom J. Tropics,* 8: 15-22.

10. Saxena, S. and Rai, R.D. 1992. Effect of nitrogen on the production of extracellular degradative enzymes by *Pleurotus sajor-caju* on wheat straw. *Mushroom Res.*, 1: 45-48.

SAGAR, M.P.

Integration of extension methods for transfer of mushroom production technology

M.P. Sagar obtained his M.Sc. (Extension Education) in 1991 and Ph. D (Extension Education) in 1996 from Indian Veterinary Research Institute, Izatnagar, Bareilly (UP) for his studies on Impact of Lab to Land/ Operational Research Programmes and Integrated Tribal Development Programme. He joined Agricultural Research Services of ICAR in 1996 as Scientist (Agricultural Extension) at National Research Centre for Mushroom, Solan(HP). He was awarded the Young Scientist Award in Extension Education in 2007. He visited Bangladesh as an expert to train field officers, youths and mushroom growers in mushroom cultivation during the training programme jointly organized for this purpose by Commonwealth Youth Programme Asia Centre, Chandigarh (India) and Min. of Youth & Sport, Dhaka, Bangladesh from 25th to 31st May, 2008 at Youth Centre, Savor, Dhaka. He was transferred to CARI, Izatnagar in June, 2009.

Description of Research

The main focus of Dr. M.P.Sagar's earlier research in the field of mushroom was on impact assessment of training programmes, course content analysis, training needs analysis, knowledge, adoption, constraints analysis, extension teaching methods effectiveness in transfer of mushroom cultivation, documentation of ITKs, verification & refinement of ITKs, integrated farming systems, recycling of spent mushroom substrate. The brief of research conducted by Dr. Sagar is decribed as under.

Integration of Extension Methods for Transfer of Mushroom Production Technology and its Impact on Adoption and Knowledge of Mushroom Cultivation: The study was aimed particularly to ascertain the knowledge gain, adoption and factors responsible for non-adoption of mushroom cultivation technology, transferred to farmers using TOT tools single as well as in combination

and thereby popularization of mushroom cultivation amongst both the selected and neighbouring farmers.

The impact of various methods was assessed in terms of knowledge gain in various areas of mushroom cultivation and adoption amongst farmers. He concluded that the farm visit to mushroom unit supported with printed literature followed by training & demonstration had proved as best combination of TOT tools as it lead to highest knowledge gain about mushroom cultivation

The symbolic adoption was highest amongst radio pathshala listeners followed by farm visit supported with printed literature and training, and farm visit supported with printed literature, training & demonstration. The combinations- training & demonstration, and farm visit & demonstration were also better in mobilizing the farmers for adoption of mushroom cultivation.

Documentation and verification of indigenous technical knowledge about recycling of spent mushroom substrate: In the study of Refinement in Recycling Technologies of Spent Mushrooms Substrate for Soil Amelioration and Bioremediation, documentation and verification of ITKs about recycling of SMS was done by Dr. Sagar. He concluded that SMS of varying ages ranging between 0 to 24 months is being used as organic manure. There were wide variations in the doses of SMS used in cereal and vegetable crops and it ranged between 10 kg to 50 q / bigha, while in case of fruit crops particularly in apple it was 4-6 kg of SMS per plant. Mushroom growers noticed yield enhancement between 5 % to 100% by its incorporation in the various crops without any negative effect. Lower incidence of insects & diseases was reported in majority of the crops.The improvement in soil texture from heavy to light with increase in fertility level and water holding capacity was also one the benefit of use of SMS.

Collection, Documentation and Validation of ITKs about mushroom cultivation: Dr. Sagar has worked on collection, documentation and validation of ITKs about mushroom cultivation. He has collected various ITKs from mushroom growers namely- use of burnt rice husk mixed with FYM, soil and coir pith as casing material, spray of english wine on crop of button mushroom to raise the temperature of mushroom beds during extreme winter, seasonal mushroom growing in mud-house (mud walls & RCC slab), pasteurization of compost without injecting steam, flat floor method of oyster mushroom cultivation, traditional outdoor and indoor methods of paddy straw mushroom cultivation, indigenous under stacking aeration system in the composting yard, indigenous bunker system for compost preparation,

indigenous cooling system of thatched shed/pakka house. He has also verified these ITKs through experiments, experts and scientific literature.

Evaluation of course content of training programmes: In order to make the training programmes suitable to the training needs of learner, usefulness of lectures delivered and practicals conducted during the training programmes must be known. Dr Sagar has evaluated the course contents of entrepreneurs and farmers training programmes with the help of structured questionnaire just after completion of the training programmes. He concluded that majority of the lectures of entrepreneurs training programme (80.8%) and practicals (81.8%) were very useful.

The study conducted to evaluate the course contents of the National Training Course on Mushroom Production Technology for farmers, farm women and unemployed youths revealed that nearly 3/4 of the course contents was perceived as highly useful whereas rest 1/4 course contents was of medium usefulness. Majority of the practicals (67.7%) were highly useful.

Impact assessment of training programmes on mushroom cultivation: This programme has an impact on knowledge and adoption of mushroom cultivation all over the country as the farmers after undergoing one week training programme had registered an increase of 73.6 per cent in mean knowledge score about mushroom cultivation. The trained farmers had taken up mushroom cultivation by an extent of 21 %.

Training programmes on mushroom cultivation for horticulture officers were also evaluated for their impact. Before participation in the training programme, majority of the horticulture officers (60%) were belonging to medium level of knowledge about mushroom cultivation followed by low level (32%) and no knowledge (8%). After participation in the training programme, all the officers belonging to “no & low knowledge level categories” before participation (8 & 32%) shifted into high level knowledge category.

Training needs assessment and their fulfillment: The study on assessment and fulfillment of training needs of the trainees of entrepreneurs training programme reveals that majority of the entrepreneurs (70.5%) perceived all the aspects of mushroom cultivation as “most needed training needs” followed by “needed”(27.8%) and “least needed”(1.7%). The study further reveals that majority of the trainees (55.2%) were satisfied, while only 27.1% were most satisfied followed by least satisfied (14.8%) with their training needs in mushroom cultivation.

Transfer of Technology of mushrooms

Dr. Sagar has been playing leading role in carrying out extension activities such as organizing training programmes, holding mushroom melas & kisan gosthies, mushroom pathshala on AIR and conducting on- farm trials particularly in mushrooms.

- Organisation of mushroom mela at this Centre was initiated and first Mushroom Mela was organized in the year1997 at Solan (H.P.) with the limited participation of farmers and extension workers. Now it has become a regular major extension activity.

- In order to increase interaction with mushroom growers and to provide solution of their problems related to mushroom cultivation, he has initiated to organise on & off-campus kisan gosthies, farmers meetings and field days on general and specific issues of mushroom cultivation.

- He has created a lot of awareness about mushroom cultivation through putting up stall at various international, national, regional and state level exhibitions/ kisan melas, distribution of extension literature and radio talkes. A fifteen episode mushroom pathashala was also organized and broadcasted on AIR, Shimla (H.P.) to create awareness about button and oyster mushrooms.

- Oyster mushroom cultivation technology was popularized among button mushroom growers in Solan district by supplying ready made bags on no profit no loss basis, providing literature and guidance.

- He has played major role in popularization of high temperature tolerant milky mushroom through lecture – cum- demonstrations at various places in North India. As a result, mushroom growers of Haryana, Punjab, Himachal Pradesh and J&K have started growing milky mushroom and are fetching good price.

- He laid out several on-farm trials on cultivation of white button, oyster and milky mushrooms in H.P. and Haryana states to transfer cultivation technology and major research findings.

- He has published extension literature- Krishi Suchana Patra (quarterly publication), leaflets, folders, bulletins and posters on various aspects of mushrooms cultivation to transfer mushroom cultivation technologies through print media to farmers and mushroom growers.

- He has organised 70 off and on-campus training programmes on mushroom cultivation to train farmers, farm women, unemployed youths, mushroom growers and subject matter specialists.

- In order to popularize mushrooms as health food and source of income and employment generation, he has published several popular articles in leading newspapers and magazines.

Selected Publications

1. Ahlawat, O.P., Raj, Dev, Sagar, M.P., Gupta, Pardeep, and Vijay, B. 2007. Effect of recomposted of button mushroom spent substrate on growth, yield and quality of Ginger(*Zingiber officinale*). *Indian Journal of Mushrooms*, 24(1&2):13-18.

2. Ahlawat, O.P., Raj, Dev, Sagar, M.P., Gupta, Pardeep and Vijay, B. 2006. Effect of recomposted button mushroom spent substrate on yield, quality and disease-pest managemennt of cauliflower. *Mushroom Research*, 15(2): 149-152.

3. Ahlawat, O.P., Sagar, M.P., Raj, Dev, Indurani, C, Gupta, Pardeep, and Vijay, B. 2007. Effect of spent substrate on yield and quality of capsicum. *Indian Journal of Horticulture,* 64(4):430-434.

4. Sagar, M. P. 2002. Evaluation of course contents of training on mushroom production technology for entrepreneurs. *Maharashtra Jour. of Extension Education,* 21(1): 41-44.

5. Sagar, M. P. 2002. Impact of training programme on knowledge and adoption of mushroom cultivation. *Mushroom Research*, 11(1) :pp 39-42.

6. Sagar, M. P. and Vijay, B. 2005. Impact of integration of extension methods on adoption of mushroom cultivation. *Indian Res. Jour. of Extn Edn.*, 5(2&3): 64-66.

7. Sagar, M. P. and Vijay, B. 2006. Impact of mushroom cultivation training on horticulture officers. *Indian Res. Jour. of Extn. Edn.*, 6(1&2) : 45-47

8. Sagar, M. P. 2005. Impact of integration of extension methods on farmers knowledge level about mushroom cultivation. *Indian Res. Jour. of Extension Education*, 5(1) : 56-58.

9. Sagar, M. P.and Vijay, B. 2004. Role of Radio in Transfer of Mushroom Cultivation Technology. *Indian Jour. of Extension Education,* 40(1&2): 43-45.

10. Sagar, M.P., Ahlawat, O.P., Raj, Dev, Vijay, B. and Indurani,C.2009. Indigenous technical knowledge about use of spent mushroom substrate. *Indian Journal of Traditional Knowledge,* 8(2): 242-248.

SAXENA, SANJEEV

Fungal degradation of ligno-celluloses by mushrooms

Sanjeev Saxena obtained his M.Sc. and Ph.D. degrees in Plant Physiology from Indian Agricultural Research Institute in 1979 and 1987, respectively. He joined NRCM, then NCMRT as Scientist, Plant Physiology on 23 January 1985 and became Scientist Senior Scale in 1990. He was transferred to National Bureau of Plant Genetic Resources, New Delhi in July 1992. Presently he is Principal Scientist in IPR and Policy Section at Indian Council of Agricultural Research Headquarters, New Delhi.

Description of Research

Dr. Saxena was associated with the research on biochemical changes occurring during postharvest storage of different mushrooms. Protein content decreased with increasing storage durations and there is also decrease in total sugars during storage. He studied the effect of storage temperature on vitamin C content of mushrooms. He reported that four days storage of the mushrooms resulted in 12-25% loss of vitamin C. Major changes were noticed in the proportion of reduced: oxidized form of vitamin C. Dr. Saxena also worked extensively on the production of extracellular degradative enzymes by *Pleurotus sajor-caju* and established that the fungus produced significant activities of extracellular endoglucanase (EG), β-glucosidase, xylanase, laminarinase, laccase and polyphenol oxidase (PPO) on unsupplemented wheat straw. Supplementation of the medium with ammonium sulphate decreased the production of all the enzymes in general and EG in particular (almost undetectable activity). While studying the effect of pretreatments of wheat straw on biodegradation by *P.sajor-caju* he established that significant degradation of all the constituents started only after 8 days of incubation. Lignin and cellulose were degraded at a faster rate than hemicellulose. Cellulose degradation was higher in hot water treated wheat straw than that in chemically treated or autoclaved. A short term storage of white button mushroom in the non-perforated and perforated bags and revealed that perforation (0.5%) of packets significantly increased veil opening, weight loss and browning, the effect was more pronounced at higher temperatures. His studies

on comparative nutritional value of various *Pleurotus* spp. grown under identical conditions revealed that these species contain on fresh weight basis, dry matter 6-10.4, protein 1.6-2.5, soluble protein 0.42-0.89, free amino acids 0.23-0.50, carbohydrated 2.98-5.68 fat 0.09-0.18, ash 0.52-0.83, crude fibre 0.7-1.3, soluble sugars 0.32-0.49, reducing sugars 0.028-0.041 and non-reducing sugars 0.28-0.46.

Selected Publications

1. Rai, R.D. and Saxena, S. 1987. Effect of storage temperature on vitamin C content of the mushroom (*Agaricus bisporus*). Curr. Sci., 57: 434-435.

2. Rai, R.D., Saxena, S., Upadhyay, R.C. and Sohi, H.S. 1988. Comparative nutritional value of various *Pleurotus* species grown under identical conditions. *Mushroom J. Tropics,* 8: 93-98.

3. Saxena, S. and Rai, R.D. 1988. Storage of button mushrooms (*Agaricus bisporus*) - the effect of temperature, perforation of packs and pretreatment with potassium metabisulphite. *Mushroom J. Tropics,* 8: 15-22.

4. Rai, R.D. and Saxena, S. 1989. Suitability of method of estimation for critical assessment of vitamin C. in mushrooms. *Mushroom J. Tropics*, 9: 43-46.

5. Rai, R.D. and Saxena, S. 1989. Biochemical changes during post-harvest storage of mushroom (*Agaricus bisporus*). *Curr. Sci.*, 58: 508-510.

6. Rai, R.D., Vijay, B. and Saxena, S. 1990. Production of extracellular enzymes by the mesophilic fungi of mushroom compost. *Indian Phytopath.*, 43:542-546.

7. Saxena, S. 1990. Casing quality and the process of casing for Agaricus. Summer Institute Recent Dev. Cult. Technol. Edible Mushrooms, NCMRT, Solan, 21 May- 9 June, 1990. pp109-111.

8. Saxena, S. 1990. Mushrooms: Nature's biodegraders are also a nutritious food for man. *Eco-Dimensions,* **1:** 7-9.

9. Saxena, S. and Rai, R.D. 1992. Effect of nitrogen on the production of extracellular degradative enzymes by *Pleurotus sajor-caju* on wheat straw. *Mushroom Res.*, 1: 45-48.

10. Rai, R.D. and Saxena, S. 1992. Effect of pretreatments on biodegradation of wheat straw by *Pleurotus sajor-caju* (Fr.) Sing. *Mushroom Res.*, 1: 131-133.

SHARMA, S.R.

Disease management and production of edible mushrooms

S.R. Sharma obtained his M.Sc. (Plant Pathology) in 1970 and Ph.D. (Plant Pathology) in 1975 from Indian Agricultural Research Institute, New Delhi. He worked as Pool Officer at CPRI, Shimla from December, 1975 to March, 1976 and joined IIHR, Bangalore as Junior Plant Pathologist in March, 1976. He was promoted to Sr. Scientist (Plant Pathology) in July, 1982 and was transferred to NRCM, Solan in July, 1989. He was selected as Principal Scientist in December, 1997. He served as acting Director of NRCM, Solan and Project Coordinator of AICMIP from March, 1990 to October, 1994 and April, 2002 to July, 2002. He was also the Course Director of the two Summer Schools on Mushroom Production Technology held at NRCM, Solan in 1990 and 2003. He has been actively involved in various Extension activities and has organized dozens of training programmes for farmers, entrepreneurs and Subject Matter Specialists. He also visited Sri Lanka from October, 2003 to December, 2003 as Consultant under IFAD and successfully grew button mushroom in Sri Lanka. Dr. Sharma retired as Principal Scientist on 30 June, 2009 and has joined the Directorate as Emeritus Scientist on 1st July, 2009.

Dr. Sharma has conducted research on viral, mycoplasmal and fungal diseases of horticultural crops namely, cowpea, French bean, cluster bean, winged bean, peas, mung bean, onion, raddish, tomato, chillies, citrus, banana and mushrooms. He has also worked on the cultivation of specialty mushrooms and perfected the production technology of shiitake, black ear and milky mushroom. In addition, he has also been actively associated with the insect-pests and nematode problems in mushroom and has extended adivory services to the farmers of Himachal Pradesh, Haryana, Punjab, Uttaranchal and Uttar Pradesh. His contributions on cross protection in citrus, bunchy top of banana and integrated pests and disease management in mushrooms are noteworthy. His contribution towards mushroom research are described here.

Description of Research

Production technology of shiitake (*Lentinula edodes*) has been standardized on saw dust of broad leaved trees with the BE of 60%. Among different methods of substrate preparation pasteurization of wheat straw substrate has resulted in maximum yield of *Calocybe indica*. Pasteurization or hot water treatment of wheat straw supplemented with 5% wheat bran or rice bran has resulted in 140% BE of black ear mushroom.

Surveys of different mushroom growing units in Punjab, Haryana, Himachal, Uttarakhand and Uttar Pradesh have revealed the wide spread incidence of wet bubble, green mould, brown plaster mould and a large number of abiotic disorders. Loss estimation with respect to wet bubble, dry bubble, brown plaster mould, green mould and yellow mould have been carried out in button mushroom and package of practices for the effective management of major diseases or button and oyster mushroom have been recommended and are being adopted by the seasonal mushroom grower. For the management of insect pests yellow light sticky trap has been devised and is being used by the farmers.

Selected Publications

1. Sharma, S. R. 1991. Mycoflora of casing soil. *Indian Mushrooms*, 56-58.

2. Sharma, S. R. 1992. Compost and casing mycoflora from mushroom farms in northern India *Mush. Res.,* 1: 119-121.

3. Sharma, S. R. and Vijay. B. 1995. Assessment of yield loss in *Agaricus bisporus* caused by *Coprinus fimetarius*. *Mush. Res.,* 4: 85-86.

4. Sharma, S. R. and Vijay. B.1996. Yield loss in *Pleurotus* spp. induced by *Trichoderma viride*. *Mush. Res.,* 5: 19-22.

5. Sharma, S. R. and Vijay. B. 1996. Prevalence and interaction of competitor and parasitic moulds in *Agaricus bisporus. Mush. Res.,* 5: 13-18.

6. Kumar, S. and Sharma, S.R. 1998. Transmission of parasitic and competitor moulds of button mushroom through flies. *Mush. Res.,* 7: 25-27.

7. Vijay, B. Sharma, S.R. and Lakhanpal, T.N. 2000. *In vivo* interaction studies on mesophilic fungi isolated during *Agaricus bisporus* composting. *In* : *Science and Cultivation of Edible Fungi.* (L. J. L. D. Van Grievisven, ed.) Netherlands, pp. 409-415.

8. Sharma, S. R. and Kumar, S. 2000. Studies on wet bubble disease of white button mushroom (*Agaricus bisporus*) caused by *Mycogone perniciosa* In: *Science and Cultivation of Edible Fungi.* (L.J.L.D. VanGrievisven,ed.) pp. 569 -575.

9. Kumar, S. and Sharma, S.R. 1999. Yellow coloured light trap – a cheap method for management of mushroom flies. *Mush. Res.*, 8: 57.

10. Sharma, S.R., Kumar, S. and Sharma, V.P. 2006. Physiological requirements and cultivation of Malaysian strain of shiitake, *Lentinula edodes* (Berk) Sing. *J. Myco. Plant Path.*, 36: 149-152.

SHARMA,VED PARKASH

Disease management, molecular characterization of mycoparasites and production of edible mushrooms

V.P. Sharma obtained his B.Sc (Agri) degree from Himachal Pradesh Krishi Visva Vidyalaya, Palampur, in 1984 and M.Sc (Plant Path.) from Dr Y.S. Parmar University of Horticulture and Forestry, Solan, in 1986. He did his Ph.D. (Plant Pathology) in 1989 from Dr Y.S Parmar University of Horticulture and Forestry. He started his carrier as Asstt. Mycologist in the Deptt. of Mycology and Plant Pathology, UHF, Solan in May, 1990. From 1999 May to Feb, 2004 he served the university as Mycologist and in Feb, 2004 joined National Research Center for Mushroom Chambaghat, as senior scientist. From May, 2007 he is serving NRCM as a Principal scientist (Plant Pathology). In the university he worked on various aspects of diseases competitors and pests associated with mushrooms, breeding of white button and strain evaluation and cultivation of oyster and other mushrooms. He was also engaged in teaching UG and PG courses and guiding PG students in the Department of Mycology and Plant pathology, UHF, Solan. Dr. Sharma was also Course Director of a summer school held at the Directorate in 2009. At NRCM he is working on molecular and physiological characterization of the moulds and bacterial pathogens associated with mushrooms, Integrated disease and pests management and cultivation of specialty mushrooms. Dr Sharma has been awarded Yadvindra Young Scientist Award twice (1994 and 1997) by Mushroom Society of India.

Description of Research

Management of diseases: The main focus of Dr VP Sharma's research was to manage diseases, competitors and pests associated with mushrooms. He conducted physiological, biological and management studies on the three most important diseases viz., wet bubble, yellow mould and false truffle of mushrooms. He observed that contaminated casing soil is the main source of infection of wet bubble disease and spraying the crop with sporgon or bavistin is most successful in managing the disease. Package of practices for the management of yellow mould

(*Sepedonium* spp) was evolved after evaluating various plant products and chemicals. Chicken manure and compost are the main sources of primary infection.

Management of nematodes: Out of the eight *Pleurotus* species four (*P. ostreatus, P. citrinopileatus, P. cornucopiae*, and *P. sajor-caju*) showed nematophagus activity against the two (*Aphelenchoides composticola* and *Ditylenchus myceliophagus*) most important nematodes of button mushroom. Nematicidal principle from *Pleurotus sajor-caju* was identified as muscarine.

Package of practices for the management of wet bubble (*Mycogone perniciosa*) disease was also evolved. Chlamydospores through casing are the main source of primary infection. Hygiene is of paramount importance in successful management of the disease.

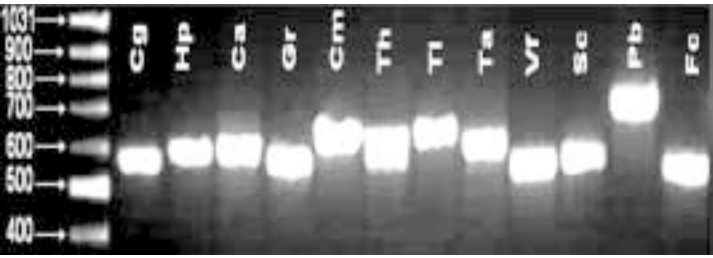
Studies on formalin: Formalin encourages green mould fungi so its use must be discouraged where green mould is a problem during mushroom cultivation. Chemical sterilization for the cultivation of *Calocybe indica* and other specialty mushroom is risky.

Cultivation of speciality mushrooms: Dr Sharma is also exploring the cultivation technologies of least exploited mushrooms. He has contributed significantly in

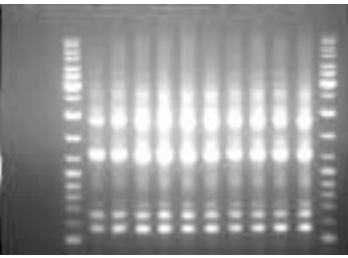
Agrocybe aegerita ***Flammulina velutipes*** ***Lentinula edodes***

diversification by standardizing the cultivation technology of mushroom species namely, *Flammulina velutipes, Agrocybe aegerita, Lentinula edodes* and *Macrolepoita procera*.

Molecular characterization of mycoparasites: Dr Sharma is also working on morphological and molecular characterization of different mycoparasites and moulds associated with mushrooms.



ITS profile of mycoparasites



RAPD profiles of *Hypomyces perniciosus* isolate

Nucleotide sequence comparisons of 30 *Trichoderma* isolates catalogued them into four taxa namely, *T. harzianum, T. asperellum, T. longibrachiatum* and *T. virens.* Based on physiological, biochemical and molecular studies these isolates have been grouped into virulent and non virulent isolates for a particular mushroom. Molecular characterization of various isolates of *Hypomyces perniciosus* causing wet bubble, revealed no genetic variability among 10 isolates and suggested that this strain is widely distributed across different geographical locations of India.

The nucleotide sequence comparisons of 15 *Cladobotryum* isolates revealed the presence of four taxa namely, *C. dendroides, C. mycophilum, Hypomyces aurantius* and *C. asterophorum*. In the light of molecular identification the cultures of *C. dendroides* were redesignated as *C. mycophilum* and *C. asterophorum.* The studies indicated that at least four species are associated with cobweb disease of different cultivated mushrooms in India and *C. mycophilum* is potential cause of cobweb disease in *Agaricus bisporus* and not *C. dendroides* as described earlier. *C. mycophilum* has wide host range and it can also infect milky mushroom. *C. asterophorum* was found associated with different species of oyster mushrooms and suggests wide geographical distribution and is a potential threat to the *Pleurotus* cultivation.

He has published more than 80 research papers in various national and international journals and has written four books on mushrooms, two technical bulletins and published 8 folders.

Selected Publications

1. Sharma, V.P. and Sharma, S.R. 2009. Molecular identification and cultivation of the black poplar culinary medicinal mushroom *Agrocybe aegerita* (V.Brig.) Singer (Agaricomycetideae). *International Journal of Medicinal Mushrooms*, 11(1): 87-91.

2. Sharma, V.P., Sharma, S.R. and Kumar, S. 2008. Effect of various supplements on lignocellulolytic enzyme production and yield of culinary- medicinal mushroom *Flammulina velutipes* (w. Curt.: Fr.) Singer (agaricomycetidae). *International Journal of Medicinal Mushrooms*,10: 87-92.

3. Sharma, V.P., Sharma, S.R. and Kumar, S. 2006. Effect of supplementation and cultivation containers on the productivity of *Flammulina velutipes*. *Mush. Res.,* 15: 129-134

4. Sharma, V.P., Sharma, S.R. and Kumar, S. 2006. Comparative studies on substrate treatment methods for cultivation of *Calocybe indica. J. Mycol. Pl. Path.*,36:145-148.

5. Sharma, V.P., Kumar, S. and Kumari, Ranjna. 2006. Symptomatology and management of cobweb disease of oyster mushroom. *Mush. Res.*,15: 55-58.

6. Singh, S.K., Sharma, V.P., Sharma, S.R. and Kumar, S. 2005. Molecular characterization of *Trichoderma* taxa causing green mould disease in edible mushrooms. *Current Sci.,*90: 427-431.

7. Sharma, V.P., Sharma, S.R. and Kumar, S. 2005. Nutritional requirements for mycelial growth and cultivation of *Flammulina velutipes*. *Mush. Res.*,14 : 13-18.

8. Sharma, V.P., Kumar,S. Sharma, S.R. and Singh, S.K. 2005. Extracellular enzyme profile of *Trichoderma* species associated with green moulds of various mushrooms. *Mush. Res.,*14: 68-71.

9. Sharma, V.P., Kumar, S. and Sharma, S.R. 2005. Studies on chemical sterilization of substrate for the cultivation of some specialty mushrooms. *Mush. Res.*, 14: 41-45.

10. Sharma, V.P., Kumar, S. and Singh, S.K. 2006. *Trichoderma* causing green mould in mushrooms and its management - A review. *Mush. Res.,* 15:93-102.

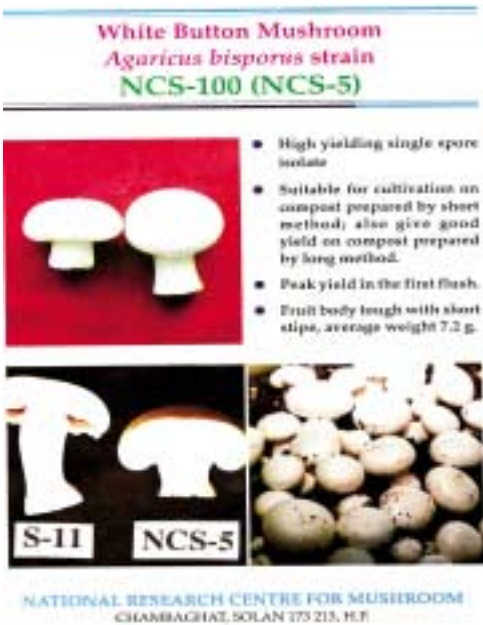
SINGH, MANJIT

Genetic improvement of mushroom: hybridization in *Agaricus bisporus* using non-fertile single spore isolates

Manjit Singh obtained his M.Sc degree in 1974 and Ph.D in 1979 from Punjab Agricultural University Ludhiana. In 1976 he started his scientific career as Scientist in Agricultural Research Service of ICAR. After serving Central Potato Research Institute from 1976 to 1984, he joined NCMRT (now DMR), Solan on 6th March, 1984 and worked at the Centre till 6th Jan, 1988. Thereafter he joined Central Arid Zone Research Institute, Jodhpur where he served as Head, Division of Plant Sciences and Biotechnology till Dec. 2008. He received M.S. Randhawa Medal from PAU, Ludhiana in 1975 and ICAR Team Award in 1993. Presently he is serving as Director of DMR, Solan.

Description of Research

During his stay at the Centre his main area of research was genetic improvement of mushrooms. Work on hybridization of white button mushroom was initiated in mid 80's soon after the establishment of the Centre. Prior to this, the work in this area was scanty as the mycologists were busy understanding the exact life cycle and mating system of this mushroom. Dr Manjit and co-workers started work on mushroom improvement by collecting germplasm available in the country and its evaluation on compost prepared by both long and short method. To begin with, various simple approaches like multi-spore culture, mixing of strains,



etc were attempted, but without any success. Based on the evaluations, parents with contrasting traits viz., ones with higher yield and the others with better quality and morphological characteristics of the button were selected. This was followed by the time consuming tedious patient work of developing single spore isolates from the spore prints of each of the selected strain, preparation of spawn of each isolate, their evaluation for ability to produce fruit bodies and to classify the isolates into fertile and non-fertile isolates. Few shortcuts were attempted that included cultivation of mushroom in petri-plates under controlled conditions, recording the characteristics of mycelia, etc, but the authentic way to establish non-fertile nature of an isolate was through field evaluation. The only compromise to accommodate more isolates was to use small bags each having 2-3 kg compost. Intermating of non-fertile isolates from different strains followed this. Only few of the inter-matings resulted in formation of hybrids as judged by evaluation of each of the culture made using mycelia from inter-mating zone. During the process of this work promisng fertile single spore isolates were also selected and evaluated. The selected isolates and hybrids were evaluated under AICMIP for many years at different locations and based on the results three strains NCS 100, NCS 101 and NCH 102 were released. The first two were fertile isolates where as the third one was the hybrid. This was the first successful attempt on production of hybrid in buttom mushroom in the country.

The exercise of development of single spore isolates and their inter-mating was also undertaken in oyster mushroom. The isolation was much easier as there was no need for evaluation of fertility. Similarly the hybridization was also simpler due to distinct characteristics in the case of successful hybridization and exchange of nuclei in the inter-mating zone. However, the germplasm available was very limited and none of the hybrids produced could outyield the parents. One of the prime inference from the hybridization programme in mushrooms was that there is urgent need to collect and conserve germplasm of important edible species. A major step in this direction has been taken by the Centre by developing facilities and techniques for conservation of culture collections.

Wood ear mushroom on wheat straw

Naturally occurring edible mushroom in desert – *Phellorina* and *Podaxis*

Another interesting work initiated in mid 80's by Dr Manjit Singh and his team members was in the area of exploitation of other edible fungi. The word 'other' implied mushrooms other than button, oyster and paddy straw mushroom. Success was obtained in cultivation of *Auricularia polytricha* (wood ear mushroom) on wheat straw and it was the first report of its cultivation in the country.

He continued work in mushroom biology at CAZRI Jodhpur where the focus was on evaluation of different species of oyster mushroom on different substrates and studies on native mushrooms of the desert like *Phellorina* and *Podaxis.*

Selected Publications

1. Bhandal, M.S. and Mehta, K.B. 1987. Evaluation and improvement of strains of *Agaricus bisporus*. *Mushroom Science,* 12(1): 25-35.

2. Bhandal, M.S. and Mehta, K.B. 1987. Cultivation of *Auricularia polytricha* (Mont.) Sacc (Jew's Ear Mushroom) on wheat straw. *Mushroom Science,* 12(2): 387-393.

3. Bhandal, M.S. and Mehta, K.B. 1987. Extra mushroom flush after cropping by reversing and recasing compost bags. *Indian J. Mycol. and Pl. Pathol.,* 17(3): 295-297.

4. Bhandal, M.S. and Mehta, K.B. 1988. Some thoughts from India on carbon dioxide and the cultivation of white button mushroom. *The Mushroom J.,* 185: 569-570.

5. Bhandal, M.S. and Mehta, K.B. 1994. Genetic Improvement of *Pleurotus* species. In *Advances in Mushroom Biotechnology* (Eds. M.C. Nair, C. Gokulapalan and Lulu Das), Scientific Publishers, Jodhpur, pp. 127-133.

6. Mehta, K.B and Bhandal, M.S. 1994. Genetic improvement of white button mushroom – *Agaricus bisporus.* In *Advances in Mushroom Biotechnology* (Eds. M.C. Nair, C. Gokulapalan and Lulu Das), Scientific Publishers, Jodhpur, pp. 70-76.

7. Mehta, K.B. and Bhandal, M.S. 1988. Mycelial growth variation of six *Pleurotus* species at different temperature. *Indian J. Mush.*, 14: 64-65.

8. Mehta, K.B., Kumar, S. and Bhandal, M.S. 1988. Validity of mycelial growth as selection criterion for yield in *Agaricus bisporus*. *Indian J. Mush.*, 14: 16-19.

9. Thakur, K.B. and Bhandal, M.S. 1992. Hybridisation in *Agaricus bisporus* using non-fertile isolates. *Mushroom Research,* 1: 79-81.

10. Thakur, K.B. and Bhandal, M.S. 1993. Monosporus isolates and their intermating in *Pleurotus sapidus* and *P. sajor-caju*. *Mushroom Research,* 2: 41-44.

SINGH, SUNIL KUMAR

Molecular characterization, cryopreservation and production of edible mushrooms

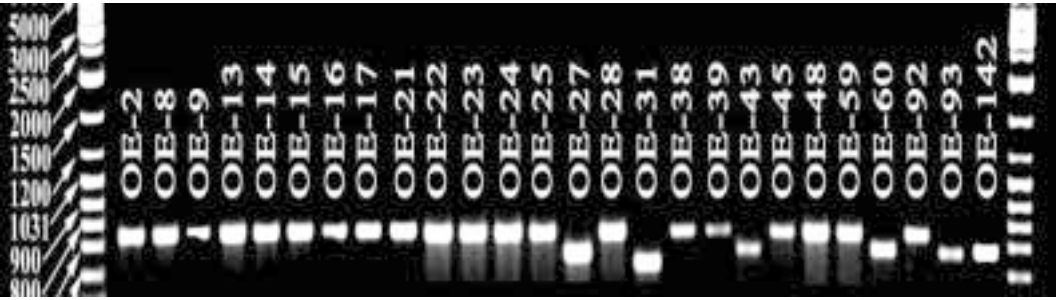
Sunil Kumar Singh obtained his M.Sc. and Ph.D. degrees in Botany with specialization in Advanced Plant Pathology from Jai Narain Vyas University, Jodhpur in 1982 and 1986, respectively. He obtained his Post Doctorate from International Crops Research Institute for the Semi Arid Tropics (ICRISAT), Patancheru, Andra Pradesh in 1989. He served SKUAST (J&K) as Assistant Professor from 1989-1998. He joined NRCM as Senior Scientist, Plant Pathology in March 1998 and became Principal Scientist in March, 2006. He was transferred to Central Arid Zone Research Institute, Jodhpur, Rajasthan in June, 2008. In his early career he won Young Scientist Award instituted by Department of Science and Technology in 1994 in Agricultural Sciences.

Description of Research

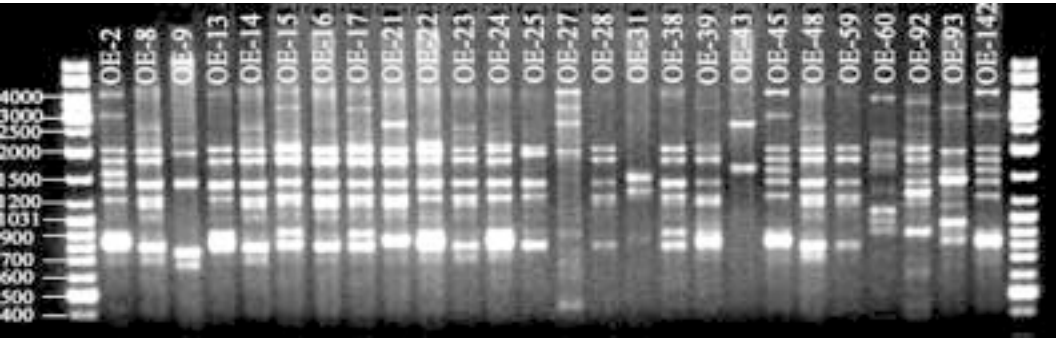
His earlier contributions as Plant Pathologist were research on integrated pest management of legumes and oilseed, Post Graduate teaching and guiding students. He served Mushroom Society of India as Editor-in-Chief of Mushroom Research- from 2004-2008. He was trained at Friedrich Sheller University, Jena, Germany for 3 months in DNA fingerprinting of mushrooms.

Molecular characterization of National Mushroom Repository NRCM, Solan using sequencing of 5.8S rRNA gene: 15 wrongly identified taxa were re-designated and placed in proper genera. Gen accession numbers were assigned to more than 50 new gene sequences by NCBI, USA and are now available in public domain worldwide.

Genetically distinguished eight species of family Morchellaceae by identifying decamer primers and diagnostics using RFLP of ITS region of 5.8S ribosomal RNA gene: Molecular markers for species identification were developed with a view to improve morel phylogeny and reduce the need and expenses for DNA sequencing. of wild germplasm.



Internal Transcribed Spacer PCR amplified product of 5.8S rRNA gene of different NRCM *Lentinula* accessions



RAPD profiles of *Lentinula* accessions

Strain genotyping of thermotolerant fungi: *Scytalidium thermophilum*, *Humicola insolens* and *Humicola grisea*, the pre-dominant thermophilic fungi from *Agaricus bisporus* mushroom compost, were identified in genetically distinct groups by strain genotyping. These genetically different strains have now been exploited for reducing the composting duration for *Agaricus bisporus* at National Research Centre for Mushroom, Solan.

Cryopreservation of mushroom cultures: The liquid nitrogen protocols for mycelial culture preservation of mushrooms were developed, modified and tested for five years. The modified protocols with experimental demonstration of viability and genetic stability of mushroom stock cultures validate the use of mushroom cryopreservation techniques and support studies on genetic stability of preserved biological materials.

Mushroom germplasm in Liquid nitrogen

Lyophilization: A novel lyophilization protocol was developed by culturing mycelial stock cultures of edible mushrooms on pearl millet grains, subjected to lyophilization under vacuum in glass ampoules at -60°C, and sealed.

The novel lyophilization protocol resulted in 100% survival of eleven commercial mushroom strains including temperature sensitive strains of *Volvariella* and *Morchella* mushrooms. This technique demonstrated the highest survival of filamentous fungi as compared to world renound culture repositories like IMI, England and ATCC, USA.

Advanced cytology: An epifluorescent microscopy technique has been developed using combination of DAPI (4,6-diamidino-2-phenylindole) and Calcoflour (Fluorescent Brightner-28) for differential staining of nuclei and septa of mushroom mycelium. This is first report of advanced cytological technique in the field of mushroom.

Cultivation Technology of Shiitake mushroom: An improved technology for production of Shiitake (*Lentinula edodes*) mushroom, was developed using superior strains and sawdust which gave consistently higher yields (65-76%). The technology based on sawdust spawn and substrate proved advantageous in reducing spawn run period from 4-5 months to 3 months and brought down the cost of cultivation.The improved management of physical growth parameters namely, RH, CO_2 concentration, fresh air exchange and exposure to white light eliminated the need of repeated chilling treatment.

Selected Publications

1. Singh, S.K., Upadhyay R.C., Kamal, S. and Tiwari, M. 2004. Mushroom cryopreservation and its effect on survival, Yield and genetic stability. *Cryoletters,* (London) 25: 23-32.

2. Singh, S.K., Upadhyay, R.C., Yadav, M.C. and Tiwari, M. 2004. Development of a novel lyophilization protocol for preservation of mushroom mycelial cultures. *Current Science*, 87(5): 568-570.

3. Singh, S. K., Vijay, B. Mediratta,V., Ahlawat, O.P. and Kamal, S. 2005. Molecular characterization of *Humicola grisea* isolates associated with *Agaricus bisporus* compost. *Current Science,* 89 (10): 1745-1749

4. Singh, S. K., Sharma,V.P., Sharma,S.R. Kumar, S. and Tiwari, M. 2005. Molecular characterization of *Trichoderma* taxa causing green mould disease in edible mushrooms. *Current Science,* 90 (3): 427-431.

5. Singh, S. K., Doshi, A., Yadav, M.C. and Kamal, S. 2006. Molecular characterization of specialty mushrooms of Rajasthan, India. *Current Science,* 91(9): 1225-1230.

6. Singh, S. K., Kamal, S., Tiwari, M., Yadav, M.C. and. Upadhyay, R.C. 2004. Arbitrary primer based RAPD- A useful genetic marker for species identification in morels. *Journal of Plant Biochemistry and Biotechnology,* 13(2): 7-12.

7. Singh, S. K., Tiwari, M., Kamal, S., and Yadav, M.C. 2005. Morel Phylogeny and diagnostics based on restriction fragment length polymorphism analysis of ITS region of 5.8S ribosomal DNA. *Journal of Plant Biochemistry and Biotechnology,* 14: 179-183.

8. Singh, S. K., Rai, R.D. and Kamal., S. 2005. Molecular Identification of Some Medicinally Important Aphyllophorales by Direct Sequencing of 5.8S rRNA Gene. *International Journal of Medicinal Mushroom*, Israel 7(4): 587-594.

9. Singh, S.K., Yadav, M.C., Upadhyay, R.C., Kamal, S., Rai, R.D. and Tewari, R.P. 2003. Molecular characterization of specialty mushroom germplasm of the National Mushroom Repository. *Mushroom Research*, 12(2): 67-78.

10. Singh, S.K., Yadav., M.C., R.C. Upadhyay, Shwet Kamal, R.D.Rai, R.P.Tewari. 2004. Molecular characterization of the specialty mushroom germplasm of the National Mushroom Repository. *Mushroom Research,* 12 (2): 79-86.

SOHI, H.S.

Taxonomy and cultivation of different mushroom species

Harnek Singh Sohi was born on Februry 25, 1930 in Ropar Punjab. He obtained his Ph.D. from IARI, New-Delhi in 1966 and served in Plant Pathology Division, IARI New – Delhi from 1954-62, and in Himachal Pradesh as state Plant Pathologist and Deputy Director (Crop Research) from 1962-1969. Dr. Sohi served as Head, Division of Plant Pathology IIHR Bangalore (1972-79) and Chairman, Botany Dept. Panjab University, Chandigarh (1979-83). Dr. Sohi was the 1st regular Director of the NRCM, Solan and Project Coordinator AICRP on Mushroom from 1984-1990. Dr. Sohi worked on fungal diseases of fruits, vegetables and several ornamental crops. He identified several new taxa of fungal pathogens and mushrooms. Dr. Sohi guided several M.Sc. and Ph.D. students and published one book and around 300 research papers in national and international Journals. Dr. Sohi served several scientific societies and occupied key position as President, Indian Phytopathological Society (1992), Indian Society of Mycology, Madras (1994) and Indian Mushroom growers Association (1999-2007). Dr. Sohi was awarded Fellow of Indian National Science Academy (FNA), Indian Academy of Horticulture, Society of Plant Pathologist and National Academy of Agricultural Sciences. Dr. Sohi after Joining at NRCM, Solan in 1984 brought out 1st bulletins on cultivation of mushrooms and diseases of mushrooms.

Description of Research

Dr. Sohi was instrumental in initiating work on mushroom taxonomy and described 7 spp. of *Auricularia, Strobilurus stephanocystis, Stropharia rugoso annulata,* etc. He was member to the team that gave chemical sterilization technique of substrate treatment for growing *Pleurotus* spp. Various *Pleurotus* spp. were screened for their temperature requirement and yield evaluation. Apple pomace, an industrial waste, was successfully used for growing oyster mushroom. He took extensive visits to mushroom farmers in Badhana District Sonepat, Haryana and gave technical advice for growing button mushroom and control of various diseases and moulds. His initial hard work paved the way for the present day large scale

seasonal cultivation of mushrooms in Haryana. Several botanicals were screened for the control of saprophytic and pathogenic mushroom nematodes. We lost this great scientist on 11 February, 2007.

Selected Publications

1. Sohi, H.S. and Upadhyay, R.C. 1986. Occurrence of *Cladobotryum variospermum* (Link) Hughes on polyporous fungi under natural conditions. *Current Science*, 55: 1037-1038.

2. Sohi, H.S. and Upadhyay, R.C. 1989. Effect of temperature on mycelial growth of *Pleurotus* species and their yield performance on selected substrates. *Mushroom Science*, XII (Part2): 49-56.

3. Sohi, H.S. and Upadhyay, R.C. 1989. New and noteworthy disease problems of edible mushrooms in India. *Mushroom Science*, XII (Part2): 611-614.

4. Sohi, H.S. and Upadhyay, R.C. 1990. Natural occurrence of different species of *Auricularia* in Himachal Pradesh. *Mushroom Journal for the Tropics*, 10: 47-51.

5. Sohi, H.S., Mehta, K.B., Gupta, Y. Upadhyay, R.C. and Bhandal, M.S. 1989. Abnormalities and indicator moulds in white button mushroom: how and when they appear during cultivation. *Indian Hort.*, 36: 23-26.

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TEWARI, R.P.

Cultivation of different mushrooms

R.P. Tewari did his M.Sc. (1968) and Ph.D. (1974) in Botany from the University of Gorakhpur. He joined the Central Potato Research Institute, Shimla for a brief period in 1971 before he was selected in the Indian Institute of Horticultural Research, Bangalore and remained there till 2002. He headed the Division of Plant Pathology, IIHR, Bangalore for a period of six years. Dr. Tewari established a full-fledged mushroom laboratory in the IIHR and significantly contributed to mushroom research and development in South India. Besides conducting research on varied aspects of different mushrooms, he specially excelled in the transfer of technology of mushroom production. He received advanced training in the field of mushroom production technology from INRA, France and was Coordinator of Indo-Dutch Project in India. He served as International Consultant to FAO under Integrated Horticulture and Nutrition Development Project in Bangladesh during 2001-2006 where he developed Spawn Laboratory and training facilities in 15 Centres including Chitgaon Hill Tracks. He joined National Research Centre for Mushroom as Director in July, 2002. During his tenure he modernized the Centre by improving infrastructure and introducing Hitech equipments for advance research in the field of mushroom and has given priority for diversification in mushroom production so that country may produce mushrooms in all seasons and regions and introduced commercial production of milky mushroom in India.

Description of Research

During his association with mushrooms for more than 35 years, Dr. Tewari has worked on various aspects of button, oyster, paddy straw and milky mushroom.

Button Mushroom: In India commercial production of button mushroom started in North India on wheat straw based compost. However, in South India it is not available in many places. Paddy straw is available in plenty. Dr. Tewari developed various formulations of compost for button mushroom production based on paddy straw, maize stalk, chicken manure and horse dung. In Bangalore Turf Club horse dung bedded with paddy straw is available almost free of cost in plenty and this was

utilized to produce button mushroom resulting in very low cost of production. He also helped growers to take up mushroom production in Karnataka, Goa, Andhra Pradesh, Maharashtra, Tamil Nadu and Kerala.

Oyster Mushroom: The commercial production of oyster mushroom (*Pleurotus sajor-caju* and *P.florida*) became popular due to his efforts. He standardized cultivation of oyster mushroom on various agrowastes including vegetable crops' residue and introduced *P. florida,* a white strain, which has become popular throughout the country. Spore allergy from oyster mushroom is well known. He was instrumental in identifying a natural sporeless mutant and developed sporeless.

Milky Mushroom: Milky mushroom cultivation was reported by Dr. Purkayastha from West Bengal. Dr. Tewari improved and simplified its cultivation and introduced it for commercial cultivation in the country. The technology was similar to oyster mushroom except that higher dose of spawn and casing was required to support mushroom production. This technology was tested under AICMIP and introduced throughout the country. In North India it has been introduced on both wheat straw and paddy straw.

Paddy straw Mushroom: This variety was grown on small beds for better yield. Dr. Tewari used pasteurized cotton seed hulls and chicken manure as supplement and reported three times increase in yield. The selection of strains from IIHR was reported to be highest yielding from PAU, Ludhiana in strainal evaluation.

Disease and Pest Management: He reported for the first time virus disease in India. He formulated paddy straw based compost supplemented with neem cake to counter nematodes problem. The residue problem in mushroom was studied by him and found that pesticides broke very fast in composting process and chemicals like bavistin and dichlorovos degraded very fast during cropping.

Postharvest Technology: He introduced a unique canning process for button mushroom using tomato juice which was appreciated as both mushroom and tomato juice can be utilized. Mushroom steeping preservation was standardized for 6 months storage.

Transfer of Technology: He was instrumental to promote mushroom production in South India by conducing training programmes and extension activities. Due to his efforts South India has become an important region for mushroom production and today alongwith button mushroom, oyster and milky mushroom cultivation has become very popular creating employment for hundreds of people.

Mechanization of spawn and mushroom production: He was PI of indigenous mechanization of spawn and mushroom production and developed compost turner

with a capacity of 5 tonnes/hour, conveyer belt, drum to mix substrate and a portable system for pasteurization of substrate to grow oyster, milky, paddy straw, shiitake and *Ganoderma*.

Selected Publications

1. Adsule,P.G., Onkaraya,H., Tewari,R.P.and Girija,V.1984.Tomato juice as a new canning medium for European mushroom(*Agaricus bisporus*)(Lange Sing.). *The mushroom Journal,* 124:143-145.
2. Ganeshan, G. Tewari,R.P. and Bhargava, B.S.1987. Influence of residual vegetable crop biomass on the yield and mineral content of *Pleurotus sajor caju*(Fr.)Sing. *Mushroom science,* 12(2): 91-97.
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4. Pandey, M.and Tewari,R.P.1989. A natural spoerless varient of *Pleurotus. Indian Journal of Mushrooms*, 15:25-28.
5. Rao, M.S.,Tewari,R.P. and Pandey,M. 1994. Integrated management of mushroom nematode(*Aphelenchoides composticola*). *Indian J. of Agricultural Sciences*, 64:(12):878-881.
6. Sharma,D. Awasthi,M.D. andTewari,R.P.1996. Entry of Hexaxachlorocyclohexane residue in mushrooms from substrate. *Mushroom Res.*, 5:109-112.
7. Tewari, R.P. 1985. Paddy (rice) straw mushroom(*Volvariella diplasia*) cultivation in moderate climate. *The Mushroom Journal,* 150:213-215.
8. Tewari, R.P. and Girija, V 1983. Yield performance of *Agaricus bisporus* (Lange) Sing. on paddy straw based compost in relation to different termination periods at two level of nitrogen. *Indian Mushroom Science*, 2:35-39.
9. Tewari, R.P. and Sohi, H.S. 1976. studies on the use of paddy straw and maize stalk as substitute for wheat straw to prepare synthetic compost for the cultivation of European mushroom (*Agaricus bisporus*) (Lange)Moller and Schaffer). *Indian Journal of Mushrooms*, 2(2):18-20.
10. Venkateshwarlu, G. Chandravadana,M.V. and Tewari, R.P.1999. Volatile flavour components of some edible mushrooms(Basidiomycetes). *Flavour and Fragrance Journal*,14:191-194.

THAKUR, K.B.

Genetic improvement of mushrooms and cultivation of *Agaricus bisporus, Pleurotus* spp. and *Auricularia polytricha*

Kiran Thakur had brilliant academic career, being first class throughout. After clearing Higher Secondary in 1976 from CBSE she joined Himachal Pradesh Krishi Vishva Vidalaya where she passed B. Sc in1980. During M.Sc at HPKVV she studied breeding aspects of white mushroom (*Agaricus bisorus*), isolated single spores, studied their growth patterns on different media and compost and subsequently published her work on spore germination, ecological and nutritional requirements of single spore isolates, spawn production and validity of mycelial growth as selection criterion for yield in button mushroom. After clearing her M.Sc in 1982 she joined Ph. D in the same university where she continued her work on mushroom research. During this period she studied various aspects of cultivation, physiology, nutrition and genetics of oyster mushroom (*Pleurotus sapidus*) and completed her Ph. D in Nov 1985 in Mycology and Plant Pathology. She joined ICAR as Scientist S-1 through ARS on 26.11.1984 at DMR, then referred as NCMRT, Solan. She was promoted as Scientist (Sr Scale) w.e.f 27.11.1989 and continued her work on mushrooms at the Centre up to 1.8.1995 where after she resigned and migrated to US.

Description of research

At the Centre she worked on Strain improvement of Mushrooms with major focus on white button (*Agaricus bisporus*). The major focus was on identification of physiological, biochemical or cytological parameters correlated with yield, quality and other desirable traits of mushrooms with the ultimate goal of developing superior strains through selection, screening isolates and inter-mating of selected strains within limited time frame.

She attended training course on 'Cultivation of Edible Mushroom in Tropical Agricultural Waste' in Belgium from 24th August to 16th September 1992. Besides scientific publications, she was involved in compiling and editing of various books. She was part of the team that brought out the Souvenir on Mushroom (1986),

Bibliography of Mushroom research in India (1991) and Mushroom workers in India (1992).

She worked on isolation of single spores of different mushrooms including *Agaricus bisporus*, evaluation of single spore isolates and their inter-mating, etc. She was also instrumental in planning and execution of research related to cultivation of *Auricularia* on wheat straw and studies on spores and other aspects of *Auricularia polytricha*.

She has to her credit release of two single spore isolates and the first mushroom hybrid of *A. bisporus* in the country and has cultivated wood ear mushroom, *Auricularia polytricha* for the first time in the country. She has also coordinated the first Summer Institute on Mushrooms at the Centre.

Selected Publications

1. Bhandal, M.S. and Mehta, K.B. 1987. Cultivation of *Auricularia polytricha* (Mont.) Sacc (Jew's Ear Mushroom) on wheat straw. *Mushroom Science,* 12(2): 387-393.
2. Bhandal, M.S. and Mehta, K.B. 1987. Evaluation and improvement of strains of *Agaricus bisporus*. *Mushroom Science,* 12(1): 25-35.
3. Bhandal, M.S. and Mehta, K.B. 1987. Extra mushroom flush after cropping by reversing and recasing compost bags. *Indian J. Mycol. and Pl. Pathol.,* 17(3): 295-297.
4. Bhandal, M.S. and Mehta, K.B. 1988. Some thoughts from India on carbon dioxide and the cultivation of white button mushroom. *The Mushroom J.,* 185: 569-570.
5. Mehta, K.B and Bhandal, M.S. 1994. Genetic improvement of white button mushroom – *Agaricus bisporus*. In *Advances in Mushroom Biotechnology* (Eds. M.C. Nair, C. Gokulapalan and Lulu Das), Scientific Publishers, Jodhpur, pp. 70-76.
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7. Mehta, K.B. and Jandaik, C.L. 1989. Cultivation of *Pleurotus* cfr. s*apidus* (Schulzer) Kalchbr. in India. *Mush. Sci.*, 12(2): 179-185.
8. Mehta, K.B. and Bhandal, M.S. 1990. Studies on mycelial growth and fructification in *Auricularia polytricha* (Mont.) Sacc. *Indian J. Mush.,* 16: 42-45.
9. Thakur, K.B. and Bhandal, M.S. 1992. Hybridisation in *Agaricus bisporus* using non-fertile isolates. *Mushroom Research,* 1: 79-81.
10. Thakur, K.B. and Bhandal, M.S. 1993. Monosporus isolates and their intermating in *Pleurotus sapidus* and *P. sajor-caju*. *Mushroom Research,* 2: 41-45.

UPADHYAY, R.C.

Identification of wild mushrooms and development of hybrid strains in *Pleurotus* spp. (Oyster mushrooms)

R.C. Upadhyay obtained his Master of Science in Botany from Vikram University, Ujjain in 1976. He joined Agricultural Research Service of ICAR in 1977. His 1st place of posting was at the Central Potato Research Station, Patna (Bihar) where he joined on 17-09-1977 as Scientist S-1 (Plant Pathology). He joined NCMRT (now Directorate of Mushroom Research), Solan on 5th Dec. 1983. He obtained his Dr. Rer. Naturalium (Ph.D.) from Friedrich Schiller University, Jena Germany in 1995. He worked on "Metabolism of phenolic substances by *Pleurotus flabellatus* and *Agrocybe aegerita*" for his Dr. Rer. Nat degree. Dr. Upadhyay attended the 13th International Mushroom Congress at Dublin, Ireland and presented paper on, "Cultivation of *Pleurotus* species during winter in India". He was sponsored by the European Economic Commission to attend summer school of European postgraduate Eco-technie from 14th June 1993 to 20th June 1993 at the Free University, Brussels, Belgium. Dr. Upadhyay attended the conference of Noble Prize Winner in medicine from 28th June 1993 to 2nd July 1993 at Lindau, Germany. Dr. Upadhyay was awarded "DAAD re-invitation Fellowship" for doing research work at the International Hochschule Institute, Zittau (Germany) "on isolation, purification and characterization of oxidases and peroxidases enzymes from *Agrocybe aegerita* and other wild mushrooms" from 24th April to 22nd June 2007. Dr. Upadhyay has completed two externally funded research project sponsored by CSIR, HRDG, New Delhi from Sept.2002 March 2004 and Sept. 2004 to Sept. 2008. Currently he has two research projects sponsored by CSIR, HRDG, New Delhi and AMAAS, NBAIM, Mau (ICAR). Dr. Upadhyay is looking after Mushroom Gene Bank at DMR, Solan since last twelve years. He has been involved in functioning of Mushroom Society of India (MSI) as Secretary/Editor/Joint-Secretary. At present he is Vice President, of the Society. Dr. Upadhyay has been awarded "Fellow of Mushroom Society of India" in 2008 .

Description of Research

Dr. Upadhyay has varied areas of research interest in mushroom including taxonomy and identification of fleshy fungi, cultivation of *Pleurotus* and other mushroom species, improvement and developing hybrid strains of Oyster mushroom, ligninolytic enzymes of various white and brown rot fungi and microbial degradation of xenobiotics. He has established a Mushroom Herbarium at the DMR Solan with more than 3000 preserved specimens and facilities for molecular work. There are only 15 *Auricularia* species recorded from the world and he has identified 8 species of *Auricularia* namely *A. auricula, A. delicata, A. fuscosuccinea, A. peltata, A. mesentrica, A. polytricha, A. tenuis* and a new species with two medulla zones. The list of new species mushroom described from India by Dr. Upadhyay and his team includes *Agaricus nivescens, A. rubronanus, A. rhopalopodius, Amanita avellanosquamosa, A. concentrica, A. foetidissma, A. grieseofarinosa, A. nivescens, A. subjunquilla var.alba, A. subjunquilla var. subjunquilla, A. sinensis, A. umbrinolutea, Agrocybe putaminum, A. badia, Lacrymaria glareosa, Cortinarius collinitus, Gymanopilus zenkeri, G. subspectabilis, Phaeocollybia latispora, Entoloma canobrunnescens, E. corneri, E. incanum, E. niphoides, E. vernum, E. vulsum, Hygrotrama microsporum, Pluteus plautus, Pholiota spumosa, Strophoria rugoso-annulata, Tricholomella constricta, Clitocybe ditopa, Laccaria lateritia, Lepiota hyalodes, Melanoleuca tritis, Tricholomopsis crocobapha.*

Dr. Upadhyay reported several disease causing moulds and parasites namely: *Cldobotryum variospermum* and *C. apiculatum* from *Pleurorus* spp. and *Mycogone rosea* from *Stropharia rugoso- annulata*. Oyster mushroom (*Pleurotus* spp.) which was earliar cultivated only during summer was explored for winter cultivation by Dr. Upadhyay. He reported that *P. florida, P. ostreatus, P. cornucopiae, P.eryngii* and *P. fossulatus* could be cultivated during winter. Several low cost cheap industrial wastes like apple pomace, teal leaf waste and dry poplar leaves were successfully used for Oyster mushrooms cultivation. The cultivation technique of Kabul Dhingri has been perfected by him and very good yield (60-70% BE) has been obtained by using various supplements under Indian conditions. Specialty mushroom namely *Strophoria rugoso annulata*, *Lentinus squarrosulus* and *Auricularia mesenterica* were also exploited for the first time by him in India.

During his research work in Germany he has found one alkaline peroxidase from *Agrocybe aegerita* as “Alkaline Lignin Peroxidase” which can oxidize several aromatic compounds including veratryl alcohol to veratryl aldehyde in the presence of hydrogen peroxide. This enzyme is presently known as *Agrocybe aegerita*

peroxidase(AaP). The enzyme has its optimum pH at 7.0 and it is active up to 9.0 pH. He studied metabolism of various phenols for bioremediation using *Agrocybe aegerita* and *Pleurotus flabellatus.*

Selected Publications

1. Semwal, K.C., Tulloss, R.E., Bhatt, R.P., Stephenson, S.L. and Upadhyay, R.C. 2007. New Records of *Amanita* from Garhwal Himalaya. *Mycotaxon,* 101:331-348.

2. Sohi, H.S. and Upadhyay, R.C. 1986. Occurrence of *Cladobotryum variospermum* (Link) Hughes on polyporous fungi under natural conditions. *Current Science*, 55: 1037-1038.

3. Sohi, H.S. and Upadhyay, R.C. 1989. New and noteworthy disease problems of edible mushrooms in India. *Mushroom Science*, XII (Part2): 611-614.

4. Sohi, H.S. and Upadhyay, R.C. 1990. Natural occurrence of different species of *Auricularia* in Himachal Pradesh. *Mushroom Journal for the Tropics*, 10: 47-51.

5. Upadhyay, R. C. and Rai, R. D. 1999. Cultivation and Nutritive value of *Lentinus squarrosulus. Mush Res.*, 8(2): 35-38.

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10. Upadhyay, R.C. and Vijay, B. 1991. Cultivation of *Pleurotus* species during winter in India. *Mushroom science*, XIII (Part 2): 533-537.

VERMA, RABINDRA NATH

Fungal biology as well as genetic improvement

Rabindra Nath Verma obtained his M.Sc. Botany (Cytogenetics and Plant Breeding) degree from Patna University, Patna in 1961.He started his professional carrier as Lecturer in Botany at Deoghar College, Deoghar of Bhagalpur University in 1962. In 1969, he underwent a 4-weeks' training in Microbiology at a USAID sponsored Summer Institute at Bombay University. In 1970 he was awarded a research scholarship by Bhagalpur University wherefrom he completed his Ph.D in1973. He co-authored a university level book "Physiology of Fungi" while working as UGC post-doc fellow from 1973-75. He also jointly translated (with S.C. Tiwary) five Masterpieces of Botany including P.Maheshwari's book " Embryology of Angiosperms" during 1965-68 working as Assistant Director Hindi Book Production Cell at Ranchi University, Ranchi. He joined ICAR Research Complex for NEH Region in 1975 as Senior Scientist (Plant Pathology) and was inducted in the Agricultural Research Service of ICAR the same year as Scientist S-2 (Pl. Path.). In 1979 he attended a 4-months training in "Genetic Evaluation and Utilization of Rice" at the International Rice Research Institute, Manila. In 1981, he was selected as Scientist S-3 and HOD of Plant Pathology Division at ICAR Research Complex HQrs. at Shillong, where he continued as Principal Scientist from 1986 to 1992. From Aug., 1992 to Oct., 1994, he served at the ICAR HQrs in the Education Division as Principal Scientist(Education), before being selected as the Director of National Centre for Mushroom Research & Training (later named as NRCM), Solan, where he joined on 19-10-1994 and retired on 31-03-2002.

Description of Research

Dr. Verma worked on various aspects of mushroom, including mushroom bio-diversity, characterization and conservation of germplasm, production of edible types and genetic improvement of strains through molecular techniques. Working as the Principal Investigator of a World-Bank (NATP) funded project on "Development of improved Strains of Mushrooms and Domestication of *Morchella* spp. using molecular techniques" he formed a working group and developed the protocols for

DNA Fingerprinting of Mushroom Germplasm through the use of RAPD, AFLP markers. Also, he helped in collecting a large number of exotic and indigenous mushroom germplasm particularly of *Agaricus* spp. and *Pleurotus* spp.

Dr. Verma, with his Masters in Botany with Specialization in Cytogenetics and Plant Breeding and an International training in Genetic Evaluation and Utilization of Rice at the International Rice Research Institute, Philippines, where he worked with the world renowned Rice Breeder Dr. G. S. Khush, has also worked on Resistance Breeding of Rice, Maize and Soybean and some of his breeding lines were included in the All India Coordinated Rice Improvement Project trials for Hill region and have been adopted by Farmers of Meghalaya.

Dr. Verma Published over 150 Research papers, 100 Abstracts, 4 Extension Bulletins, 14 Editorial Assignments, Several Book-Chapters, 4 Documentary Films, and has translated 6 masterpieces of Botany from English to Hindi, besides writing two original Books in English.

Selected Publications

1. Singh, S.K. and Verma, R.N. 2000. Effect of Nutrients on Mycelial Growth of Sclerotia Formation in M.esculenta. 15th International Congress on Sci. & Cultivation of Edible Fungi, 15-19 May, 2000 Mastricht, The Netherlands.

2. Singh, S.K., Rana, M.K. and Verma, R.N. 2000. Amplified DNA Polymorphism of cultivated mushrooms. *Mush. Res.*, 9(1): 19-25.

3. Singh, S.K., Upadhyay, R.C. and Verma, R.N. 2000. Physico-chemical preferences for efficient mycelial colonization in edible mushrooms. *Mush. Res.*, 9(2): 85-89..

4. Verma, R.N. 2000. Role of Mushroom Genetic Resources for Enhancing Food and Nutritional Security. An invited lecture delivered at the Panel discussion on Agro-Biodiversity held at the International Conference on Managing Natural Resources in the 21st Century, 14-18th February, 2000, New Delhi.

5. Verma, R.N. and Yadav, M.C. 2000. Transgenics for enhancing and sustaining mushroom productivity and quality: Present status, problems and prospects. In proceedings of national symposium on transgenic crops and foods, 7-8 November, 2000, Hyderabad.

6. Verma, R.N. and Khanna, P.K. 2000. Genetic improvement in mushroom. Symposium on Mushroom Research in 21st Century, NRCM, Solan, 3-4 May, 2000.

7. Verma, R.N. and Upadhyay, R.C. 2000. Mushroom Genetic Resources in India. Mushroom Genetic Resources for Food and Agriculture. Eds. J.E. Labarere and U.G. Menini Bordeaux, France, pp 153-157.

8. Verma, R.N., Yadav, M.C., Dhar, B.L. and Upadhyay, R.C. 2000. Strategies for genetic improvement of mushrooms-future perspectives. *Mush. Res.,* 9(1) 1-10.

9. Yadav, M.C., Dhar, B.L. and Verma, R.N. 2000. Breeding studies on development of high yielding quality hybrids of Agaricus bitorquis. *Mush. Sci.,* 15(1): 299-304.

10. Yadav, M.C., Verma, R.N. and Dhar, B.L. 1999. Studies on development of improved strains and hybrids of white button mushroom Agaricus bisporus (Lange) Imbach. IIIrd International Conference on Mushroom Biology and Mushroom Products, Sydney, Australia.

VIJAY, B.

Crop management of mushrooms and role of thermophilic fungi in compost production

Bhuvnesh Vijay obtained his M.Sc. Botany (specilization in Plant Pathology) from Vikram University Ujjain (M.P.) in 1974. He served as Assistant Professor (Pl. Pathology) at Agriulture Research Station, Durgapura, Jaipur from 1974 to 1977. After that he joined the Agricultural Research Service of ICAR and is working at Directorate of Mushroom Research, Solan (HP) since October, 1983. He completed his doctoral research on "Investigations on compost mycoflora and crop improvement in *Agaricus bisporus* (Lange) Sing from HP University Shimla (HP) in 1996.

Description of Research

Main focus of Dr. B. Vijay's earlier research was on refinement in cultivation technologies of oyster and white button mushroom and also on the role of mycoflora in compost production for white button mushroom (*Agaricus bisporus*).

Oyster mushroom: Among the total production of mushrooms, oyster mushrooms are ranked at the second place in India while 3rd in the world. Commercial cultivation of oyster mushroom (*Pleurotus* spp.) is generally not successful on unpasteurized substrate due to inconsistent yield as a result of occurrence of various competitor moulds. The technology available till 1986 involved its cultivation on steam pasteurized (80°C for 2h) wheat/paddy straw. Steam pasteurized straw is generally colonized by various fungi especially *Trichoderma viride* resulting in decreased yield or total crop failure. Besides above, this technique is cumbersome and not very economical. In view of above through series of experiments he developed a new simple foolproof chemical sterilization technique (CST) for oyster mushroom cultivation. The technique involves steeping of straw (10kg) in 100 litres water containing 500 ppm formalin and 75 ppm bavistin for 18 hours followed by spawning. This technique gives higher biological efficiency compared to steam pasteurized straw and also gives 100% protection to the crop against the invasion of *T. viride*

(green mould). Later studies showed that the same chemical solution can be used at least two times for the sterilization of the straw and fruit bodies raised using this technique are safe for human consumption as the carbendazim level in them was below tolerance limit. In the same study around 40 fungal competitors were isolated from the beds of oyster mushrooms and their role investigated. Use of carbendazim along with steam pasteurization of straw was also advocated by him for the control of green mould. He also investigated role of N fixing bacteria in oyster mushroom cultivation and *Azotobacter chroococcum* was found to increase the yield. Further, Use of chicken manure as a supplement was also advocated for increased yields of oyster mushroom.

White button mushroom (*Agaricus bisporus*): At present India is roughly producing around 1.2 lakh tons of button mushroom per annum. Casing soil plays a vital role in the cultivation of white button mushroom. Peat moss is widely acclaimed as the best casing media in the world, however this material is not available in India. Farmers in our country get sub optimal yields by using other casing mixtures. A new casing media in lieu of peat moss was developed in the country. Moss *Funaria* spp (dried) can be utilized as casing medium after its fumigation with formaldehyde. This material not only out yields other locally available casing media, but also give heavier mushrooms without any flush break. In another investigation, a technique for getting early pinning and higher yields of white button mushroom was developed wherein N fixing bacteria *Azotobacter chroococcum* carried on lignite base when added in the casing @ 20g/ 15 kg compost gave early pinning, heavier fruit bodies and higher yield. Post composting supplementation of the prepared compost has become a routine cultural practice in white button mushroom elsewhere in the world, however, it is not so common in our country for the want of suitable supplements and its package of practices. Through a series of experiments on this aspect viz., choice of supplement, rate of supplement, period of supplementation, treatment of supplement, compost suitable for supplementation, varieties for supplementation, crop management after supplementation etc. technique for post composting supplementation was standardized by him. Supplementation @ 1% fresh weight basis of compost can be tried, however, supplementation at casing gives best results. Deoiled soybean meal, cottonseed meal and soybean meal are the suitable sources for supplementation. Of the ten strains of *A.bisporus* tried for their suitability for supplementation both under short and long method composts, strains S-11, 44, 791, S-310, P-1, P-2 and U-3 responded favourably. Strains 56, 89 and 76 did not responded well on both the kinds of compost.

Further he also developed a new compost formulation based on 70% chicken manure and 7% cotton seed cake for higher production of white button mushroom. He also standardized casing thickness on the beds of white button mushroom.

Appreciable quantities of white button mushroom are produced in India on compost prepared by long method (unpasteurized compost). Such compost harbours a large number of organisms, many of which are strong competitor of *A.bisporus*. In the year 1991-92 about 40% of the crop raised by this method was lost in Sonepat area (Haryana State) due to the attack of yellow mould (*Myceliophthora lutea* and *Sepedonium chrysospermum*). In the recent past its infection was noticed around Solan also. Best way to eliminate these organisms is to use pasteurized compost prepared by short method. However, procurement of pasteurized compost is beyond the reach of many farmers in the country. In view of above detailed investigations were carried out to pasteurize the long method compost by chemicals for the control of various diseases and yellow moulds in particular. Studies carried out at the Centre with three kinds of compost revealed that long method compost can suitably be pasteurized by treating 1000 kg of compost with 1.5 litres of formalin and 50g of bavistin dissolved in 40 litres of water 48 hours before spawning. This technique has given 100% protection to the crop against yellow moulds fungi and reduced the incidence of other competitors. Study also indicated that paddy straw based compost is more prone to the infection of yellow moulds and there is no adverse effects of above chemicals on the dormant thermophilic fungal population of the compost. This technique has also been confirmed at All India Co-ordinated Mushroom Improvement Project. On farm trials conducted at the infested farms showed promising results and technique has since been adopted by the growers in the country cultivating white button mushroom by long method.

Methodology for the production by environment friendly indoor compost had been standardized by him using a combination of INRA method (double phase high temperature method) and Anglo Dutch method (single phase low temperature method) for the cultivation of button mushroom. Such method was developed using aerated bunker and phase two tunnels in 12 days time against 20 days of short method of composting exploiting the use of natural thermophilic flora present in the ingredients. Almost identical yields per unit weight of compost as compared to short method compost were obtained by this technique. However, overall yields were higher in compost obtained with newly developed technique as this produced around 30 % more compost biomass. Further, such compost improved the consistency of the compost quality, improved material handling, and reduction in raw material losses

during composting with minimal air pollution. Technology so developed has since been passed on to the growers and commercial plant set up at HAIC, Murthal (Haryana).

Mycoflora of *A. bisporus* compost: Fungal organisms especially the thermophilic fungi play a very vital role in the production of compost. They degrade the compost ingredients and convert the soluble form of nitrogen into microbial cell substances, which are later on utilized by mushroom mycelium as nutritional source. Working on this aspect he also carried out detailed investigations on the occurrence and role of mesophilic and thermophilic fungi in the compost piles prepared with different N levels. In all 35 mesophilic and 24 thermophilic fungi were isolated from different piles. Succession of different fungi was definitely observed. It was concluded from the study that required N level in the compounding mixture should be kept between 1.5-1.75% for getting higher yield. 1.5-1.75 % N levels attract less number of fungi at spawning. *Stachybotrys atra* and *Sepedonium maheshwarianum* which invade the compost at low and high N levels respectively are responsible for low yields or total crop failure in such composts are not accessible at these N levels (1.5 – 1.75N). Population of thermophilic fungi, *Scytalidium thermophilum, Humicola insolens* and *Humicola grisea* is more in such composts which are known to play a major role for the nutrition of *A.bisporus*. Based on these studies he further stressed that use of chicken manure should be discouraged under long method of composting, since it was found to be the major source of *S.maheshwarianum* and *Stachybotrys* spp. If at all it is used under long method of composting it should be treated with DDVP + bavistin @ 3ml and 1.5g respectively per 10kg compost at 1.5N level for bringing out its suitability in *A.bisporus* cultivation and Strain S-11 followed by S-310 were the highest yielder on such compost. In the same studies *S.maheshwarianum* a new potent competitor of *A.bisporus* was identified. In further studies protocol for productive long method compost production using *S. thermophilum* and *H. insolens* developed and *S. thermophilum* and *H. insolens* inoculated composts gave higher yields compared to control. Studies further indicated that composting period could be shortened by inoculating the pile with *H.insolens* and *S.thermophilum*, which is a finding of immense practical importance. He further found that long method compost fermented at standard temp. gives better yield then fermented at 45-50°C, and 50-55°C, when inoculated artificially with *H. insolens.*

He also developed and standardized protocol for *A.bisporus* compost following pre pasteurization conditioning. Steam from boiler is almost omitted in such procedure and it takes lesser duration for completion of phase-II, thus a substantial saving of time energy and money.

In vitro studies on 24 selected mesophilic fungi and *A.bisporus* were also conducted and study indicated that many a fungi produce inhibiting substances, which completely reduce the growth of *A.bisporus*. *In vivo* inoculation studies of *A.bisporus* compost with *S.maheshwarianum, T.viride, Fusarium acuminatum, Stachybotrys atra, Cladobotryum dendroides, Chaetomium indicum* and *Verticillium fungicola* indicated 5-51% reduction in yield of *A.bisporus*. Dual culture studies between various thermophilic fungi and *A.bisporus* and its competitors indicated reduction in growth of above fungi. However *S. thermophlium* and *H.insolens* increased the growth of *A.bisporus.* Same trend was observed with their cultural filtrates.

In another study seven, eight and six different strains of *S. thermophilum, H. insolens,* and *H. grisea* respectively were identified at molecular level. Many of these strains assist appreciably in compost production. Compost was successfully prepared by bypassing phase-I with S-7 strain of *S. thermophilum*, and S-5 strain of *H. insolens. S. thermophilum* and *Chaetomium. thermophile* were most important thermophiles for production of extra cellular enzymes. Wheat straw substrate is the best and cheap source for the growth and multiplication of *S. thermophilum*.

Selected Publications

1. Vijay, B., Sharma, S. R. and Lakhanpal, T. N. 1997. Mycoflora of *Agaricus bisporus* compost. In: *Advances in Mushroom Biology and Production* (Rai, R. D., Dhar, B. L. and Verma, R. N., eds.) pp. 140-159. NRCM, Solan.

2. Vijay, B. and Sharma, S. R. 1996. Effect of chemical treatment of long method compost on yellow moulds, compost microflora and yield of *Agaricus bisporus.* In: *Mushroom Biology and Mushroom Products* (Royse, D. J., ed.) pp 503-514. Penn. State Univ., USA.

3. Vijay, B. and Sohi, H. S. 1989. Fungal competitors of *Pleurotus sajor-caju* (Fr.) Singer. *Mush. J. Tropics,* 9(1): 29-35.

4. Vijay, B. and Gupta, Y. 1992. Studies on fungal competitors of *Agaricus bisporus. Indian Phytopath.*, 45 (2): 228-232.

5. Vijay, B. and Gupta, Y. 1992. Studies on manipulation of casing microflora on the yield of *Agaricus bisporus* (Lange.) Sing. *Mushroom Research,* 1 (1) : 61-63.

6. Vijay, B. and Rai, R. D. 1991. Further studies on chemical sterilization of wheat straw substrate for the cultivation of oyster mushroom. *Indian Mushrooms,* 117-122.

7. Vijay, B. and Sohi, H. S. 1987. Cultivation of oyster mushroom *Pleurotus sajor-caju* (Fr.) Singer on chemically sterilized wheat straw. *Mush. J. Tropics,* 7 (2): 67-75.

8. Vijay, B. and Upadhyay, R. C. 1988. Chicken manure as a new nitrogen supplement in oyster mushroom cultivation. *Indian J. Mycol. Pl. Pathol.*, 19 (3) : 297-298.

9. Vijay, B. Saxena, S. and Sohi, H. S. 1987. Studies on new casing media for *Agaricus bisporus* (Lange) Sing. *The Mushroom Journal,* 178 : 313-315.

10. Vijay, B., Gupta, Y. and Upadhyay, R. C. 1988. Effect of casing thickness on yield of *Agaricus bisporus. Indian J. Mycol. Pl. Pathol.,* 18 (2) : 209-210.

YADAV, MAHESH C.

DNA markers in germplasm characterization; Molecular approaches for mushroom breeding

Mahesh Yadav obtained his M. Sc. (Genetics) in 1992 from PG School, Indian Agricultural Research Institute (Deemed University), New Delhi. He joined Agricultural Research Services (ARS) in 1996 at Directorate of Mushroom Research (DMR), Solan after completing Ph. D. academic requirements and research work from IARI. He was awarded Ph. D. (Genetics) in April, 1998 for his *cytogenetic studies on maize aneuploids*. Dr. Yadav was deputed for advanced training in molecular genetics and biotechnology and worked under the guidance of renowned mushroom geneticists Dr. T.J. Elliott and Dr. M.P. Challen on *ITS sequencing and phylogenetics of button mushrooms* at Horticulture Research International, Wellesbourne, UK during 2002. He was given Yadavindra Young Scientist Award in 2002 for his research on molecular breeding of button mushroom.

Description of Research

The main focus of Dr. Yadav's earlier research was to standardize protocols for high frequency single spore germination, isolation and characterization of spore progenies, and to develop genetically improved high-yielding and superior quality strains and hybrids in button mushroom. He has developed numerous genetic stocks of *Agaricus bisporus* that included broad stipe strain and more than 2500 single spore isolates (SSIs). At present his group at DMR is involved in the following research programmes.

Molecular characterization of mushroom germplasm: Information on genetic characteristics of germplasm lines and assessment of genetic variation within species are essentially required for use of genetic resources in breeding programmes. With implementation of IPR and Plant Variety Protection Act, the need for precise genotypic characterization with Distinctness (D), Uniformity (U) and stability (S) has attained greater importance. Dr. Yadav and his group has characterized more than 300 germplasm strains of various mushrooms using DNA based markers like RAPD, AFLP, ITS-RFLP and ITS sequencing. The brief achievements in this research programme are:

- Molecular identities and genetic variation have been studied in 43 strains of *A. bisporus* and 15 strains of *A. bitorquis* using RAPD, AFLP and ITS sequencing of 5.8S rRNA gene.

- Genetic variation was detected among 63 single spore progenies of *A. bisporus* and 16 haploid lines of *A. bitorquis* using RAPD markers for their use in genetic improvement.

- DNA fingerprinting of germplasm of Mushroom Gene Bank has generated unique bands that will help in legal protection of our national germplasm in the present scenario of PVP and IPR regimes under WTO.

Genetic manipulations for high yield and better quality in button mushroom: The white button mushroom, *A. bisporus* (Lange) Imbach, is a commercially important vegetable crop and significantly contributes to the economies of many countries. This species of cultivated mushrooms accounts for 85 per cent of mushroom production in India and is a potential indoor crop for rural livelihood and health food. Cultivated mushrooms represent a unique exploitation of microbial biotechnology for conversion of cellulosic agro-wastes into valuable protein-rich food. However, the dearth of genetic markers in these mushrooms makes the selection of superior genotypes and consequently the development of genetically improved varieties a difficult proposition. Now, the use of DNA markers has opened up new possibilities for genetic analysis and hybrid breeding. The DNA markers have been employed to assess the genetic distance between potential parents for hybridization programme. Single spore selection and mating (hybridization) between genetically diverse haploid breeding lines continue to be a method of choice for genetic improvement in *A. bisporus*. Significant achievements of this programme are:

- Three high yielding varieties and one hybrid of *A. bisporus* have been recommended for commercial release by the 10th AICMIP workshop.
- Two newly developed intra-specific hybrids of *A. bitorquis* have shown promise under both initial evaluation trials and farmers' fields.
- Phylogenetic relationship and assessment of molecular variation in indigenously collected/procured germ plasm of *Agaricus* species for introgression of useful genes from related species.
- Development and molecular analysis of mutants and protoplast isolates in *A. bisporus*.

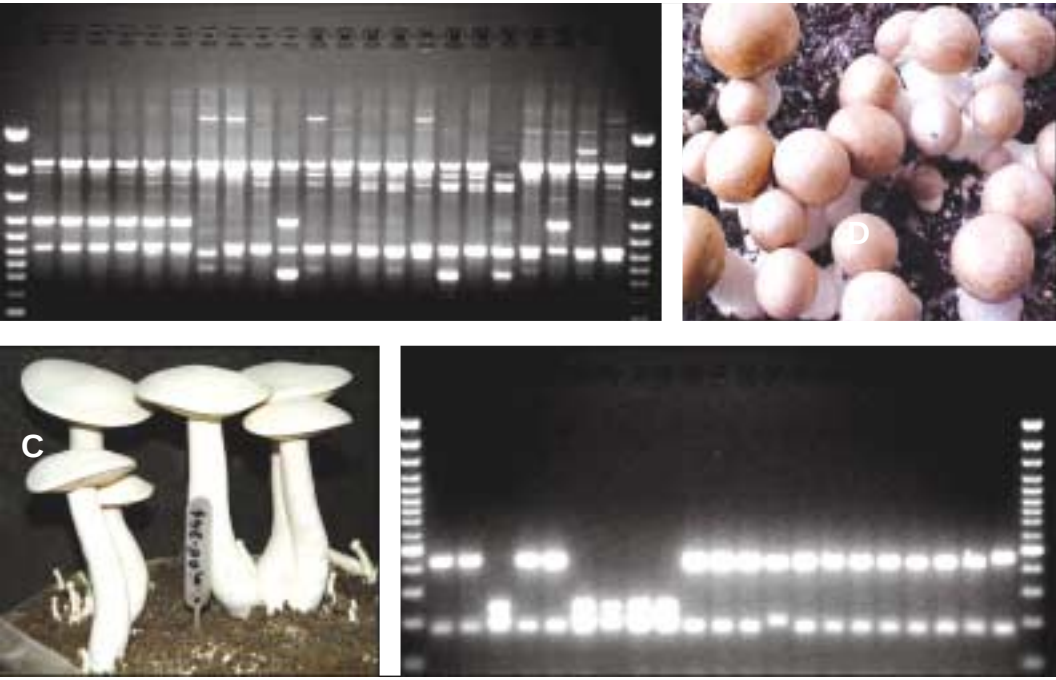

Fig: (A) Genotyping of button mushroom (*A. bisporus*) germplasm strains with RAPD markers. (B) Early fruiting in brown mutant of *A. bisporus* developed using EMS mutagenesis. (C) High-yielding strain of milky mushroom (*Calocybe indica*). (D) ITS-DNA RFLP fingerprints of various strains of oyster mushroom (*Pleurotus* spp.).

Genetic improvement for high yield and better quality in specialty mushrooms:

Specialty mushrooms like milky (*Calocybe indica*) and shiitake (*Lentinula edodes*)

have recently become an import addition to the expanding Indian mushroom portfolio. Milky mushroom, an up-coming species, is well suited to our country's tropical and sub-tropical climate. Similarly, Shiitake (*L. edodes*) is an important medicinal mushroom species. The genetic improvement in milky and shiitake mushrooms using cutting edge techniques of molecular genetics and biotechnology will result in the development of high yielding, better quality cultivars of these very important speciality mushrooms. Genetically diverse parents have been identified using yield evaluation trials, RAPD, ITS-RFLP, SNP and ISSR markers. The main achievements in this programme are:

- Four high-yielding strains *viz*., OE-334, OE-343, OE-345 and OE-348 with 82.1, 64.5, 74.3 and 61.2% B.E.
- In shiitake, hybrid S-31 yielded maximum mushrooms with 95.5% B.E.
- DNA analysis – RAPD analysis and ITS sequencing have been carried out in 24 germplasm strains of milky and 28 strains of shiitake mushrooms.

Selected Publications

1. Yadav, M.C., Challen, M.P., Singh, S.K. and Elliott, T.J. 2007. DNA analysis reveals genomic homogeneity and single nucleotide polymorphism in 5.8S ribosomal RNA gene spacer region among commercial cultivars of the button mushroom *Agaricus bisporus* in India. *Current Science,* 93: 1383-1389.

2. Mahfooz, S., Yadav, M.C., Kamal, S., Singh, S.K. and Prakash, A. 2007. Genetic variation in extracellular lignolytic enzymes and their effect on mushroom yield in single spore progenies of *Agaricus bisporus. Mushroom Research,* 16: 1-7.

3. Yadav, M.C., Sharma, R.K., Singh, S.K. and Mohapatra, T. 2006. Molecular differentiation of sexually incompatible strains of *Agaricus bitorquis* using RAPD and AFLP markers. *Journal of Plant Biochemistry and Biotechnology,* 15: 109-116.

4. Singh, S.K., Doshi, A., Yadav, M.C. and Kamal, S. 2006. Molecular characterization of specialty mushrooms of western Rajasthan, India. *Current Science,* 91: 1225-1230.

5. Singh, S.K., Kamal, S., Tiwari, M. and Yadav, M.C. 2005. Morel phylogeny and diagnostics based on restriction fragment length polymorphism analysis of ITS region of 5.8S ribosomal RNA gene. *Journal of Plant Biochemistry and Biotechnology,* 14: 179-183.

6. Yadav, M.C., Kamal, S., Mahfooz, S., Singh, S.K., Upadhyay, R.C. and Rai, R.D. 2004. Laccase polymorphism in *Agaricus bitorquis* strains. *Mushroom Research,* 13: 7-11.

7. Yadav, M.C., Mahfooz, S., Singh, S.K. and Upadhyay, R.C. 2003. RAPD markers assisted selection of genetically diverse parents for hybridization in *Agaricus bisporus*. *Mushroom Research,* 12: 19-26.

8. Yadav, M.C., Singh, S.K. Upadhyay, R.C. and Mahfooz, S. 2003. Molecular profiling and morpho-physiological characterization of *Agaricus bitorquis* germplasm. *Mushroom Research,* 12: 79-86.

9. Yadav, M.C., Verma, R.N., Dhar, B.L. and Upadhyay, R.C. 2002. Development of genetically improved strains of button mushroom *Agaricus bisporus* using single spore selection. *Mushroom Research,* 11: 55-63.

10. Yadav, M.C., Dhar, B.L. and Verma, R.N. 2000. Breeding studies on development of high yielding and quality hybrids of *Agaricus bitorquis*. *Mushroom Science,* 15:299-304.

OTHER WORKERS

Some of the other scientists worked at the Directorate are:

1. Dr T.P. Trivedi – Presently Director DIPA joined the Centre on12.12.1983 as scientist (entomology) and remained here till 20.06.1984 when he was transferred to Central Potato Research Station Bangalore.

2. Dr Satyavir Singh joined this Centre on 8th August as scientist (extension) and continued till 12th Janaury, 1996 when he was transferred to Directorate of Wheat Reaserch, Karnal.

3. Dr. S. Dayal joined the Centre on 3rd June, 1993 as scientist (SS). He worked on genetic and breeding studies for improvement of mushrooms. Dr. Dayal developed many crosses by dimon-dimon mating in *A. bisporus* and evaluated them for yield. He observed cross number 1,3,5 as the highest yielder giving 30.5 kg yield per/quintal compost in 12 weeks cropping following by cross number 12 resulting 28 kg mushroom production/quintal compost. Dr. Dayal also isolated large number of single spores of S-11 strains of *A. bisporus* strains and observed that Lambert's medium supplemented with 0.25% succinic acid gave the best results for germination of single spores. He was transferred to CPRI, on 11th January, 2003.

4. Er. Chandra Shekhar joined this Centre on 3rd October, 1998 as scientist(ASPE) and continued till 12th July, 2001, when he was transferred to NDRS, Bangalore. During his stay at the Centre he worked on low cost mechanization for small scale mushroom cultivation and processing industry.

Selected Publications

1. Chandrasekar, V., Rai, R.D. and Verma, R.N. 1999. Suitable mechanization and engineering support to the seasonal mushroom growers of India. IIIrd Int. Conference on Mushroom Biology and Mushroom Products, Sydney, Australia, 11-16 October, 1999.

2. Chandrasekar, V., Verma, R.N. and Rai, R.D. 2000. Need for automatic water spraying system for mushroom growing. International Conference on Micro and Sprinkler Irrigation Systems. 8-10 February, 2000. Jalgaon (Maharashtra).

3. Chandrasekar, V., Rai, R.D., Srinivas, G.T.K. and Verma, R.N. 2001. Studies on preparation and storage of mushroom (*Agaricus bisporus*) curry in retort pouch. *Mushroom Research,* 10:103-108.

4. Gupta, Y. and Dayal, S. 2003. Mushroom Magic. *Science Reporter*, May, 2003, pp. 52-55.

5. Rai, R.D., Chandrasekar, V. and Verma, R.N. 2002. Postharvest technology of mushrooms. Indian Mushroom Conference, 2002, March 6-7, 2002, Coimbatore (T.N.).

6. Arumuganathan, T. Rai, R.D., Chandrasekar, V. and Hemkar, A.K. 2003. Studies on canning of button mushroom, *Agaricus bisporus* for improved quality. *Mushroom Research* 12:117-120.

7. Rai, R.D., Chandrasekar, V. and Arumuganathan, T. 2003. Post-harvest technology in mushrooms. In: *Current Vistas in mushroom Biology and Production* (R.C. Upadhyay, S.K. Singh and R.D. Rai, eds.), MSI, NRCM, Solan. pp.225-236.

THE YOUNG GENERATION

The following scientists have recently joined DMR

1. Dr. Goraksha Chimaji Wakchaure, joined the Directorate as scientist (Agricultural Structure and Process Engineering) on 20.06.2009. He did M.Sc. (2005) and Ph.D.(2009) in Agricultural Engineering with specialization in Farm Power and Equipment, IARI, New Delhi-110012.

2. Mr. Mahantesh Shirur, joined the Directorate as Scientist (Agricultural Extension) on 28.08.2009. He did M.Sc. (2003) in Agricultural Extension, ANGRAU, Hyderabad.

3. Dr. K. Manikandan, joined the Directorate as Scientist (Soil Science and Agricultural Chemistry) on 29.08.2009. He did M. Sc. (2003) and Ph.D (2007) in Soil Science and Agricultural Chemistry, TNAU, Coimbatore.

OTHER STAFF MEMBERS

No organization can achieve laurels without active support of administrative, technical and supporting staff. During the last 25 years number of people has served at the Centre. We acknowledge their contribution. They are:

(a) Staff: Reteired/Transferred

	Name of Officer/ Official	Designation at retirement/ transfer	Date of joining at DMR	Status	Date of relieving
	Administrative				
1	Sh. B.D.Chandna	Admn.Officer	29.11.1984	Transferred	05.08.1985
2	Sh. R.R. Parwana	Admn.Officer	28.09.1987	Transferred	15.06.1992
3	Sh. C.M. Joshi	Admn.Officer	29.09.1992	Retired	31.5.1993
4	Sh. Roshan Lal*	Admn.Officer	18.10.1993	Transferred	07.06.1995
5	Sh. S.K. Gajmoti	Admn.Officer	15.01.1996	Transferred	21.07.2001
6	Sh. Hari Singh	Admn.Officer	09.07.2001	Transferred	04.04.2007
7	Sh. S.R.Sharma*	AAO	05.07.1984	Expired	07.02.2001
8	Sh. Lalit Kumar	UDC	01.12.1983	VRS	01.06.1989
9	Sh.Tarun Kumar	UDC	09.05.1995	Transferred	30.11.1995
10	Sh. Anil Kumar	Jr.Steno	16.03.1991	Transferred	12.07.1993
11	Sh. Roshan Lal Verma	PA	20.02.1989	Transferred	28.02.1990
	Technical				
1	Sh.Sudhir Gupta	Librarian	15.02.1989	Resigned	19.02.1990
2	Sh.Surender Pal	Library Asstt.	23.03.1991	Transferred	25.11.1992
3	Sh.Laxmi Kant	Photographer	06.06.1992	Transferred	02.07.1993
	Supporting				
1	Sh. Kaman Singh Negi	Lab.Attdt.	27.09.1989	Resigned	03.09.1991
2	Sh.Joginder Pal	Daftri	04.01.1984	VRS	15.01.2004
3	Sh.Dhani Ram*	SSG-IV	06.02.1984	Retired	31.10.2006
4	Sh.Vinod Kumar*	Safaiwala	08.02.1984	Terminated	19.10.1985
5.	Sh.Ashok Kumar	Safaiwala	09.03.1989	Terminated	25.08.1989

* Expired

(b) Staff: In Position

		Designation	Date of joining
	Administrative		
1	Sh. Raj Kumar	Admn.Officer	25.05.2007
2.	Sh. Jiwan Lal	AFACO	02.11.1994
3	Sh. Rishi Ram	AAO	06.12.1989
4	Sh. R.K. Bhatnagar	Asstt.	19.03.1984
5	Sh. Rajinder Sharma	Asstt.	01.06.1985
6	Sh. Bhim Singh	Asstt.	04.10.1989
7	Sh. Surjit Singh	PA	24.03.1990
8	Smt. Sunila Thakur	Steno Gr.III	06.12.1993
9	Sh. Deep Kumar	Steno Gr.III	03.10.1994
10	Sh. T.D. Sharma	UDC	20.01.1998
11	Sh. N.P. Negi	UDC	20.01.1998
12	Sh. Satinder Thakur	UDC	28.08.1993
13	Sh. Dharam Dass	LDC	01.02.1995
14	Smt. Shashi Poonam	LDC	09.02.1995
15	Sh. Roshan Lal Negi	LDC	17.06.1996
16	Sh. Sanjeev Sharma	LDC	15.11.1995
	Technical		
1	Sh. Sunil Verma	TO	11.01.1995
2	Smt. Reeta Bhatia	TO	20.08.1993
3	Sh. Jia Lal	TO	01.06.1983
4	Smt. Shailja Verma	TO	26.08.1994
5	Sh. Gian Chand	T-4	24.04.1991
6	Sh. Lekh Raj Rana	T-1-3	14.03.1986
7	Sh. Ram Swaroop	T-2	17.03.1986

		Designation	Date of joining
8	Sh. Parmanand	T-1-3	09.01.1989
9	Sh. Dala Ram	Driver T-3	09.12.1987
10	Sh. Ram Lal	Driver T-3	19.09.1996
11	Sh. Ram Ditta	Driver T-3	01.01.2000
12	Sh. Jeet Ram	T-2	13.10.1995
13	Sh. Guler Singh Rana	Electrician T-2	27.10.1995
14	Sh. Deepak Sharma	T-2	27.10.2001
	Supporting		
1	Smt. Dayawanti	SSG-IV	25.02.1991
2	Sh. Naresh Kumar	SSG-III	30.04.1990
3	Sh. Nika Ram	SSG-III	26.03.1991
4	Sh. Tej Ram	SSG-II	29.10.1991
5	Smt. Meera Devi	SSG-II	31.03.1992
6	Sh. Raj Kumar	SSG-II	01.02.1995
7	Sh. Ajeet Kumar	SSG-II	02.02.1995
8.	Sh. Arjun Dass	SSG-I	06.10.1995
9	Sh.Vinay Sharma	SSG-I	31.05.2002

Staff: In Position (Administrative)
















Staff: In Position (Technical)














Staff: In Position (Supporting)