वार्षिक प्रतिवेदन
ANNUAL REPORT
2005-2006

राष्ट्रीय खुम्ब अनुसंधान केन्द्र
NATIONAL RESEARCH CENTRE FOR MUSHROOM
(भारतीय कृषि अनुसंधान परिषद्)
(Indian Council of Agricultural Research)
चम्बाघाट, सोलन-173 213 (हि.प्र.), भारत
Chambaghat, Solan-173 213 (H.P.) India

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Compiled and Edited by : Dr. V.P. Sharma, Senior Scientist
Dr. Satish Kumar, Senior Scientist
Dr. M.P. Sagar, Senior Scientist

Published by : **Dr. R.P. Tewari**
Director,
National Research Centre for Mushroom
(Indian Council of Agricultural Research)
Chambaghat, Solan - 173 213 (H.P.)

Photography by : Mrs. Shailja Verma, Technical Officer
(Art & Photography Cell)

Hindi Translation : Dr. Shwet Kamal, SRF
Dr. M.P. Sagar
Mrs. Sunila Thakur, Stenographer (Typing)

Cover page designed by : Sh. Deepak Sharma, Computer Operator

Printed at : Yugantar Prakashan (P) Ltd., New Delhi-110064,
Ph: 011-28115949, 28116018

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PREFACE

The achievements of National Research Centre for Mushroom during 2005-2006 are summarized under various heads. During the year National Mushroom Respository has been enriched by addition of 371 mushroom cultures of which some are new records for India. RAPD markers were used as molecular tools for the molecular characterization of genetic variation induced via meiotic recombination and chromosomal segregation in the mushroom germplasm. Genetic improvement studies on temperate and tropical mushrooms were conducted and some promising single spore isolates in *Volvariella volvacea* and *Agaricus bisporus* and few hybrids in *Pleurotus florida* have been identified.

NRCM made a significant achievement in reducing the composting period by preparing button mushroom compost under total indoor condition in seven days time completely bypassing Phase-I condition of composting, with the help of thermophilic fungi. Spent Mushroom Substrate and Coir Pith proved to be the best casing materials and resulted in the highest mushroom yield. Moving ahead towards diversification, the cultivation technology of *Flammulina velutipes* has been standardized using polypropylene bags as cultivation containers. Efforts were made to increase the yields of *F. velutipes* and *Agrocybe aegerita* by supplementing the cultivation substrates with 10 per cent wheat bran which resulted in early spawn run and significantly higher yields of both the mushrooms. Different cultures of *Ganoderma lucidum* were evaluated for the yield potential and Thai culture was found to give the highest yield. The cultivation of Button, Oyster and Paddy straw mushrooms in low cost bamboo huts with good economic yields were demonstrated to the farmers. A workshop has been established at NRCM with various machineries. The design of semi-automatic compost turner of 5 tonnes/ hour capacity has been finalized and the fabrication is under progress. Studies on the effect of different commonly used insecticides in mushroom industry on some edible fungi were carried out which revealed that dichlorvos and chlorpyriphos completely inhibited the growth of all edible fungi and cyromazin was highly toxic to *Lentinula edodes* and *Pleutotus ostreatus*. Studies on persistence of malathion and phorate were also conducted and safer waiting periods have been worked out. Molecular characterization of various *Mycogone* cultures collected from different mushroom farms revealed no genetic variability whereas *Trichoderma* isolates, collected from various mushroom farms and procured from different AICMIP Centres were identified as *Trichoderma asperellum, T. harzianum T. longibrachiatum* and *T. virens* by DNA sequencing of 5.8S r RNA gene. NRCM has evoloved effective control measures against most of the important diseases and pests of mushrooms.

During the year under report, the Centre has organised a total number of 14 On & Off-campus training programmes for farmers, entrepreneurs & Agril/Hort Officers. Under the Central Sector Scheme “Integrated Development of Horticulture” in North- Eastern States under Technology Mission (Mini Mission–I), the Centre has planned to develop mushroom cultivation in all the NE states. One day Mushroom Mela was organised on 10th September, 2005. It was attended by about 650 mushroom growers, farmers, farm women, researchers, extension workers and businessmen from various states of India.

A progrssive farmer Mr. Vikash Benal was felicitated for adopting innovative practices in mushroom cultivation on larger scale.

Two scientists have been trained in advanced molecular techniques. One patent on "A method for preparing a mushroom growth promoting agent" was also granted to NRCM vide Indian Patent Office No. 193331 on 16th February, 2006. Besides this, several students were trained on various aspects of mushroom production technology.The employees of the centre participated in ICAR Zonal Sports Meet and won 6 medals including 3 gold medals.

India is blessed with varied agroclimate, abundance of agricultural wastes and manpower making it the most suitable for the cultivation of all types of mushrooms. NRCM is giving greater emphasis on the diversification in mushroom cultivation. Keeping in view the sub- tropical conditions of our country efforts are being made to standardize the cultivation technology of such mushroom species which suits to our conditions. Farmers are being motivated to cultivate these new mushrooms for better returns. Some growers have started the cultivation of milky mushroom and efforts are being made to popularize few other mushrooms like shiitake, winter, black ear, Reishi and black popular mushrooms whose cultivation technologies have been standardized. Awareness is being created among growers and in public that nutritionally, these mushrooms are not only at par with button mushroom but also have better medicinal values. Shiitake especially is becoming very popular among the consumers because of its unique taste and flavour and presence of a plasma lowering chemical. Diversification will also provide an opportunity to the seasonal mushroom growers for round the year cultivation and for utilization of different cultivation substrates.

NRCM developed infrastructrure facilities like water harvesting tank of one lakh litres capacity and one Type-I & II Qtrs. Face lifting of main building (Exterior and Interior) and special repair of hostel building is also completed. Temporary shed for parking of vehicles is provided and repair of rolling shutters as well as partition walls in Car Garrages of Resi. Complex completed.

The Centre is indebted to ICAR for financial support and Division of Horticulture for technical guidance. The editorial committee members of this annual report deserve appreciation for their sincere efforts in reflecting the significant achievements of NRCM.

(R.P. Tewari)
Director

कार्य सारांश

वर्ष 2005-06 के दौरान राष्ट्रीय खुम्ब अनुसंधान केन्द्र ने अनुसंधान, प्रसार एवं मानव संसाधन विकास के क्षेत्र में उल्लेखनीय प्रगति की है जिनका विवरण फसल उन्नयन, फसल उत्पादन, फसल संरक्षण, फसल पोषण एवं उपयोग, प्रसार एवं तकनीकी हस्तांतरण, खुम्ब सूचना प्रौद्योगिकी, शिक्षा एवं प्रशिक्षण, प्रकाशन, खेल-कूद एवं अन्य कार्यकलापों के अंतर्गत प्रस्तुत किया गया है।

फसल उन्नयन

क) जैव संपदा संग्रहण:- इस वर्ष हिमाचल प्रदेश, हरियाणा एवं चण्डीगढ़ के जंगली क्षेत्रों से कुल 371 जंगली खुम्बों के नमूने एकत्रित किये गये। जो मुख्यत: निम्नलिखित प्रजातियों के पाये गये - *एगेरिकस, एमैनिटा लिमासेला, आरमिलेरिया, बोलीटस, कैमेरोफिलस, क्लोरोफिलम, क्लाईटोसाईब, कौलीबिया, कौर्टिनेरियस, क्रेपीडोटस, इन्टोलोमा, गैलेसिया, जिम्नोपाईलस, गौर्म्फिडियस हिबेलामो, हाइग्रोफोरस, इनोसाईब, लैक्केरिया, लैक्टाईरस, लेपियोटा, लेन्टाईनस, ल्यूकोकोपराईनस, लेपिस्टा, लेक्किनम, ल्युकोपैक्सिलस, लायोफिलम, मैक्रोलेपियोटा, मारास्मियस, माईसिना, मिलैनोल्यूका, निमैटोलोमा, औडमैन्सियैला, सैथिरैला, पैनीयोलस, पैक्सिलस, प्लूटियस, प्लूरोफ्लैमुला, फोलियोटा, प्लूरोटस, पौलीपोरस, पैनस, पैनेलस, साइलोसाईब, रसूला, सुईलस, स्ट्रोबिलोमाईसेस, स्ट्रोफेरिया, ट्राइकोलोमा* एवं *वॉल्वेरियेला* आदि प्रजातियां।

ख) जंगली खुम्बों का वर्गीकरण:- इस वर्ष वर्ग *एगेरिकस* से संबद्ध खुम्बों के अलावा वर्ग *गैस्ट्रोमाईसीटस* एवं *एफाईलोफोरेलस* के भी खुम्बों का संग्रहण किया गया जिनमें से प्रमुख प्रजातियां *क्लोरोफाईलम, फोलियोटा, सी0एफ0स्कवारोजा/ स्कवेरायडस, फोलियोटा* सी0एफ0 *एल्बोक्रेनुलाटा, निमैओलोमा, जिम्नोपाईलस, क्रूगोम्फस* एवं *ल्यूकोकोपराईनस* थी। इन प्रजातियों का वर्गीकरण एवं अध्ययन विस्तार के किया गया।

ग) जैव संपदाओं का चरित्र चित्रण/विश्लेषण :- *ए0 बाईस्पोरस* की 22 श्वेत छत्रक प्रजातियों में विभिन्नता का आंकलन करने के लिये आर0ए0पी0डी0 को एक आनुवांशिक तकनीक के रूप में प्रयोग किया गया तथा यह पाया गया कि श्वेत छत्रक प्रजातियों एवं संकर प्रजातियों में डी0एन0ए0 स्तर पर बहुत कम विभिन्नता थी। इन प्रजातियों के 5.8 एस0 राईबोसोमल जीन के अनुक्रमों को देखने से यह पाया गया कि इनके आई0टी0एस0-1 एवं आई0टी0एस0-II प्रक्षेत्रों में कुछ अनुक्रमों का प्रतिस्थापन हुआ है। यू0पी0जी0एम0ए0 एवं एस0ए0एच0एन0 पर आधारित क्लस्टर (वर्ग) विश्लेषण द्वारा इन्हें दो आनुवांशिक वर्गों में विभाजित किया जा सका। इस विश्लेषण द्वारा प्रजातियों को संकर प्रजातियों से पूर्ण रूप से पृथक किया जा सका। प्रजाति एस-44, आई0ठी0सी0सी0- 1933 एवं डब्ल्यू आई0-1 को दस आर0ए0पी0डी0 प्राईमरों के आधार पर भी पृथक नहीं किया जा सका एवं इन प्राईमरों के आधार पर इनमें 100 प्रतिशत समानता पायी गई। इसी प्रकार प्रजाति एम0एस0-39 एवं आई0टी0सी0सी0-3609 को भी एक दूसरे से पृथक नहीं किया जा सका। *ए0 बाईस्पोरस* जैव संपदाओं में अनुवांशिक तौर पर समान प्रजातियों के पृथक्करण के लिये और ज्यादा आर0ए0पी0डी0 प्राईमरों का प्रयोग किया जायेगा। *कैलोसाईबी इंडिका* के 19 नमूनों को छह आर0ए0पी0डी0 प्राईमर के आधार पर सात आनुवांशिक वर्गों में विभक्त किया गया।

पुआल खुम्ब की प्रजाति ओ0ई0-210 के दस एकल बीजाणु संवर्धनों, जो कि कायकीय संरचना एवं लिग्नों-सेलूलोलाईटिक किण्वकों के उत्पादन में एक पुआल खुम्ब की प्रजाति ओ0ई0-210 के दस एकल बीजाणु संवर्धनों, जो कि कायकीय संरचना एवं लिग्नों-सेलूलोलाईटिक किण्वकों के उत्पादन में एक दूसरे से पृथक थे, का आनुवांशिक चरित्र-चित्रण

किया गया। इन एकल बीजाणु संवर्धनों एवं इनके पैतृक प्रजाति के 5.8 एस0 राईबोसोमल जीन के आई0टी0एस0 प्रक्षेत्र विश्लेषण से यह पता चला कि सभी संवर्धन एक ही अनुक्रम लंबाई (720) पर जैल पर पट्टी बनाते हैं। इन परिणामों से यह प्रमाणित हुआ कि सभी एकल बीजाणु संवर्धनों एक ही पैतृक तथा एक ही प्रजाति के हैं। इन सभी संवर्धनों का आर0ए0पी0डी0 विश्लेषण ओ0पी0बी0 श्रृंखला के पांच प्राईमरों (ओ0पी0बी0-1,2,3,4 एवं 5) के आधार पर किया गया तथा ओ0पी0बी0-3,4 एवं 5 द्वारा सभी एकल बीजाणु संवर्धन एवं पैतृक प्रजाति एक दूसरे से आनुवांशिक स्तर पर पृथक की जा सकीं।

घ) आनुवांशिक सुधार (उन्नयन):- शीतोष्ण एवं कटिबंधीय खुम्बों के आनुवांशिक उन्नयन के लिये अध्ययन किये गये। ए0 बाईस्पोरस के 44 एकल बीजाणु संवर्धनों का 16 आर0ए0पी0डी0 प्राईमरों के आधार पर आनुवांशिक चरित्र-चित्रण किया गया। आर0ए0पी0डी0 विश्लेष्ाण को बटन खुम्ब के व्यवसायिक यू0-3, एस0-2, ए0-46 एवं जंगली भूरी प्रजाति ए0-21 में अनुवांशिक विभिन्नता के आंकलन के लिये सर्वश्रेष्ठ तकनीक के रूप में पाया गया एवं आर0ए0पी0डी0 सूचकों के द्वारा इन प्रजातियों को दो आनुवांशिक वर्गो में औसतन 33 प्रतिशत की अनुवांशिक विभिन्नता के साथ वर्गीकृत किया गया। विभिन्न पैतृकों के एकल बीजाणु संवर्धनों में अनुवांशिक विभिन्नता का भी आकलन किया गया जो कि पैतृकों ए0-2 की संततियों में 15. 82 प्रतिशत, संकर ए0-46 की संततियों में 16.56 प्रतिशत, संकर यू-3 की संततियों में 17.27 प्रतिशत एवं भूरी प्रजाति ए0-21 की संततियों में 7.67 प्रतिशत पायी गई। कुल 21 एकलबीजाणु संवर्धनों में से ए0-2 प्रजाति के दो एस0एस0 आई 6301 एवं एस0एस0आई0-6305 तथा संकर प्रजाति यू-3 के दो एस0एस0आई0-8107 एवं एस0एस0आई-8109 एकल बीजाणु संवर्धनों ने सबसे अधिक पैदावार क्रमश: 17.5, 17.7, 19.2 एवं 20.2 किलोग्राम दी। जबकि यू-3 प्रजाति की उत्पादकता 15 किलोग्राम/100 किलोग्राम पास्चूरीकृत खाद में 6 हफ्तों में आंकलित की गई।

ढींगरी खुम्ब की प्रजाति *प्लूरोटस सेजोर-काजू* के 27 एकल बीजाणु संवर्धन बनाये गये तथा इनमें कायकीय विभिन्नता भी पायी गई। सभी संवर्धनों का संकरण लिंग निर्धारण के लिये किया गया। कुल 57 संकर प्रजातियां बनाई गई एवं उनके प्राथमिक उत्पादन के लिये गेहूं की तूड़ी पर प्रयोग किये गये। 35 संकर प्रजातियों में फलनकायों की प्राप्ति हुई जबकि इनमें से दो संकर प्रजातियां एच0-26 एवं एच-28 की कायकीय वृद्धि 25^0 सेल्सियस पर सबसे ज्यादा पायी गई। *प्लूरोटस फ्लोरिडा* प्रजाति के 13 एकल बीजाणु संवर्धनों के संकरण से कुल 6 संकर प्रजातियां बनायी गई जिनकी उत्पादकता पास्चूरीकृत गेहूं की तूड़ी पर अच्छी पायी गई।

पुआल खुम्ब के कुल 42 एकल बीजाणु संवर्धनों में बहुत ज्यादा विभिन्नता इनके वृद्धि, कवक जाल संरचना, कवक जाल घनत्व, वायवीय कवक जाल की उपस्थिति एवं क्लेमाईडोस्पोर की उपस्थिति के संबंध में पायी गई तथा इन मानकों के आधार पर संवर्धनों को चार वृहत वर्गो में वर्गीकृत किया गया।

वर्ष 2005-06 के दौरान 6 नये शिटाके खुम्ब (*लेन्टिन्यूला इडोडस*) संग्रहित किये गये तथा इनके शुद्ध संवर्धनों को रा0खु0अनु0 केन्द्र के संवर्धन बैंक में जमाकर इनके संवर्धन नम्बर लिये गये। शिटाके खुम्ब के 21 संवर्धन, जो कि रा0खु0अनु0केन्द्र के कल्चर बैंक से लिये गये, तथा नये संवर्धनों के डी0एन0ए0 विश्लेषण द्वारा उनमें अनुवांशिक विभिन्नता का पता लगाया गया। साथ ही साथ डी0एन0ए0 विश्लेषण द्वारा इनकी पहचान भी निर्धारित की गई। इन सभी संवर्धनों को भविष्य में प्रजनन प्रयोगों के लिये संरक्षित किया गया।

फसल उत्पादन

क) *एगेरिकस बाईस्पोरस* का उत्पादन

i) खाद निमार्ण:- इस वर्ष *ए0 बाईस्पोरस* खुम्ब उत्पादन पर दो प्रयोग किये गये जिनमें खाद निर्माण के लिये आधारभूत अवयव गेहूं की तूड़ी को लिया गया। खाद निर्माण के लिये अंत: खाद निर्माण

विधि का प्रयोग किया गया जिसमें -2 दिन पर खाद के लिये तूड़ी को गीला करना एवं अन्य अवयवों को मिलाना,-1 दिन पर खाद मिश्रण की पलटाई, एवं अवयवों को पूरी तरह से मिलाया गया- 0 दिन पर खाद मिश्रण को अवस्था-1 के टनल में भरा गया 3 दिन पर टनल से खाद मिश्रण निकालकर पलटाई की गई तथा पुनः टनल में भरी गई। अवस्था-II के दौरान 6 दिन पर, टनल में मिश्रण को भरा गया तथा 12 दिन पर तैयार खाद को बाहर निकाल कर इसकी बीजाई की गई। इस तरह से बनी खाद की मात्रा लिये गये गेहूं के भूसे से 2.9 गुना ज्यादा थी एवं औसतन उत्पादकता 14.3 किलोग्राम/100 किलोग्राम खाद चालीस दिनों में प्राप्त की गई। जबकि छोटी विधि द्वारा बनाई गई खाद की उत्पादकता इस प्रयोग में 13.46 किलोग्राम/100 किलोग्राम खाद आंकलित की गई। इस अंतः खाद निर्माण विधि द्वारा निर्मित खाद में से कुल आठ प्रकार की फफूंदियों का पृथक्करण किया जा सका जिनमें मुख्य फफूंदियां *म्यूकर, एस्परिजिलस नाईजर, एस्परजिलस* स्पी0, *पेनिसिलियम आक्जैलिकम, ट्राईकोडर्मा विरिडी, साईटेलिडियम थर्मोफिलम, ह्यूमिकोला इन्सोलेन्स* एवं एक अज्ञात फफूंद थे। इस खाद के निर्माण में अवस्था-II टनल के भरने के समय खाद में से निम्नलिखित फफूंदियों को पृथक किया गयाः *म्यूकर रेसीमोसस, साईटेलिडियम थर्मोफिलम, ह्यूमिकोला इन्सोलेन्स, ह्यूमिकोला ग्रीसिया, थर्मोमाइसेस लेनूजिनोसस, ऐलेरोमाईसेस डुपोन्टी* एवं *एस्परजिलस* स्पी0।

दूसरे प्रयोग में खाद में विभिन्न अवयवों का प्रयोग किया गया एवं इनका मूल्यांकन किया गया। इस प्रयोग के अंतर्गत खाद छोटी विधि द्वारा बनाई गई एवं सर्वश्रेष्ठ उत्पादकता (12.34 किलोग्राम/100 किलोग्राम खाद) उस खाद में पायी गई जिसमें मुर्गी की खाद एवं कपास के बिनौलों को कार्बनिक अनुपूरक के रूप में प्रयुक्त किया गया।

अंतः खाद निर्माण विधि द्वारा खाद निर्माण अवधि में महत्वपूर्ण कमी दर्ज की गई तथा इसके अंतर्गत अवस्था-I में थर्मोफिलिक फफूंदियों की मद्द से खाद बनाने की प्रक्रिया 7 दिनों में पूरी की गई तथा विभिन्न थर्मोफिलिक फफूंदियों के प्रयोग से बनी खाद की मात्रा में भी काफी विभिन्नता पायी गई। इस प्रयोग में खाद में नाईट्रोजन की मात्रा 0.91 से 3.57 प्रतिशत तक पायी गई एवं सबसे ज्यादा उत्पादकता (10.712 किलोग्राम/100 किलोग्राम खाद) एवं फलनकायों का द्रब्यमान (9.61ग्राम) ह्यूमिकोला ग्रीसिया की उपजाति एस0-4 द्वारा बनाई गई खाद में प्राप्त हुई।

ii) खाद आवरण एवं फसल प्रबंधनः- सर्वश्रेष्ठ खाद आवरण की पहचान हेतु विभिन्न प्रकार के खाद आवरणों का मूल्यांकन किया गया जैसे नारियल के रेशे-1, नारियल के रेशे-2, गोबर की खाद, अवशिष्ट खुम्ब खाद, शहरी अवशिष्ट खाद, अवशिष्ट खुम्ब खाद एवं नारियल के रेशे, गोबर की खाद एवं जली हुई धान की भूसी, नारियल के रेशे-1 जली जुई धान की भूसी, मिट्टी एवं जली हुई धान की भूसी इत्यादि। खुम्ब के फलनकायों का तुड़ान सर्वप्रथम अवशिष्ट खुम्ब खाद् नारियल के रेश में, अवशिष्ट खुम्ब खाद-जली हुई धान की भूसी तथा अवशिष्ट खुम्ब खाद में, खुम्ब आवरण के 15 दिनों बाद की गई। खुम्ब की अधिकतम उत्पादकता अवशिष्ट खुम्ब खाद एवं नारियल के रेशे के साथ प्राप्त हुई। साथ ही साथ नारियल के रेशे, जली हुई धान की भूसी में भी अच्छी खुम्ब की फसल दर्ज की गई। फसल प्रबंधन प्रयोगों से यह निष्कर्ष निकाला गया कि प्रति बैग प्रति दिन 200 मि0ली0 पानी का छिड़काव सर्वश्रेष्ठ फसल देता है।

ख) ढींगरी उत्पादन

ढींगरी उत्पादन में प्रकाश के प्रभाव के आंकलन के लिये विभिन्न ढींगरी प्रजातियों पर प्रयोग किये गये जिनमें से प्रमुख हैं *प्लूरोटस सजोर-काजू, पी0 फ्लोरिडा, पी0 फ्लैबेलेटस, पी0 इरिंजाई, पी0 फौसूलेटस* एवं *पी0 जैमोर।* इन प्रयोगों के परिणामों से यह पता चला कि कवक जाल फेलाव की अवधि में प्रकाश का प्रभाव कवक जाल वृद्धि एवं उत्पादकता पर ऋणात्मक पड़ता है एवं सभी *प्लूरोटस* प्रजाति *पी0 जैमोर* व *पी0 रोसियस* को छोड़कर जिनको कवक जाल फैलाव के लिये प्रकाश नहीं दिया गया, की उत्पादकता अच्छी पायी गई। पांच *प्लूरोटस* प्रजाति,

पी0 सजोर-काजू, पी0 फ्लोरिडा, पी0 फ्लेबेलेटस, पी0 सैपिडस एवं *पी0 जैमोर* की वाष्पीकरण द्वारा तापक्रम को नियंत्रित किया गया तथा औसत 10 प्रतिशत खुम्ब की फसल प्राप्त की गई।

ग) विशिष्ट खुम्बों का उत्पादन

एग्रोसाईबी एगेरिटा एवं *फ्लैमुलिना वेलुटिपस* की कवकजाल वृद्धि एवं उत्पादन पर विभिन्न प्रयोग किये गये तथा यह देखा गया कि जब चोकर को 10 प्रतिशत की दर से अनुपूरक के तौर पर प्रयोग किया गया तो खुम्ब की अधिकतम रैखिक वृद्धि एवं उत्पादकता (66.2 प्रतिशत एवं 37.5 प्रतिशत क्रमश:) प्राप्त हुई।

इन प्रयोगों में दोनों खुम्बों *(ए0 एगेरिटा* एवं *फ्लैमुलिना वेलुटिपस*) के लिग्नों सेलूलोसिक किण्वकों का परीक्षण किया गया तथा पाया गया कि चोकर के मिश्रण से सेलूलेज एवं हेमीसेलूलेज किण्वकों की अभिक्रिया में वृद्धि होती है जबकि कपास के बनौलों को मिलाने से सेलूलेज किण्वक की अभिक्रिया में ह्रास होता है।

दूधिया खुम्ब के उत्पादन के लिये माध्यम के पास्चूरीकरण की विधियों के मूल्यांकन पर प्रयोग किये गये तथा पाया गया कि पास्चूरीकृत माध्यम पर कवक-जाल वृद्धि सर्वश्रेष्ठ हुई एवं उत्पादकता भी अधिकतम पायी गई।

घ) औषधीय खुम्बों का उत्पादन

गैनोडर्मा ल्यूसीडम (रिशी) खुम्ब के चार विदेशी संवर्धनों का मूल्यांकन उनकी उत्पादकता एवं गुणवत्ता के लिये किया गया तथा थाईलैंड से मंगायी गई उपजाति जी-45 की उत्पादकता अधिकतम पायी गई एवं कोरिया की उपजाति ओ0ई0-53 की उत्पादकता थाईलैंड के जी-45 की तुलना में कम पायी गई।

ड.) खुम्ब फार्म संरचना

श्वेत बटन खुम्ब का उत्पादन बांस के बने उत्पादन कक्ष में लम्बी विधि द्वारा बनायी गई खाद पर किया गया तथा अच्छी फसल प्राप्त की गई। ढींगरी एवं पुआल खुम्ब का उत्पादन की पास्चूरीकृत गेहूं के भूसे पर बांस के बने उत्पादन कक्ष में सफलतापूर्वक किया गया। एक अन्य प्रयोग में मिट्टी के बने खुम्ब उत्पादन कक्ष में गर्मी के मौसम में लम्बी विधि द्वारा बनायी गई खाद पर श्वेत बटन खुम्ब की उत्पादकता का मूल्यांकन किया गया। इस मिट्टी के कक्ष में वाष्पीकरण द्वारा तापक्रम को नियंत्रित किया गया तथा औसत 10 प्रतिशत खुम्ब की फसल प्राप्त की गई।

फसल संरक्षण

हरियाणा एवं हिमाचल प्रदेश की विभिन्न खुम्ब इकाईयों का सर्वेक्षण किया गया तथा इनमें गीला बुलबुला बीमारी, ब्राउन प्लास्टर मोल्ड, हरी फफूंदी एवं इंक कैप का प्रकोप अधिकतम इकाईयों में पाया गया। इन सभी इकाईयों में सियारिड मक्खियां, माईटस एवं स्प्रिंगटेल नामक मक्खियां प्रमुखत: पाई गई।

मइकोगोन पर्निसियोसा का विस्तृत शरीरतंत्रीय अध्ययन किया गया एवं इस फफूंदी की वृद्धि के लिये वाक्समैन अगर एवं माल्ट एक्सट्रेक्ट पेप्टोन डेक्सट्रोज अगर माध्यम को सर्वश्रेष्ठ पाया गया। विभिन्न तापक्रमों पर इस फफूंदी की वृद्धि के लिये प्रयोग किये गये एवं 20^0 सेल्सियस तथा 25^0 सेल्सियस पर इसकी वृद्धि अधिकतम दर्ज की गई। साथ ही साथ मैनीटोल एवं एलानाइन को सर्वश्रेष्ठ कार्बन एवं नाईट्रोजन स्त्रोत पाया गया जबकि एस्पाराजीन को इस फफूंदी द्वारा सबसे कम प्रयोग किया गया। इन फफूंदी के प्रबंधन के लिये सर्वोत्तम फफूंदीनाशक क्लोरोथैलोनिल (कवच) को पाया गया जबकि किसी भी पादप के अर्क द्वारा इस फफूंदी की कवकजाल वृद्धि पर कोई प्रभाव नहीं पड़ा।

सेपीडोनियम क्राइसोस्पोरियम के शरीरतंत्रीय अध्ययन से जैपेकडाक्स एवं सबोरैडस माध्यम को कवक जाल वृद्धि के लिये सर्वश्रेष्ठ आंका गया तथा तापक्रम आवश्यकता अध्ध्यन से पता चला कि क्रमश: अधिकतम कवक जाल वृद्धि 30^0 से 25^0 सेल्सियस पर होती है। माल्टोज एवं सोडियम नाईट्रेट को क्रमश: सर्वश्रेष्ठ कार्बन तथा नाईट्रोजन स्त्रोत

आंका गया। इस फफूंदी के प्रबंधन के लिये बैविस्टीन, कैप्टाफॉल एवं स्पोरगौन को सबसे ज्यादा प्रभावशाली पाया गया जबकि पादप अर्को में कैस्टर के अर्क द्वारा इस फफूंदी की कवकजाल वृद्धि को 24 प्रतिशत तक रोका जा सका।

खुम्ब उत्पादन के दौरान साधारणत: प्रयोग होने वाले कीटनाशकों का प्रभाव सात विभिन्न खुम्बों पर प्रयोगशाला स्थितियों में देखा गया तथा इनका प्रभाव सियारिड लार्वा पर ए0बाईस्पोरस के उत्पादन के दौरान चार बार छिड़काव करके देखा गया। इन प्रयोगों के परिणाम से यह पता चला कि डाइक्लोरवॉस (0.1 प्रतिशत) एवं क्लोरोपाइरीफॉस (0.1 प्रतिशत) द्वारा सभी खुम्बों की कायिक वृद्धि 100 प्रतिशत तक रूक जाती है तथा क्रयोमाईजिन को लेन्टान्यूला इडोडस एवं प्लूरोटस ऑस्ट्रीएटस पर सबसे ज्यादा प्रभावी पाया गया। जबकि डीकामेथ्रीन को इन दोनों खुम्ब के प्रति अप्रभावी पाया गया। नीमैक्स (1 प्रतिशत) को (सिवाय *ले0इडोडस* के सभी खुम्बों के प्रति विषाक्त नहीं पाया गया) मैलाथियोन के छिड़काव से खुम्बों में खोखलेपन की समस्या नहीं आयी परंतु उत्पादकता में कमी अवश्य दर्ज की गई। सबसे ज्यादा खुम्ब की उत्पादकता (16.36 किलोग्राम) डीकामैथ्रीन के छिड़काव के साथ पायी गई जबकि सबसे कम उत्पादकता क्लोरपाईरीफास के छिड़काव द्वारा दर्ज की गई। नीमैक्स के छिड़काव वाले प्रयोग में खुम्ब में खोखलेपन की समस्या पायी गई तथा *ट्राइकोडर्मा वाइरेन्स* (टी0-1-1 एवं टी-21) द्वारा सबसे ज्यादा फसल उत्पादन का ह्रास पाया गया तथा तत्पश्चात *ट्राइकोडर्मा हर्जिएनम* द्वारा अधिकतम फसल का ह्रास दर्ज किया गया। जबकि *ट्राइकोडर्मा हर्जिएनम* (टी-18 एवं टी-16) द्वारा *प्लूरोटस सेजोर-काजू* एवं *कैलोसाईब इंडिका* की फसल का अधिकतम नुकसान दर्ज किया गया। साथ ही साथ ये भी देखा गया कि जब ट्राइकोडर्मा को बीजाई के समय खुम्ब के माध्यम में डाला गया तो सबसे ज्यादा नुकसान दर्ज किया गया।

फसल पोषण एवं उपयोग

श्वेत बटन खुम्ब के रख-रखाव के अध्ययन के दौरान खुम्बों के रंग में बदलाव का अध्ययन किया गया तथा इसके लिये एल0 ए0 एवं बी0 प्रणाली का प्रयोग किया गया। इस अध्ययन में विभन्न प्रकार के पैकिंग पदार्थ जैसे कि पॉलीथीन, पॉलीप्रोपीलीन एवं पी0वी0सी0 के थैलों का प्रयोग किया गया। साथ ही साथ इन प्रयोगों में खुम्बों के नमूने विभिन्न अंतरालों पर लेकर उनकी गुणवत्ता का विश्लेषण भी किया गया। एक अन्य प्रयोग में मोडिफायड एटमोस्फेयर पैकेजिंग का प्रयोग किया गया जिसके परिणाम का विश्लेषण किया जा रहा है।

खुम्ब उपकरणों का निर्माण

राष्ट्रीय खुम्ब अनुसंधान केन्द्र में एक अभियांत्रिकी कार्यशाला का निर्माण किया गया ताकि खुम्ब उत्पादन में प्रयुक्त विभिन्न क्रिया-कलापों के लिये उपयुक्त एवं किफायती उपकरणों की रूपरेखा एवं निर्माण किया जा सके। इस परियोजना के अंतर्गत एक कम्पोस्ट टर्नर की रूप रेखा एवं निर्माण का कार्य प्रगति में है।

प्रसार एवं तकनीकी हस्तांतरण

स्थानीय तकनीकी ज्ञान जैसे बटन खुम्ब उत्पादन हेतु कृत्रिम खाद का उपयोग, जली हुई धान की भूसी, गोबर की खाद एवं मिट्टी के विभिन्न अनुपातों से सत्यापित किया गया। इन प्रयोगों से यह पता चला कि कृत्रिम खाद का प्रयोग बटन खुम्ब उगाने के लिये नहीं किया जा सकता है। जबकि खाद आवरण के रूप में जली हुई धान की भूसी, गोबर की खाद एवं मिट्टी के मिश्रण में सभी अनुपातों में बहुत ही अच्दी कवक जाल वृद्धि दर्ज की गई। परंतु कवक जाल फेलाव में साधारण खाद आवरण के अपेक्षा अधिक समय लगा। सर्वाधिक खुम्ब उत्पादकता जली हुई धान की भूसी+मिट्टी एवं गोबर की खाद (1:1:1 v/v) में प्राप्त हुई। खुम्ब उत्पादन में विविधता लाने को ध्यान में रखते हुए केन्द्र में अप्रैल से जुलाई माह, 2005 तक मिल्की खुम्ब की एक फसल उगाई गई तथा इसकी उत्पादन तकनीकी का प्रसार हिमाचल प्रदेश के जैसे हमीरपुर, बिलासपुर, मण्डी एंव उना जिलों में किया गया। इस वर्ष सोलन जिले के खुम्ब उत्पादकों को भी गर्मियों में मिल्की खुम्ब के उत्पादन के लिये प्रेरित किया

तथा ग्राम तोप की बेड़ के तीन किसानों की खुम्ब इकाईयों पर केन्द्र द्वारा मिल्की खुम्बी की फसल प्रसार कार्य हेतु लगाई गई। राष्ट्रीय खुम्ब अनुसंधान केन्द्र ने इस वर्ष भारतीय पशु चिकित्सा अनुसंधान संस्थान द्वारा आयोजित प्रदर्शनी में 18-20 अक्टूबर, 2005 तक तथा प्रगति मैदान में आयोजित कृषि प्रदर्शनी 2006 में 8-12 मार्च, 2006 तक भाग लिया।

खुम्ब सूचना प्रोद्यौगिकी

केन्द्र द्वारा अर्जित सूचनाओं के आधार पर वर्ष 2005-06 के दौरान भारत वर्ष में खुम्ब उत्पादन 72000 टन आंका गया है। इस वर्ष केन्द्र में आयोजित प्रशिक्षण शिविरों में दिये जाने वाले व्याख्यानों को केन्द्र की वेबसाईट पर भी उपलब्ध कराया गया एंव अब विभिन्न वैज्ञानिको से वेबसाईट पर ही सम्पर्क किया जा सकता है। इससे खुम्ब उत्पादन से संबद्ध जानकारियाँ आसानी से विश्व के किसी भी कोने में बैठे-बैठे प्राप्त की जा सकती है।

केन्द्र का अंकीय रेखाचित्र बनाया गया जिसमें केन्द्र की गतिविधियों को विस्तार से बताया गया है। साथ ही साथ विभिन्न खुम्ब उत्पादन उनकी वित्तीय विश्लेषण एंव औषधीय गुणों से संबद्ध जानकारियों को भी अंकीय रूप में वेबसाईट पर दिया गया है।

शिक्षा एंव प्रशिक्षण

इस वर्ष केन्द्र ने मानव संसाधन विकास के क्षेत्र में महत्वपूर्ण प्रगति की है। डा0 महेश चंद्र यादव ने **जैव सूचना प्राद्योगिकी एंव पादप अनुवांशिकी** पर 3 दिनों का एक प्रशिक्षण लिया जो कि जैव सूचना प्राद्योगिकी केन्द्र चौधरी श्रवण कुमार हिमाचल पद्रेश कृषि विश्वविद्यालय, पालमपूर में हुई। इसके अलावा डा0 आर0सी0 उपाध्याय ने जैव-रसायन विभाग भारतीय कृषि अनुसंधान संस्थान में 21 दिनों का एक प्रशिक्षण **विकसित जैव-रसायनिक एंव आवणिक जीव-विज्ञान तकनीक'** पर लिया। डा0 आर0पी0 तिवारी, निदेशक ने बंगलादेश में खाद्य एंव कृषि संगठन के सलाहकार के रूप में दो महीने दिसम्बर, 2005 से फरवरी, 2006 तक कार्य किया। उन्होनें समेकित बागवानी एंव पोद्दाण परियोजना में खुम्ब के विशेषज्ञ के रूप में कार्य किया। डा0बी0एल0 धर को इंडियन माईकोलौजिकल सोसाइटी द्वारा खुम्ब के क्षेत्र में कार्य करने के लिये फेलो के रूप में वनस्पति विज्ञान विभाग, कलकत्ता विश्वविद्यालय में सम्मानित किया गया।

प्रकाशन

इस वर्ष केन्द्र के वैज्ञानिकों द्वारा कुल 17 शोध-पत्र राष्ट्रीय एंव अन्तर्राष्ट्रीय शोध पत्रिकाओं में प्रकाशित किये गये। इसके अलावा 17 पुस्तक अनुभाग, दो तकनीकी बुलेटिन, 9 तकनीकी लेख एंव 22 सारांश भी प्रकाशित किये गये।

खेल एंव अन्य क्रियाकलाप

वर्ष 2005-06 में राष्ट्रीय खुम्ब अनुसंधान केन्द्र ने राष्ट्रीय डेरी अनुंसधान संस्थान में हुई भारतीय कृषि अनुसंधान परिषद द्वारा आयोजित क्षेत्रीय खेल-कूद प्रतियोगिता में भाग लिया एंव विभिन्न प्रतियोगिताओं में 3 स्वर्ण पदक एंव 3 रजत पदक जीते। इस वर्ष केन्द्र के दो वैज्ञानिकों एंव एक तकनीकी कर्मचारी को पदोन्नत किया गया।

EXECUTIVE SUMMARY

The Centre has made significant progress in research, transfer of technology and human resource development. The achievements of National Research Centre for Mushroom during 2005-2006 are summarized under the heads; Crop Improvement, Crop Production, Crop Protection, Crop Nutrition and Utilization, Development of Indigenous Machinery, Transfer of Technology, Mushroom Information Technology, Education and Training, Publications, Sports and other activities.

CROP IMPROVEMENT

(a) Germplasm Collection: During the year 371 wild mushrooms were collected from the forest areas of Himachal Pradesh, Haryana and Chandigarh. The major genera collected were: *Agaricus, Amanita Armillaria, Boletus, Camerophyllus, Chlorophyllum, Clitocybe, Collybia, Cortinarius, Crepidotus, Entoloma, Galerina, Gymnopilus, Gomphidius, Hebeloma, Hygrophorus, Inocybe, Laccaria, Lactarius, Lepiota, Lentinula, Leucocoprinus, Lepista, Leccinum, Leucopaxillus, Lyophyllum, Macrolepiota, Marasmius, Mycena, Melanoleuca, Nematoloma, Oudmansiella, Psathyrella, Paneolus Paxillus, Pluteus, Pleuroflammula, Pholiota, Pleurotus, Polyporus, Panus, Panellus, Psilocybe, Russula, Suillus, Strobilomyces, Stropharia, Tricholoma* and *Volvariella* .

(b) Taxonomy of wild mushrooms: In addition to agaricoid fleshy fungi specimens were also collected of several Gasteromycetes and Aphyllophorales. Some of the interesting collections namely, *Chlorophyllum* sp., *Pholiota* c.f. *squarrosa/ squarroides, Pholiota* c.f. *albocrenulata, Naematoloma, Gymnopilus,Chroogomphus,* and *Leucocoprinus* sp. examined during the year were described in detail.

(c) Germplasm characterization: RAPD markers were used as molecular tools for genetic characterization and assessment of diversity in 22 *A. bisporus* white pileus strains. White pileus strains and hybrids exhibited low level of DNA polymorphism. DNA sequencing of 5.8S rRNA gene revealed base pair substitutions both in ITS-I and ITS-II regions. The cluster analysis based on UPGMA and SAHN revealed two phylogenetic groups among 22 genotypes studied. The hybrids were clearly distinguished from the strains and were clustered in a separate group. The strains S-44, ITCC-1933 and WI-1 could not be distinguished from each other using ten random primers and showed 100% similarity among them. Similarly, strains MS-39 and ITCC-3609 were not distinguished from each other. More RAPD primers shall be used to ascertain the duplicate/ genetically close strains in the germplasm of *A. bisporus*. The phylogenetic analysis of the RAPD scorable prominent bands exhibited both inter- and intra-specific polymorphism in *Calocybe* group of accessions. All the six arbitrary decamer RAPD primers amplified the genomic scorable DNA fragments of all the 19 accessions of *Calocybe indica* and separated them into seven distinct phylogenetic sub-clades.

Molecular characterization of 10 single spore isolates of paddy straw mushroom with parent strain OE-210 showing variations in their morphological growth characteristics and in lingo-cellulolytic enzymes activities was carried out. The PCR – amplified product of the ITS region of 5.8S ribosomal gene by using two primers

(ITS-1 and ITS-4) revealed that all the SSIs and the parent strain exhibited bands at nearly 720 bp length on the gel. The results proved that all the SSIs belong to the same species as of the parent strain and there was no variation at species level or contamination from other related mushroom mycelia. The variations in all the single spore isolates and the parent strain OE-210 were studied by obtaining the RAPD profiles by using 5 different OPB series primers (OPB-1, 2, 3, 4 and 5). Primer OPB-3, OPB-4 and OPB-5 generated different discrete bands in different SSIs and the parent strain.

(d) Genetic improvement: Studies for genetic improvement of temperate and tropical mushrooms were conducted in different mushrooms. Molecular characterization of 44 SSIs of *A. bisporus* was accomplished using 16 random primers. RAPD fingerprinting was found as an efficient tool to reveal usable levels of DNA polymorphism among the progenies of commercial hybrid U-3, strain A-2, hybrid A-46 and wild brown strain A-21. RAPD markers clustered the genotypes into two phylogenetic groups with average genetic diversity of 33%. The genetic diversity among progenies of parent A-2 was 15.82%, while it was 16.56% in SSIs of hybrid A-46, 12.27% in SSS of hybrid U-3 and 7.67% in SSIs of brown strain A-21. Out of 21 single spore progenies, four single spore selections namely SSI-6301, SSI-6305 from strain A-2 and SSI-8107 and SSI-8109 from hybrid U-3 produced significantly higher yields of 17.5, 17.7, 19.2 and 20.2 kg, respectively, while, standard check hybrid U-3 yielded 15.0 kg/ 100kg pasteurized compost, in 6 weeks of cropping under partially controlled environmental conditions.

In case of oyster mushroom twenty seven single spore cultures of *Pleurotus sajor-caju* were isolated. The single spores cultures showed wide variability. All the isolates were hybridized for determining mating types. In all a total of 57 hybrids were developed. Preliminary cultivation trail using wheat straw gave fructifications in 35 strains. Two hybrids viz. H-26 and H-28 were found very fast growing at 25°C. Six out of 31 strains of *Pleurotus florida* developed by hybridization of thirteen single spores, were found promising in terms of yield performance on pasteurized wheat straw during winter.

In case of paddy straw mushroom a total of 42 single spore isolates were studied. These SSIs showed wide variations in their growth rates, type of mycelial thread, density of mycelial growth, presence of the aerial mycelia and the chlamydospores. Based upon these growth parameters the SSIs were found to belong to 4 major groups.

Twenty-one shiitake (*Lentinula edodes*) strains were procured from NRCM Culture Bank and Six new shiitake strains were collected during 2005-06. New cultures have been deposited in NRCM culture bank and accession numbers assigned. Assessment of genetic diversity and strain typing validated that all the strains are of *Lentinula edodes*. All the 27 shiitake strains were sub-cultured twice during 2005-06 for their use in breeding programme.

CROP PRODUCTION

(a) *Agaricus bisporus* cultivation

(i) Compost preparation

Cultivation trial were conducted two times in the season taking wheat straw as the base material. Compost was prepared by wetting and mixing of ingredients on -2 day: Wetting and mixing of the ingredients out doors, -1 day:Turning, trampling by Bobcat and thorough mixing of the ingredients, addition of water, 0 day: Filling in the phase-I tunnel, +3 day: Emptying the

tunnel, turning and mixing of the ingredients, addition of water and filling the Phase-I tunnel, +6 day: Filling the phase-II tunnel, +12 day: Phase-II operation over. Wheat straw to compost conversion ratio was 2.9 times. An average yield of 14.03Kg/ 100Kg compost was obtained from the trial in forty days of cropping period as against 13.46 Kg obtained with short method of compost. A total number of eight mesophilic fungi were isolated which included, *Mucor* sp., *Aspergillus niger, Aspergillus* sp., *Penicillium oxalicum., Trichoderma viride, Scytalidium thermophilum, Humicola insolens* and an unidentified species. At filling seven fungi namely *Mucor racemosus, Scytalidium thermophilum, H. insolens, H. grisea, Thermomyces lanuginosus, Talaromyces duponti* and *Aspergillus* sp. were isolated. In another trial different compost formulations were evaluated. Different piles were prepared using different formulations. Compost was prepared by short method of composting. The highest yield (12.34 kg/ 100kg compost) was recorded in the treatment in which chicken manure and cotton linter were added as the organic supplements.

Composting period was considerably reduced by preparing *A. bisporus* compost under total indoor condition in seven days time completely by passing Phase-I condition of composting, with the help of thermophilic fungi. Sifnificant variation was noticed in weight loss of the compounding mixture in different treatments using different thermophillic fungi. N% ranged between 0.91-3.57 in different treatments. The highest fruit body weight (9.61g) and the highest yield of 10.7 Kg/100Kg compost was obtained with S-4 strain of *H. grisea.*

(ii) Casing and crop Management in *Agaricus bisporus*: Coirpith-1, Coirpith-2, Farm Yard Manure, Spent Mushroom Substrate, City Refuse Compost, SMS + Coir pith, FYM+Burnt Rice Husk, SMS + Burnt Rice Husk, Coir pith-I + Burnt Rice Husk and Press Mud + Burnt Rice Husk were tested. Mushrooms were harvested in shortest time of 15 days after casing with SMC + Coir pith, SMS + Burnt Rice Husk and Spent Mushroom Substrate casing materials. The highest mushroom yields were recorded from SMS, CP-II, CP-I followed by SMS+CP and SMS+BRH treatments. Determination of water regime studies revealed that application at 200 ml of water per day per bag resulted in higher crop yields.

(b) Oyster mushroom cultivation: Effect of light on different *Pleurotus* spp. namely *P. sajor-caju, P. florida, P. flabellatus, P. eryngii, P. fossulatus* and *P. djamor* was assessed. The result indicated that light during incubation has negative influence on mycelial growth and yield. All the *Pleurotus* species incubated in dark gave better yield then the bags kept in light except *P. djamor* var. *roseus*. Five *Pleurotus* spp. namely *P. sajor-caju, P. florida, P. flabellatus, P. sapidus* and *P. djamor* were selected to assess the effect of temperature shock treatment on growth. Plates of *P. djamor* kept at 15ºC did not give fructifications while all the plates kept at 20, 25 and 30ºC gave fructification. Evaluation of different spawn rates in *Pleurotus fossulatus* revealed that 10% spawn rate was optimum as it resulted in the highest yield followed by 8%, 6%, 4% and 2% in decreasing order. Supplementation of wheat straw with wheat bran resulted in the highest productivity of *P. fossulatus.*

(c) Cultivation of Specialty mushroom: Investigations on the effect of different supplements on the mycelial growth and yield of *Agrocybe aegerita* revealed that wheat bran at the rate of 10 per cent supported the fastest linear

growth. Addition of 10 per cent wheat bran in wheat straw resulted in the quickest spawn run and the highest (66.2%) biological efficiency. In case of *Flammulina velutipes*, wheat bran at the rate of 10 per cent supported the fastest linear growth. Addition of 10 per cent wheat bran in saw dust resulted in the quickest spawn run and the highest (37.5%) biological efficiency. Addition of wheat bran resulted in increased activity of cellulases and hemicellulases in *Agrocybe aegerita* whereas cotton seed cake resulted in reduced activity of cellulases. Similarly, addition of wheat bran resulted in increased activity of cellulases, hemicellulases and peroxidases in *Flammulina velutipes*, whereas cotton seed cake, soybean meal and deoiled soybean resulted in reduced activity of these enzymes.

Evaluation of substrate treatment methods for the cultivation of milky mushroom revealed that bavistin and formaldehyde completely inhibited the mycelial growth of *Calocybe indica* at all the concentrations tried under *in vitro* conditions. The highest yield was recorded in pasteurized substrate, whereas, spawn failed to colonize the substrate which was chemically treated.

(d) Cultivation of medicinal mushrooms: Four exotic cultures of the medicinal mushroom Reishi (*Ganoderma lucidum*) were evaluated for yield and quality and Thai culture gave the highest yield followed by Korean OE-53.

(e) Mushroom farm design: Button mushroom was raised in bamboo hut seasonally on compost prepared by long method. Oyster mushroom and paddy straw mushroom were also grown in early summer on steam pasteurized wheat straw substrate with partial success. A cultivation trial on button mushroom using the compost prepared by long method and evaporative cooling system in mud house resulted in 10 % crop yield.

CROP PROTECTION

Survey of different mushroom farms revealed the widespread incidence of wet bubble, brown plaster mould, green moulds, ink caps in different farms of Haryana and Himachal Pradesh. Sciarid flies, phorid flies, mites and sprigtails were common in most of the farms visited. Detailed physiological studies on *M. perniciosa* were conducted which revealed that Walksmen agar medium was the best followed by malt extract peptone dextrose agar medium. Among the different temperature regimes tested, best growth was recorded in 25^{0}C followed by 20^{0}C. Mannintol and alanine were proved to be the best carbon and nitrogen sources, respectively, whereas, asparagine was found to be least acceptable nitrogen source . Management studies revealed that chlorothalonil (kavach) was the most toxic, whereas, none of the plant extract were able to cause inhibition of mycelial growth of *M. perniciosa*.

Physiological studies on *S. chrysospermum* revealed that Czapekdox agar medium was the best followed by Subourands medium. Among the different temperature regimes tested, best growth was recorded at 30^{0}C followed by 25^{0}C. Maltose and sodium nitrate were proved to be the best carbon and nitrogen sources, respectively. Management studies revealed that bavistin, captafol and sporgon were the most toxic fungicides, whereas, among plant extract castor was able to inhibit the mycelial growth of *S. chrysospermum* up to 24 per cent.

Effect of some insecticides commonly used during mushroom cultivation, was studied on seven edible fungi under *in-vitro* conditions by food poisoned technique and also on sciarid larvae under *in-vivo*

conditions during *Agaricus bisporus* cultivation by giving 4 sprays starting at casing. Dichlorvos (0.1%) and chlorpyriphos (0.1%) completely inhibited the growth of all edible fungi and cyromazin was highly toxic to *Lentinula edodes* and *Pleurotus ostreatus*. Decamethrin was not toxic to *L. edodes* and *P. ostreatus*. Neemax (1.0%) was least toxic to all the edible fungi except *L. edodes*. Tunneling index was nil in mushroom fruit bodies when Malathion was sprayed but yield was also marginally reduced over control. Highest yield (16.36Kg/100 kg compost) was recorded in case of decamethrin. Highest tunneling index (4) was recorded in case of neemax and lowest yield in chlorpyriphos. Screening of different *Pleurotus* spp. against sciarid larvae revealed that under laboratory conditions, *P. eryngii* proved most susceptible to sciarids followed by *P. ostreatus* and *P. sajor-caju*. However, no feeding was observed on *P. sapidus*. Studies on persistence of malathion on white button mushroom revealed that when five sprays of 0.01% concentration were given during different growth stages of crop, residue of malathion ranged from 0.172-0.011ppm, 0.254-0.083ppm and 0.0189-0.062 ppm in first, second and third flushes , respectively. When 0.05% concentration was sprayed, residue in first, second and third flush ranged from 0.0624-0.316ppm, 0.066-0.141ppm and 0.874-0.004ppm, respectively. When 0.1% concentration was sprayed, residue in first, second and third flush ranged from 0.698-0.091ppm, 0.102-0.429ppm and 0.167-0.132 ppm, respectively.

Studies on persistence of phorate on white button mushroom revealed that in long method compost incorporation of 600 g phorate/ 300 kg of compost resulted in much higher than the maximum permissible residue level of phorate.

Ten *Mycogone* cultures collected from different locations were identified as *Mycogone perniciosa* by ITS sequencing of 5.8S r RNA gene . RAPD profile studies of these *Mycogone* isolates exhibited no genetic variability .

Eight *Trichoderma* isolates, isolated from various mushrooms namely, *Lentinula edodes, A. bisporus , Pleurotus sajor-caju* and four procured from different AICMIP centres, Ludhiana, Coimbatore, Vellayani and Ranchi were identified as *Trichoderma asperellum, T. harzianum T. longibrachiatum* and *T. virens* by ITS sequencing of 5.8S r RNA gene.

Molecular characterization of six isolates of *Cladobotryum* collected from *Pleurotus, Calocybe* and *Agaricus bisporus* revealed their identities as *Cladobotryum dendroides* and *C. asterophorum* by ITS sequencing of 5.8S r RNA gene. Phylogenetic analysis of 6 *Cladobotryum* isolates exhibited four phylogenetic groups.

T1-1 (*Trichoderma virens*) and T21 (*T. virens*) isolates resulted in the maximum yield loss in *Agaricus bisporus* followed by T16 *(T. harzianum).* T-18 *(T. harzianum)* isolate resulted in the maximum yield loss in *Pleurotus sajor-caju* and *Calocybe indica* followed by T16. Irrespective of isolates and mushrooms the yield loss was more when inoculation was done at spawning stage.

CROP NUTRITION AND UTILIZATION

The colour values in terms of three-dimensional space L, a, b system was adopted for the measurement of colour of button mushroom. Studies are being carried out on the modified atmospheric packaging (MAP) of button mushroom in polythene, polypropylene bags and in the cardboard punnets wrapped with PVC film.

DEVELOPMENT OF INDIGENOUS MACHINERY

A workshop has been established at NRCM with various machineries. The design of semi-automatic compost turner of 5 tonnes/ hour capacity has been finalized and the fabrication of the machine is under progress.

TRANSFER OF TECHNOLOGY

Indigenous technical knowledge viz. use of vermicompost as growing substrate for button mushroom and use of burnt rice husk mixed with F.Y.M. and soil in different ratio as casing material were verified through experimental trials. Use of vermicompost as substrate for white button mushroom cultivation was not found suitable. In I.T.K.use of burnt rice husk in combination with soil and F.Y.M. as casing material revealed excellent case run in all the combinations but time taken for case run was more than standard. The maximum yield was recorded in those bags where burnt rice husk+soil+FYM, (1:1:1v/v) was used. Refinement in I.T.K. about use of Spent Mushroom Substrate as manure in the field crops revealed that twelve months old aerobically recomposted SMS and 6-24 months old naturally weathered SMS application @ 2.5 kg/m^2 gave the higher yield of tomato and lower incidence from blossom end rot and buckeye rot diseases. Six to eighteen months old naturally weathered SMS and 12 months old anaerobically recomposted SMS enhanced the yield of capsicum and restricted incidence of fruit rot disease. The 18 months old naturally weathered and anaerobically recomposted SMS gave better yield and quality of pea along with lower incidence of *Fusarium* wilt and powdery mildew diseases.

The Centre has conducted a number of training programmes sponsored by various departments/ agencies. Studies on impact assessment of sponsored training programme in terms of adoption of mushroom cultivation were conducted in HP. The data obtained showed 12.08 and 18.9 % adoption of mushroom cultivation in Hamirpur and Chamba districts of H.P., respectively. It indicates that sponsored training programmes are effective in mobilizing the SHGs to choose mushroom cultivation as source of income. Under the Central Sector Scheme "Integrated Development of Horticulture" in North-Eastern States under Technology Mission (Mini Mission–I), the Centre has planned to develop mushroom cultivation in all the NE states. Under this scheme, five days off-campus training programmes were also organized at Gangtoke (Sikkim), Guwahati (Assam), Imphal (Imphal) and Agartala (Tripura) . During the year under report, the Centre has organised a total number of 14 On&Off-campus training programmes for farmers, entrepreneurs & Agri./Hort Officers. One day Mushroom Mela was organised on 10th September, 2005. It was attended by about 650 farmers, farm women, mushroom growers, researchers, extension workers and businessmen from various States viz; Himachal Pradesh, Haryana, Punjab, Uttar Pradesh, Bihar, Maharashtra, Rajasthan, Delhi, Sikkim,Kerala and Uttranchal. An exhibition on improved mushroom cultivation technologies and other related aspect was also organised in which twelve Govt. Organisation, ICAR Institutes/ University, Govt. financial organisation, compost and spawn producers, mushroom product manufacturer, seed, pesticides and chemicals producers as well as NGOs displayed their valuable information/ technologies/products and provided their services to the participants of Mushroom Mela. A progrssive mushroom grower Mr. Vikash Benal, was felicitated for adopting innovative practices in mushroom cultivation on larger scale.

Keeping in mind the need of diversification in mushroom cultivation, milky mushroom crop was raised at the Centre during the period April to July, 2005. Milky mushroom cultivation has been started by farmers and mushroom growers in Hamirpur, Bilaspur, Mandi, and Una districts of H.P. Farmers of Solan district were also motivated to grow milky mushroom in summer season. On-farm trials were also laid out at three farmer's farm in a nearby village- Top Ki Ber. NRCM participated in the National & State level exhibitions organized by IVRI, Izatnagar (U.P.) from 18th –20th Oct.,05 and Krishi Expo-2006 at Pragati Maidan, New Delhi From 8-12th March, 2006.

MUSHROOM INFORMATION TECHNOLOGY

According to the information received, the total mushroom production in India was 72,000 tons during the year 2005-06. The digital compendium of lectures has been prepared and made available on the main screen of the centre website and various lectures of the experts can be accessed by simply clicking on the respective links. It would present information related to mushroom production in a more user-friendly manner. The Digital Institute Profile has also been prepared wherein the different activities of the Centre have been presented in a digital form. The digital Mushroom Profile includes information relating to the cultivation technology of different mushrooms, their economic analysis, medicinal value etc. Information relating to button mushroom, oyster, paddy straw mushroom, white milky mushroom, shiitake and black ear mushroom can be accessed by clicking on the appropriate links.

EDUCATION AND TRAINING

The Centre has made significant progress in Human resource development. Dr. M.C. Yadav attended 3 days training programme on "Bioinformatics and Plant Genomics" at Bioinformatics Centre of CSK HPKV, Palampur. Dr. R.C. Upadhayay attended 21 days training on "Advanced Biochemical and Molecular Biology techniques" at CAS in Biochemistry IARI New Delhi. Dr R.P. Tewari. Director visited Bangladesh as FAO consultant for two months during Dec, 2005 to Feb, 2006 to provide consultancy on mushroom in the project " Integrated Horticulture and Nutrition Development Project'. Dr. B.L. Dhar Principal scientist conferred as Honorary Fellow of Indian Mycological Society (for contribution in Mushroom Science) by University of Calcutta, Deptt. of Botany, Ballaey Ganj, Calcutta, West Bengal.

PUBLICATIONS

During the year, the scientists of the Centre have published 17 research papers in referreed national and international journals, 17 book chapters, 2 technical bulletins, and 9 popular / technical articles and contributed 21 abstracts to different scientific forums.

SPORTS AND OTHER ACTIVITIES

NRCM, Solan participated in ICAR Zonal Sports Meet held at National Dairy Research Institute, Karnal and won three gold medals and three silver medals in various sports.

Two scientists and one technical staff members were promoted during the year.

INTRODUCTION

Though mushroom cultivation both in east and west started many years ago, yet its cultivation in India is of recent origin. It was probably in the year 1886, when some specimens of mushroom were grown by N.W. Newton and exhibited at the annual show of Agriculture, Horticulture Society of India. The search of edible mushroom was instituted by Sir David Parin in the year 1908. Professor S.R. Bose of Bengal was successful in culturing two agarics on a sterilized dung medium in the year 1921. Paddy straw mushroom cultivation was first attempted in India at Coimbatore in 1943 by Thomas *et al*. However, first systematic attempt in cultivating button mushroom was made in 1961, when a scheme entitled "Development of mushroom cultivation in Himachal Pradesh" was started at Solan (H.P.) by Himachal Pradesh Govt. in collaboration with ICAR, New Delhi. The initial success was achieved in cultivating *Agaricus bisporus* by employing the technology developed indigenously. The project influence spread all over the country as a result Indian Council of Agricultural Research, considered the importance for establishing a National Research centre for Mushroom at Solan during Oct. 1982. NRCM started functioning w.e.f. 8.6.1983. The science of mushroom research and development in India has expanded with passage of time.

The land resources in the world for raising food crops are limited and there is no possibility of its further increase. This warrants a wise use of land with due regards to its sustainability for long terms productivity. Keeping in view these limitations mushroom cultivation is a wonderful activity which fits very well in the present scenerio and also alleviates environmental pollution besides producing a highly valuable protein rich product.

National Research Centre for Mushroom is located in Solan (H.P) known as mushroom city of India. Its office and laboratory buildings are situated at Chambaghat, Solan, on NH-22. There is no regional station of the centre but for the multi-locational testing of technology under varied agro-climatic conditions, an All India Coordinated Mushroom Improvement Project (AICMIP) has been sanctioned and established with its Headquarter at National Research Centre for Mushroom, Solan (HP). The Director of NRC for Mushroom, Solan (HP) also functions as the Project Co-ordinator of the project. Presently, coordinating centres of AICMIP are located at Ludhiana (Punjab), Pantnagar (UP), Coimbatore (Tamil Nadu) Pune (Maharashtra), Raipur (MP) Faizabad (UP), Udaipur (Rajasthan), Thrissur (Kerala), Shillong (Meghalya), Ranchi (Jharkhand) and Nauni, Solan (HP) – as Co-operating Centre.

Achievements

During the year National Mushroom Respository has been enriched by addition of 371 mushroom cultures of which some are new records for India. Advanced molecular techniques were employed for molecular characterization of mushroom germplasm. RAPD markers were used as molecular tools for the molecular characterization of genetic variation induced via meiotic recombination and chromosomal segregation in the mushroom germplasm. Genetic improvement studies of temperate and tropical mushrooms conducted revealed the identity of several single spore selections in *Volvariella volvacea*, *Agaricus bisporus* and hybrids in *Pleurotus florida*. Out of 21 single spore progenies, four single spore selections namely SSI-6301, SSI-6305

from strain A-2 and SSI-8107 and SSI-8109 from hybrid U-3 were identified to produced significantly higher yields. Six hybrid strains of *Pleurotus florida* developed from thirteen single spores, were also found promising. In case of paddy straw mushroom 42 single spore isolates were compared for their growth rates, type of mycelial thread, density of mycelial growth, presence of the aerial mycelia and the chlamydospores and based upon these growth parameters the SSIs were found to belong to 4 major groups. Ligno-cellulolytic enzymes have been identified to play important role in autolysis of fruitbodies and inactivation of mycelial cultures of paddy straw mushroom.

NRCM achieved a major breakthrough in reducing the composting period of *A. bisporus* compost. Compost was prepared under total indoor conditions in seven days time completely bypassing Phase-I condition of composting, with the help of thermophilic fungi. Among the various casing materials evaluated spent mushroom substrate and coir pith gave the highest mushroom yield. Moving ahead in standardizing the cultivation technology of *Flammulina velutipes,* polypropylene bags proved to be the best cultivation containers. Efforts were made to increase the yields of *F. velutipes* and *Agrocybe aegerita* by supplementing the cultivation substrates with 10 per cent wheat bran which resulted in early spawn run and significantly higher yield of both the mushrooms. Different cultures of *Ganoderma lucidum* were evaluated for the yield potential and it was found that Thai culture gave the highest yield followed by Korean OE-53.The cultivation of button, Oyster and Paddy straw mushrooms in low cost bamboo huts with good economic yields were demonstrated to the farmers. A work shop has been established at NRCM with various machineries. The design of semi-automatic compost turner of 5 tonnes/ hour capacity has been finalized and the fabrication work of the machine is in progress. Studies on the effect of different commonly used insecticides in mushroom industry on some edible fungi revealed that dichlorvos and chlorpyriphos completely inhibited the growth of all edible fungi and cyromazin was highly toxic to *Lentinula edodes* and *Pleutotus ostreatus*. Studies on persistence of malathion and phorate were also conducted and safer waiting periods have been worked out. Molecular characterization of various *Mycogone* cultures collected from different mushroom farms revealed no genetic variability whereas *Trichoderma* isolates collected from various farms and procured from various AICMIP centres were identified as *Trichoderma asperellum, T. harzianum T. longibrachiatum* and *T. virens.*

The Centre has conducted a number of training programmes sponsored by various departments/ agencies. Studies on impact assessment of sponsored training programme for adoption of mushroom cultivation were conducted in HP. The data obtained showed 12.08 and 18.9 % adoption of mushroom cultivation in Hamirpur and Chamba districts of H.P., respectively. Three days Off-campus training programmes were also organized at Gangtoke, Guwahati, Imphal and Agartala. One day Mushroom Mela was organised on 10th September, 2005. It was attended by about 650 farmers, farm women, mushroom growers, researchers, extension workers and businessmen from various States. To disseminate the technology, an exhibition on improved mushroom cultivation technologies and other related aspects was organised in which twelve Govt. Organisation, ICAR Institutes/University, Govt. financial organisation, compost and spawn producers, mushroom product manufacturer, seed, pesticides and chemicals producers and NGOs displayed

their valuable information/ technologies/ products and provided their services to the participants during Mushroom Mela. A progrssive farmer Mr. Vikash Benal, was felicitated for adopting innovative practices in mushroom cultivation on larger scale.To create awareness about mushroom cultivation, the centre participated in Krshi-Expo-2006 w.e.f.8-12, March, in Pragti Maidan, New Delhi. Besides this advisory services were extended to mushroom growers and queries were replied by post, e-mail and telephone.

Information regarding mushroom growers, mushroom production status and agricultural waste available in our country was collected. Total mushroom production in India was 72,000 tons during the year 2005-06. The Digital Institute Profile has been prepared wherein the different activities of the Centre have been presented in a digital form. It includes information relating to different Sections, Infrastructure etc in text as well as in pictorial form. The digital Mushroom Profile includes information relating to the cultivation technology of different mushrooms, their economic analysis, medicinal value etc. Two scientists have been trained in advanced molecular techniques. Besides this, several students were trained on various aspects of mushroom production technology.

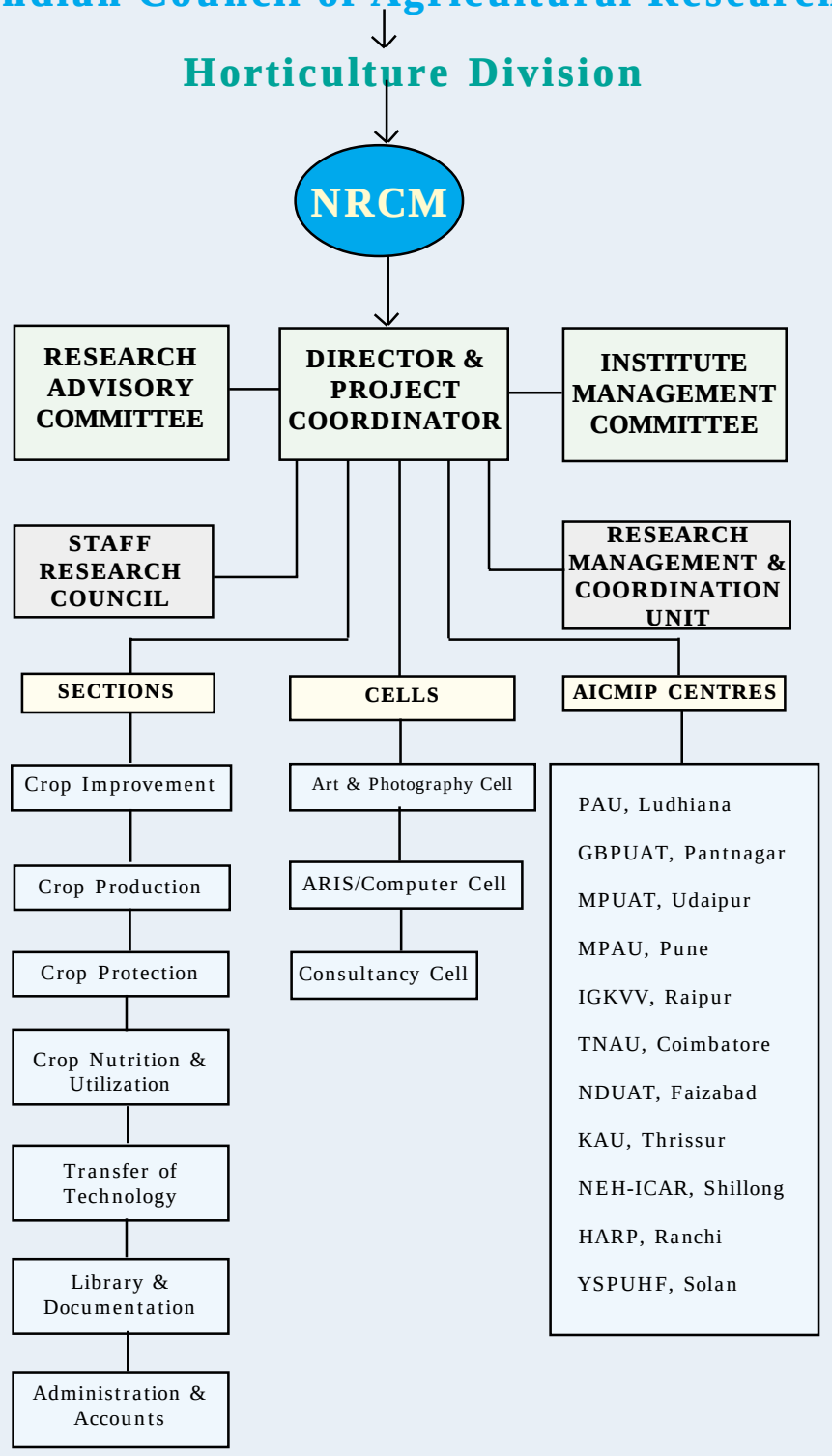
Dr R.P. Tewari. Director visited Bangladesh as FAO consultant for two months during Dec., 2005 to Feb., 2006 to provide consultancy on mushroom cultivation under the project “Integrated Horticulture and Nutrition Development”. Dr. B.L. Dhar Principal scientist conferred as Honorary Fellow of Indian Mycological Society by University of Calcutta, Deptt. of Botany, Calcutta, West Bengal. The employees of the centre participated in ICAR Zonal Sports Meet and won 6 medals including 3 gold medals.

Staff and Finance

The centre has a sanctioned strength of 15 scientists + 1 Director, 14 Technical, 16 administrative and 11 supporting staff. The staff in position on 31.03.2006 was 13 scientists, 14 technical, 16 administrative and 10 supporting staff. The annual budget of the centre for the year 2005-2006 was Rs.100 Lakhs (Plan) and Rs263 lakhs (Non Plan), the expenditure was Rs 99.70 Lakhs (Plan) and Rs.262.54 lakhs (Non Plan). The centre earned Rs.14.62 Lakhs as revenue during the year by sale of literature, mushroom cultures, spawn, fresh mushrooms, pickles, consultancy, training and other services.

Facilities

- Thirteen environmental controlled cropping rooms.
- Modern composting units comprising of 4 indoor bunkers, 4 bulk chambers, covered outdoor composting platform and related structures.
- Five well equipped laboratories with all sophisticated equipments.
- Sale of pure starter cultures of all the commercial strains of edible mushropoms and quality seed.
- Excellent Library facilities with access to world literature on mushrooms through internet, periodicals on mushroom and its related disciplines from all over the world, reference services and CD-ROM search service.



Organizational structure of NRCM, ICAR, Solan

RESEARCH ACHIEVEMENTS

1

CROP IMPROVEMENT

1. Mushrom Genetic Resources

1.1 Collection and identification of wild mushrooms

Project –NCM- 15: Survey, collection and identification of wild fleshy fungi (PI : Dr. R.C. Upadhyay)

Fungal forays were conducted in the forest areas of Himachal Pradesh namely Shilly, Fagu, Cheog, Baghi, Kufri, Narkanda, Ratnadi, Khada Pathar and Mashobra. Parts of the Haryana and Chandigarh were also visited for collection of wild mushrooms. In all 371 wild mushrooms were collected. All the specimens were examined and photographed under natural conditions. Spore prints along with dried specimens have been preserved in the Herbarium. Attempts were made to obtain tissue cultures from the fresh specimens on common mycological medium. The list of agaricoid genera and their collections family wise are mentioned in Table-1. Some of the specimens have more than 2 to 3 collections from different areas.

Table 1: List of agaricoid specimens collected (familywise)

S.No.	Family	Genera (No. of species collected)
1	Agaricaeae	*Chlorophyllum* (1), *Agaricus* (13), *Lepiota* (6), *Macrolepiota* (1), *Leucocoprinus* (1)
2	Amaniataceae	*Amanita* (18), *Limacella* (1)
3	Bolbitiaceae	*Descolea* (2), *Agrocybe* (2)
4	Boletaceae	*Boletus* (5), *Leccinum* (1), *Suillus* (1), *Strobilomyces* (1)
5	Coprinaceae	*Psathyrella* (4), *Paneolus* (1)
6	Cortinariaceae	*Cortinarius* (11), *Inocybe* (17), *Gymnopilus* (3), *Hebeloma* (1), *Galerina* (2)
7	Crepidotaceae	*Crepidotus* (3)
8	Entolomataceae	*Entoloma* (4)
9	Gomphidiaceae	*Gomphidius* (3)
10	Hygrophoraceae	*Hygrophorus* (4), *Camerophyllus* (1)
11	Paxillaceae	*Paxillus* (1)
12	Pluteaceae	*Pluteus* (2), *Volvariella* (1)
13	Polyporaceae	*Pleurotus* (8), *Polyporus* (8), *Lentinula* (6), *Panus* (1), *Panellus* (1)
14	Russulaceae	*Lactarius* (3), *Russula* (1)
15	Strophariaceae	*Psilocybe* (1), *Stropharia* (2), *Pleuroflammula* (1), *Nematoloma* (6), *Pholiota* (2)
16	Tricholomataceae	*Marasmius* (7), *Mycena* (5), *Oudmansiella* (1), *Tricholoma* (5), *Laccaria* (8), *Lyophyllum* (7), *Clitocybe* (5), *Lepista* (1), *Melanoleuca* (2), *Collybia* (6), *Armillaria* (3), *Leucopaxillus* (1)

In addition to agaricoid fleshy fungi, specimens of several Gasteromycetes and Aphyllophorales were also collected. Some of the interesting collections examined are described below.

***Chlorophyllum* sp. Pileus**: 5-9.5 cm wide, hemispherical at first, then plane with a broad disc, sometimes uplifted with age, Aztec Indian Tan (13I8) to Sayal brown (13G9) in the middle, oyster white in the margin (10B1), surface dry, non-hygrophanous, cuticle half to fully peeling, fleshy, covered with appressed to small recurved scales, cottony whitish hairs, dense and intact in the middle, expended in finely decorated (concentric) manner towards margin, detachable; margin faintly striate, 0.3-0.8 cm long, irregular, split on expansion, involute at first, uplifted with age; context white, wine red below pileipellis, 0.3-0.6 cm thick, soft, changing colour as pinkish red on sectioning or bruising, later browning. **Lamellae**: free, close to crowded, ivory (10B2), browning when drying, edges serrate, 0.5-1.0 cm wide, sometimes bifurcate; lamellulae of 4-5 ranks. **Stipe**: 7.0-10.5 x 0.6-0.9 cm, central, Ivory (10B2), terrate with a slightly bulbous base, glabrous, white mealy appearance at base, consistency fibrous, mycelial at base; context white, changing immediately pinkish red (reddening) on sectioning or handling, later browning. **Annulus**: superior, but movable. **Taste**: mild, indistinct; **Odour**: fungoid **Pileipellis**: made up of repent to sub-parallel arranged hyphae, 2.7-12 µm wide, septate, infrequently branched, septa clampless, thin to slightly thick walled, hyaline to subclourless, contents granulated, covered with hyphae of scales, 1.8-10 µm wide, branched, septate, hyaline to yellowish, hyphal ends as clavate, fusiform to sub-fusiform or cylindric, upto 15µm wide, contents granulated, mixed with few leticiferous hyphae, often upto 4.5µm wide. **Pileus context**: made up of compactly arranged hyphae, 3.6-14.0 µm wide, thin to slightly thick walled (upto 0.5 µm thick), septate, clampless, hyaline to yellowish, septa sometimes constricted, contents granulated. **Basidia**: 20-27 x 6.3-10.8 µm, clavate to widely clavate, 2-4 spored, sterigmata 2.7-4.5 x 0.9-1.8 µm, hyaline, contents granulated, basal septa clampless. **Pleurocystidia**: none. **Cheilocystidia**: 30-42 x 5.2-7.2 µm, clavate, cylindric, sometime capitate, hyaline, thin-walled, septa clampless. Gill edge sterile. **Hymenophoral trama**: regular in young specimen irregular in older specimen, made up of thin to slightly thick walled, cylindric hyphae, 8.1-13 µm wide. **Subhymenium**: cellular, composed of irregular sub-globose to ovoid cells, 5.4-11.5 x 4.5-6.3 µm, thin walled. **Stipe cuticle**: made up of longitudinally arranged hyphae, 2.7-7.2 µm wide, septate, sometimes branched, contents granulated, yellowish brown pigmented, clamps found only in the hypahe of stipe base. **Stipe context**: longitudinally arranged inflated cylindric cells, 5.0-22.5 µm wide, thin to slightly thick walled (upto 0.5 µm thick), sometimes branched, yellowish in alkali solution, contents sometimes granulated. **Annulus**: made up of abundant hyphae, 3.6-9 µm wide, septate, thin walled, yellowish brown pigmented, contents granulated, hyphal ends as clavate to fusiform, 18-55 x 9-18 µm diameter, thin walled, contents granulated. **Basidiospores**: [35/2/2](5.9-) 6.3-7.2 (-7.7) x 4.5 – 5.4 (-5.8) µm; **L'**= 6.6 µm; **W'**= 5.0 µm; **Q**= 1.23-1.36 (-1.4); **Q'**= 1.3; widely ellipsoid to ellipsoid, pseudoamyloid, smooth, apiculate, apiculus upto 0.5 µm long, wall thick, dark, without germ pore. Spore print in mass: grayish yellow (1A3-B3) (see Kornerup & Wanscher, 1978).

***Pholiota* c.f. *squarrosa/ squarroides* (208/05)**

Genus – *Pholiota*, Subsection- *Pholiota* Section- *Pholiota*

Pileus- 8-10 cm wide, conical at first then plano-convex to applanate with age, citrine

yellow (10J2) to Chinese yellow (10K6) in the middle, maize (10G5) to corn (10J5) outwards, covered with brownish appressed rhomboid scales in the middle, spread outwards, moist confluent, non-hygrophanous; margin non-striate, strongly appendiculate, connected with the annulus as forming cortina upto 2cm long when immature, ruptured with age and forming the appendiculate margin, involute first, regular with age; cuticle half to fully peeling; context- fleshy, citrin yellow (10J2), 1-1.3cm thick, unchanging. **Lamellae**- adnate, close to crowded, earlier maize (10G5), later on cloud umber (12K3), 0.5-0.7cm wide, waxy, edges serrate; lamellulae unequal with 2-4 ranks. **Stipe-** 10-12 x 1.8-2.2 cm, central, equal to tapering downwards, straw to citrine yellow (10F2-10J2) at apex, copper brown (6C12) downwards, covered with recurved scales, concolourous with cap scales, stuffed; context- yellowish white, soft. **Taste**- mild, acceptable; **Odour**- distinct, pleasant **Pileipellis-** 100-200µm thick, partially gelatinized, subrapellis made up of subparallel, loosely interwoven hyphae, 3.6-7.2µm wide, with yellowish brown to golden brown membranal and vacuolar pigments; lower layer (subpellis) composed of densely arranged interwoven hyphae, septate, thin walled, clamped, yellowish to golden brownish pigmented, 3.6-10µm wide. **Pileus context-** made up of partially inflated cylindric hyphae, upto 22µm wide, thin walled, golden brownish pigmented, with scattred yellowish brown laticeferous hyphae, 1.8-3.6µm wide. **Hymenophoral trama-** regular, 40-80µm thick, made up of cylindric hyphae, 8-14 µm wide, narrower near subhymenium, 2.7-8µm wide, yellowish to sub-colourless, septate, clamped. **Subhymenium**- narrow, 7-11µm thick. **Basidia-** 18-28 x 4.5-8µm, (2-) 4-spored, clavate to narrowly clavate, sterigmata, 2.7-4.5 µm long, often granulated, basal septa with clamps. **Pleurocystidia-** abundant, most of them as chrysocystidium, 22-42 x 6.3-15µm, lageniform with acute apex to cylindric-fusiform, wall yellowish brown. **Cheilocystidia-** similar to pleurocystedia, 26-32 x 5.4-9µm, granulated. **Stipe cuticle** made up of longitudinally alligned, clamped, septate hyphae, 1.8-8.1µm wide, with yellowish pigments, refractive, sometimes thick walled. **Annulus**- made up of thin walled hyphae, 2.7-9 µm wide, mixed with long cylindric cells, 9-28 µm wide, wall yellowish, septate, thin walled, sometimes hyphal ends as clavate. **Basidiospores-** [32/1/2] (4.5-) 4.9-6.8 (-7.2) x 3.2-4.1 (-4.5)µm; **L** = 5.63µm; **W**= 3.64µm; **Q**= (1.22-) 1.5-1.85(-2.0); **Q**= 1.6; in lateral view ellipsoid with slight median constriction, bean shaped (slightly phaseoliform), wall slightly thick, brownish to dark brown, non-amyloid, non-cyanophilic, germ pore absent. Spore print in mass: not deposited. **Habitat**: on stem of rotten *Cedrus deodara*.

Material examined: Himachal Pradesh-Narkanda- Tikker; 13.09.2005, 208/05

***Pholiota* c.f. *albocrenulata* (278/05)**

Genus- *Pholiota* Subgenus *Hemipholoita* Section- *albocrenulata*

Pileus: 6-10.5 cm wide, applanate with slight depressed centre when mature, venetian rose (5L1) in the middle, hyacinth red (4C11) outwards, sometimes covered with small, fine ornamented recurved scales, viscid when wet; margin non-striate, incurved; context creamish white. **Lamellae**- adnate, subdistant to close, iris glow (44B3) to plumbago blue (43B4) at first then Indian tan (13I8); lamellulae of 4-5 ranks, edges serrate, brighter than the face. **Stipe**- 6.5-11 x 0.8-1.3 cm, tapering upwards, ivory to straw (10B2-10F2), faintly covered with small thin hairs, slightly bulbous at base, upto 1.3 cm wide, base mycenoid; context- whitish to yellowish white. **Annulus-** fugacious,

superior, leather brown (14A10). **Pileipellis**- two layered; epicutis 200-300µm thick, made up of sub-parallel to parallel arranged hyphae in a gelatinized matrix, hyphae narrow, septate, clamped, refractive, some hyphae incrusted, 0.8-6.3µm wide, hypodermium of broad, septate, brownish yellow pigmented, thin walled hyphae, upto 14µm wide, with some incrusted, refractive hyphae, as brownish layer in the middle of the epicutis and pileus context. **Pileus context:** of septate, cylindric, clamped thin walled hypahe, upto 18µm wide. **Hymenophoral trama**: regular; 30-60µm thick, made up of septate, clamped, thin walled, refractive hyphae, 2.7-7.2 µm wide. **Subhymenium**- inconspicuous. **Basidia**- clavate, 4 spored, thin walled, 19.5-26 x 4.5-7.2µm, thin walled, sterigmata 2.7-4.5µm long, often refractive or granulated, basal septa clamped. **Cheilocystidia**- 20-36 x 4.5-7.2µm, capitate to clavate, as chrysocystidium. **Pleurocystidia**- very few, similar to cheilocystidia. **Stipe cuticle-** longitudinally arranged, thin walled septate, clamped, refractive hyphae, 1.8-5.4µm wide, wall yellowish in alkali solution, rarely branched. **Caulocystidia**- few, capitate, at the apex of the stipe (above annulus). **Annulus**- made up of thin walled, clamped, yellowish pigmented, non-gelatinized, septate hyphae, 0.9-6.3µm wide, with more or less cylindrical hyphae, upto 11µm wide. **Basidiospores:** [25/1/2] (10.3-) 10.8-13.5 (-14) x 5.4-6.3µm; **L**= 11.8µm; **W**= 5.8µm; **Q**= (1.76-) 1.9-2.2; **Q**= 2.0; narrowly amygdaliform, smooth to faintly rough, non-amyloid, wall strongly reflex around the endosporium; germ pore indistinct, contents sometimes mono- or multiguttulate. **Habitat-** on wood.

Material examined: Himachal Pradesh-Narkanda; 22.09.2005, 278/05

***Naematoloma* Karst. Pileus:** 3.5-7 cm wide, hemispherical at first, then plane with age, with a slight wide umbo, Inca Gold (11J7) to yellow ochre (11L7) in the middle, Pine apple (11J2) outwards, surface moist when wet, hygrophanous, half peeling, tough; margin regular, non-striate; context: orangish white, darker below pileipellis as wine red, 0.3-0.5 cm thick, soft unchanging. **Lamellae**: adnate with fine linear appearance at stipe apical region, moderately crowded, colonial yellow (11K3) when young, sulphine yellow (12L4) on maturity, clove brown (16A7) on drying, shortly decurrent, 0.3-0.7cm wide, edges serrate with dark spotted with age; lamellulae of 2-4 ranks. **Stipe**: 5-11.5 x 0.4-0.9cm, central, terrate, Pine apple (11J2) at apex, Buff to Nugget bronze (11K7-11L8) downwards, surface fine hairy to glabrous, stuffed then hollow; context fibrous, brownish white. **Annulus**: not seen in any stage of development of carpophore or may be washed off due to rain. **Odour:** fungoid, indistinct; **Taste:** not observed. **Pileipellis**: made up of subcellular cells, compactly arranged cylindric to ellipsoid or long ellipsoid, 40-65 x 15-32µm, thick walled (0.5-1.4µm thick), yellowish to yellowish brown membranal to vacuolar pigmented, mixed with thin to slightly thick walled, septate, clamped hyphae, 3.6-6.3µm wide, yellowish in alkali solution. **Pileus context:** made up of subfusiform to fusiform or cylindric or long ellipsopid cells, 20-50µm wide, thick walled (0.5-1.4µm thick), yellowish in alkali solution, mixed with thin to thick walled, septate, clamped hypahe, 4.5-8.1µm wide. **Hymenophoral trama**: regular, with cylindric to fusiform cells in the mediostartum, 10-23µm wide, narrower near subhymenium, 2.7-5.4µm wide, yellowish to sub-colourless. **Subhymenium**: narrow. **Basidia**:18-24 x 5.4-6.3µm, thin walled, cylindric sometimes clavate, 2-4 spored, sterigmata 3.6-5µm long, contents granulated, basal septa with clamps. **Pleurocystidia**: numerous, as chrysocystidium, clavate, mucronate,

sometimes sub-fusiform, 30-48 x 8.1-12.6µm, thin walled. **Cheilocystidia**: similar to pleurocystidia, as chrysocystidium. **Stipe cuticle**: longitudinally arranged hyphae, 2.7-13µm wide, thin to thick walled, yellowish in alkali solution, clamped. **Basidiospores**: [25/1/1] 6.3-7.2 (-8.1) x 3.6-4.1 (-4.5)µm; **L**= 7.1µm; **W**= 3.8µm; **Q**= 1.75-2; **Q**= 1.88; widely amygdaliform to amygdaliform, inamyloid, thick reddish brown walled, with wide germ pore, smooth. Spore print in mass: Purplish brown. **Habit & habitat**: Caespitose, on decaying wood of *Cedrus deodara*.

***Gymnopilus* Karst. Pilus**: 2.8-4.5cm wide, hemispherical at first, then plane in age, sometimes with slight depression in the middle, cinnamon brown (14I10) at centre Jasmine to Apricot yellow (9K4-9K5) outwards, dry, with appressed fibrils, dense and detachable outwards, often cover the entire surface, surface stained darker when treated with 5% KOH; margin irregular, non-striate, crenulate; context brownish, soft, 0.2-0.3 cm thick, unchanging. **Lamellae**: aadnate, with tooth or shortly decurrent, close, pinard yellow (9J2) to chrome yellow (9K2), 0.3-0.6cm wide, lanceolate, edges dentate with dark spots; lamellulae unequal of 2-5 ranks. **Stipe**: 2-3 x 0.3-0.5cm, central, terrate, sometimes slightly bulbous at base, Mikado orange (9J9) at apex, Indian tan (7C12), Chutnery (7J12) to Argus brown (7A12) downwards, pruinose at apex, faintly fibrillose top glabrous at below, stuffed; context brownish, fibrous. **Annulus**: may be annulated or not, no marks of annulus on stipe. **Taste**: mild; **odour**: pleasant, distinct. **Pileipellis**: made up of compactly arranged cylindric cells, 14-20µm wide, thin to thick walled (0.5-0.9µm thick) yellowish brown to golden brown pigmented, covered with strongly incrusted, compactly arranged, septate, clamped, thin to thick walled hyphae, 3.6-10µm wide, yellowish to yellowish brown pigmented. **Pileus context**: loosely to sub-compactly arranged inflated cylindric elements, often upto 25µm wide, septate, clamped, thin to thick walled, yellowish brown pigmented, leticeferous hyphae few, 3.6-6.3µm wide. **Hymenophoral trama**: regular, inflated cells abundant, cylindric to long cylindric or sub-fusiform cells, 14-28µm wide, thin to thick walled (upto 0.9µm thick), mixed with septate, clamped hyphae, 4.5-10.8µm wide, yellowish pigmented. **Subhymenium**: narrow, made up of non-infalted hyphal segments. **Basidia**: 17-26 x 4.5-8.1µm clavate to narrowly clavate, sometimes cylindric, 2-4 spored, sterigmata 3.6-4.5 x 1.4-1.8µm, sub-colourless to yellowish, granulated with multi oil droplets, basal septa sometimes clamped. **Pleurocystidia**: few, clavate, mucronate with rounded apex to subcapitate, 13.5-20 x 5.4-9µm, thin walled, hyaline, sometimes brownish yellow vacuolar pigmented. **Cheilocystidia**: 15-24 x 5-9µm, sub-capitate to mucronate with rounded apex. **Stipe cuticle**: made up of longitudinally arranged cylindric cells, often upto 20µm wide, yellowish brown pigmented, covered with incrusted, narrow, thin to thick walled, septate, clamped hyphe, 1.8-7.2µm wide. **Basidiospores**: [25/1/1] 6.3-7.2(-7.7) x 4.1-4.9µm; **L**= 6.8µm; **W**=4.5µm; **Q**= (1.36) 1.4-1.6; **Q**= 1.5; ellipsoid to widely ellipsoid, brownish to brownish black walled, surface rough as small spiny, yellowish brown in alkali solution, non-amyloid, apiculus small, germ pore absent. Spore print in mass: tobacco brown to tan rusty. **Habit & habitat:** caespitose, on decaying wood of *Cedrus deodara*.

c.f *Chroogomphus* (Sing.) O.K. Miller 318/05

Pileus: 4 - 4.6cm wide, hemispherical to plano-convex, Indian purple 947J2) in the middle, Livid brown (6D3) or Crusted berns

(6F4) outwards, surface dry, non-hygrophanous, not peeling; margin regular, inflexed, non-striate; context unchanging, fleshy. **Lamellae**: adnate, decurrent, distant, English grey, separable, waxy, 0.3-0.4cm wide, edges smooth; lamellulae unequal. **Stipe**: central, 5.5x1.0cm, terrate, stipe base blunt, consistency fleshy. Exannulate. **Pileipellis**: made up of repent hyphae, 1.8-9µm wide, partially gelatinizd, thin walled, often with some amorphous yellow contents and granulated, 1.8-9µm wide, leticiferous hyphae few, upto 6.3µm wide. **Pileus context**: loosely arranged, broad, cylindric hyphae; amyloid, septate, thin walled, 8.1-15µm wide, often yellowish pigmented, granulated. **Basidia**: 30-42 x9-15µm, clavate to long-clavate, 4 spored, sterigmata 3.6-6.3 x 0.9-1.8µm, thin walled, yellowish to hyaline, contents often granulated with multi oil droplets, basal septa without clamp connection. **Pleurocystidia**: scattered, cylindric to subfusiform, 110-180 x 11-20µm, thin to slightly thick walled, amorphous yellowish contents with multi oil droplets. **Cheilocystidia**: few, similar to pleurocystidia. **Hymenophoral trama**: regular to bilateral; mediostartum made up of thin walled, septate, yellowish pigmented hyphae, 3.6- 7.2µm wide, amyloid; lateral stratum made up of septate, broad, cylindric hyphae, often with membranal incrustation of oil contents, 10-25µm wide. **Subhymenium**: dense, made up of inflated to partially inflated hyphal segments, ovoid to subglobose or ellipsoid cells, sometimes in chains, 4.5-10.8 x 3.6-7.2µm, thin walled. **Stipe cuticle**: made up of longitudinally arranged hyphae, septate, thin walled, contents often yellowish and granulated, 2.7-10µm wide, mixed with few scattered, septate yellowish brown pigmented leticiferous hyphae. **Basidiospores**: 13.5-17.1 (-19) x 4.5-5.9 (-6.5)µm; **L**=15.2µm; **W**=5.3µm; **Q**= (2.35-) 2.46-3.33 (-3.6); **Q**= 2.88; fusoid to subfusoid, spindle shaped, thick blackish walled, smooth, non-amyloid, cyanophilic, apiculus hyaline or hyalinopus, 0.5-0.9µm long. **Habit & habitat**: gregarious, on soil in mixed forest.

***Leucocoprinus* sp.**

Pileus: 2.8-3.5 cm wide, campanulate at first, applanate in age with a short disc in the centre, greyish yellow over disc, Marguerite yellow (10C1) outwards, lighter on maturity when drying, surface farinaceous-mealy, lemon yellow, detachable on touch, often covered entire surface, dry, non-hygrophanous, half peeling; margin sulcate-pectinate, striations upto 0.8cm long, involute to regular; context soft, thin, 0.1-0.2cm thick, lemon yellow, unchanging. **Lamellae**: free with remote zone, close to crowded, concolourous with pileus, lighter when mature. 0.1-0.3cm broad, edges smooth; lamellulae of 2 ranks. **Stipe**: central, 3.5 – 8 x 0.2 – 0.5cm, terrate to tapering upwards, sometimes slightly bulbous at base, concolourous with pileus, pruinose to mealy, hollow; context soft, lemon yellow. **Annulus**: superior, membranous to cottony movable, sometimes washed off due to rain or handling. **Taste:** mild; **Odour;** pleasant. **Pileipellis**: made up of abundant inflated elements, cylindric to fusiform or sub-fusiform cells, measuring 12-24µm, thin to slightly thick walled, hypahe 2.7-8.1µm wide, thin walled, septate, infrequently branched, hyaline to sub-colourless, covered with inflated pyriform to broadly ellipsoid cells, 20-33 x 12-28µm, thin to thick walled; all hypahe clampless. **Hymenophoral trama**: irregular made up of inflated elements, cylindric to long ellipsoid or ellipsoid cells, measuring 16-33µm, mixed with septate, branched hyphae, 6.3-10µm wide, hyaline to sub-colourless, septa not clamped. **Subhymenium**: broad, made up of ovoid to subglobose or globose cells, measuring 5.4-10µm. **Basidia**: 13.5-20 x 5.4-

7.2µm, clavate to broadly clavate, 2-4 spored, sterigmata 1.3-2.7µm long, thin walled, hyaline, contents often granulated, basal septa clampless. **Pleurocystidia**: absent. **Basidioles**: plenty, pyriform to broadly clavate, 10-17 x 7.2-14.5µm. **Cheilocystidia**: 18-32 x 5.4-10.5µm, thin walled, flask-shaped, clavate to mucronate with cylindric apex, hyaline. **Stipe cuticle**: composed of longitudinally disposed hypahe, 1.8-18µm wide, thin to thick walled (0.5-0.9µm thick), septate, branched, hyaline to sub-colourless, covered with inflated elements, pyriform to napiform or clavate, 28-44 x 16-24µm. **Annulus**: made up of interwovenly arranged, abundant inflated cells, fusiform, clavate to pyriform or napiform cells, 16-26 x 8.1-15µm, mixed with thin walled, septate, branched hyphae, 2.7-6.3µm wide. **Spores**: (4.5-) 5-6.3 x (3.2-) 3.6-4.5µm; **L**= 5.2µm; **W**= 3.7µm; **Q**= 1.25-1.42 (-1.5); **Q**= 1.3; ellipsoid, pseudoamyloid, thin to slightly thick walled, apiculate, 0.5-0.9µm long, contents sometimes granulated and monoguttulate. **Habit & habitat**: caespitose, in groups, growing on soil among decomposed leaves.

Specimen examined: Near Durga Mandir, Chambaghat, Soaln, H.P., 24.06.06, RCU/6-06.

1.2 Germ plasm Characterization

Project-NCM-29: Genetic characterization of mushroom germplasm of NRCM Gene Bank (PI: Dr. M.C. Yadav)

1.2.1 Molecular and morphological characterization of *Agaricus bisporus* germplasm (PI: Dr. M.C. Yadav)

RAPD analysis: RAPD markers were used as a molecular tool for genetic characterization and assessment of diversity in 22 *A. bisporus* white pileus strains at DNA nucleotide level. The 10 polymorphic primers of the Kits OPN and OPF amplified easily recognizable and consistent DNA bands that ranged from 350 to 4000 bp in lengths. White pileus strains exhibited low level of DNA polymorphism and more genetic homogeneity in RAPD profiles. None of the random primers tested was found to be polymorphic with 100% band polymorphism. The per cent polymorphism ranges from 16.67% (OPF-11) to 85.71% (OPO-03). The Jaccard's similarity coefficients based on 74 RAPD markers varied from 0.55 to 1.00. The highest variable genotypes were ITCC-1924 (strain) and ITCC-3710 (hybrid) with 45% DNA polymorphism. The cluster analysis based on UPGMA and SAHN revealed two phylogenetic groups among 22 strains studied (Fig. 1). A perusal of the dendrogram based on Jaccard's similarity coefficients revealed that the hybrids were clearly distinguished from the strains and were clustered in a separate group (Fig. 1). However, the single spore selection NCS-101 clustered with the hybrids. The hybrids were branched at 0.66 similarity from the strains. The strains S-44, ITCC-1933 and WI-1 could not be distinguished from each other using ten random primers and showed 100% similarity among them. Similarly, strains MS-39 and ITCC-3609 were not distinguished from each other.

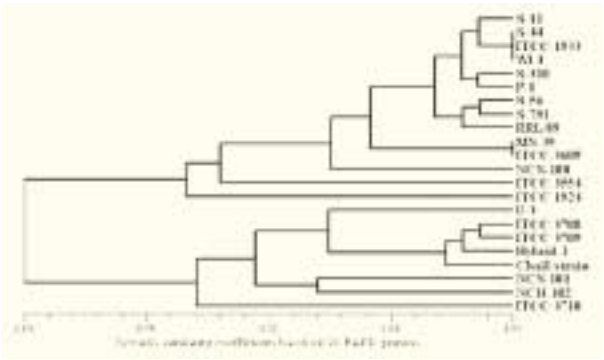


Fig. 1: UPGMA dendrogram showing genetic relationship between 22 strains of *A bisporus*

PCR amplification and sequencing of ITS rDNA regions: The 5.8S rRNA gene alongwith its ITS-I and ITS-II spacer regions were isolated and purified from the strains of *A. bisporus*. ITS sequencing results indicated base substitutions within the species, and deletion and addition mutations between species in ITS-I and ITS-II regions of 5.8S rRNA gene.

1.2.2 Molecular identification and characterization of specialty mushroom germplasm (Dr S.K.Singh)

Nineteen cultures of *Calocybe indica* were procured from Tamil Nadu Agricultural University, Coimbatore for molecular identification and characterization. The details of the cultures are given in table-2.

The pure cultures of all the 19 accessions were raised in Petri plates on Malt extract Agar culture medium for 10 days to obtain uniform mycelial growth. For DNA extraction mycelial cultures were raised in 150 ml conical flask containing 25 ml sterilized liquid culture medium (Malt extract- 10 g l^{-1}; Glucose - 5 g l^{-1}) for eight days at 25^0C under darkness and stationary culture conditions. The total DNA was extracted from 100-150 mg of fungal mycelium crushed with micro-pastle in conical micro-centrifuge tubes with liquid nitrogen. DNeasy plant mini kit protocols of QIAGEN were followed for DNA isolation. The DNA was quantified using calf thymus DNA as the standard in a DNA florimeter (DyNA Quant 200).

Amplification of 5.8S rRNA gene for studying ITS length diversity was done using primer ITS-1 and ITS-4. Amplifications by PCR was performed in a total reaction mixture of 50µl containing,

Table 2: Wild isolates of Milky mushroom collected from Tamil Nadu during 2004-05

Code No	NRCM Accession No.	Site of collection	Habitat	Soil Type
WC-1	OE-330	Erode	Sugarcane field	Black loam soil
WC-2	OE-331	Mullai Nagar	Coconut tree	Black loam soil
WC-3	OE-332	Nanjundapuram	Coconut tree	Red Loam soil
WC-4	OE-333	Anaikatti	Thorny bush	Clay soil
WC-5	OE-334	Bhavanisagar	Banana field	Black loam soil
WC-6	OE-335	Gobichettipalayam	Coconut tree	Red Loam soil
WC-7	OE-336	Glass house, TNAU	Coconut tree	Black loam soil
WC-8	OE-337	Vadavalli	Coconut tree	Black soil
WC-9	OE-338	Thondamuthur	Coconut tree	Red Loam soil
WC-10	OE-339	Pollachi	Palmyrah palm	Red sandy soil
WC-11	OE-340	Veerakeralam	Rain tree	Humus soil
WC-12	OE-341	Kalaramani	Coconut tree	Black loam soil
WC-13	OE-342	R. S. Puram	Lawn	Mixed soil
WC-14	OE-343	Thukkanaicken Palayam	Banana tree	Black soil
WC-15	OE-344	Narasimmanaicken Palayam	Near a bush	Red sandy soil
WC-16	OE-345	Mevani	Sugarcane field	Red Loam soil
WC-17	OE-346	Karupparayan Kovil	Coconut tree	Red Loam soil
WC-18	OE-347	Narasimmanaicken Palayam	Coconut tree	Red soil
WC-19	OE-348	Thukkanaicken Palayam	Coconut tree	Red sandy soil

1U Taq DNA polymerase, 5µl of 10x PCR buffer (10 mM Tris HCl, pH-8.3, 500mM KCl, 15 mM $MgCl_2$.), 160µl M each of dATP, dCTP, dGTP and dTTP, 50 pM of each ITS-1 and ITS-4 primers, 2µl of 5% glycerol and 50-60 ng of genomic DNA in sterile distilled H_2O. The reactions were performed in a thermal cycler with standard PCR conditions consisting of 34 cycles of 1 minute denaturation at 95°C, 30 seconds annealing at 50°C, 1 minutes 20 seconds elongation at 72°C, and ending by a 10 minutes final elongation step at 72°C.

Random amplified polymorphic DNA (RAPD) was performed using six decamer arbitrary primers supplied by Operon Technologies, namely, OPA-4, OPA-11, OPA-14, OPP-8, OPP-13 and OPN-20. Each amplification was performed in a total reaction mixture of 25 µl containing: decamer primer, 2 µl (50 pmol μl^{-1}); dNTP mix, 2 µl (2 mM each); $MgCl_2$, 1 µl (25 mM,); Taq DNA polymerase, 1µl (6U gl^{-1}); 10x PCR buffer, 2.5 µl (100 mM, Tris-HCl, pH-8.3, 15 mM $MgCl_2$, 250 mM KCl) and 16.5 µl of dH_2O. To this 4 µl of genomic DNA (approx. 50-60 ng) was added. RAPD-PCR amplification was performed in a thermal cycler with initial denaturation step of 94°C for 3 minutes followed by 36 amplification cycles of 94°C for 40 seconds, 50°C for 40 seconds and 72°C for 2 minutes and final elongation at 72°C for 10 minutes.

PCR amplification products were electrophoretically separated on 1.6% agarose gel prepared in 1x TAE. The gel was run for 3 hours at 45 Volt. The staining was done with ethidium bromide and visualized under 300 nm Ultra Violet light and photographed. The gel photographs were scored for presence and absence of scorable bands with the assumption of positional homology. To establish the genetic relationship among the isolates, similarity coefficients were calculated between isolates and dendrogram drawn using Unweighted pair group method using arithmetic averages algorithm (UPGMA) of the NTSYS-pc, Version 2.02h programme.

PCR product of ITS amplified region containing ITS-1, 5.8S rDNA and ITS-2 were directly sequenced using ITS-1 (Forward primer) and ITS-4 (Reverse primer) by Big dye terminator method by ABI prism DNA sequencer at Delhi University. The sequence data obtained from ITS-4 reverse primer was inversed using Gene doc software and clubbed with sequence data of ITS-1 to obtain complete sequences of amplified ITS product. Nucleotide sequence comparisons were performed by using Basic Local Alignment Search Tool (BLAST) network services against the National Centre for Biotechnology Information (NCBI), USA database. The molecular identification up to species level was done and the species designated to the sequenced cultures, analysis based on similarity with the best-aligned sequence of BLAST search. 5.8S rRNA gene sequence alignments were performed using Clustal x 1.83 software.

All the 19 accessions exhibited identical ITS lengths of approximately 650 bp on gel electrophoresis. This conformed that all the accessions belong to one Species.(Fig. 2 and 3).

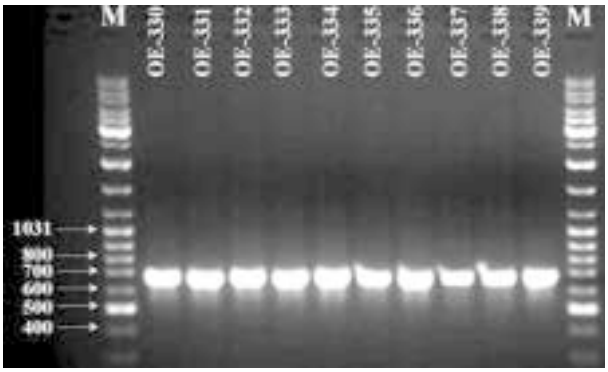


Fig. 2: ITS profile of *Calocybe indica* accessions OE-330 to OE-339

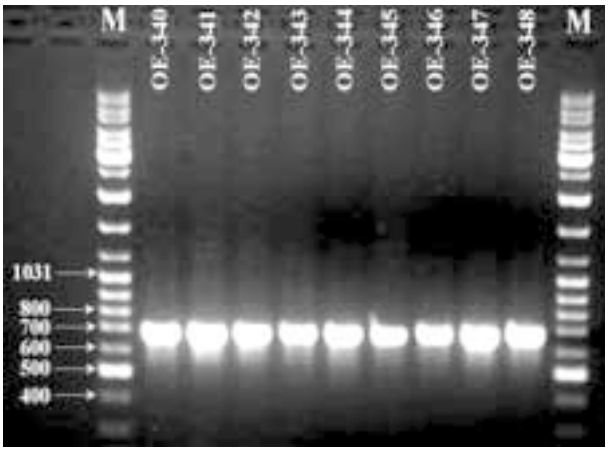


Fig. 3: ITS profile of *Calocybe indica* accessions OE-340 to OE-348

Nevertheless, direct sequencing of PCR amplified ITS regions facilitated molecular identification of all the germplasm accessions. No intra-specific polymorphism could be observed in ITS lengths in all the 19 accessions studied.

The RAPD profiles of *Calocybe indica* group of accessions generated using 6 decamer primers exhibited significant polymorphism in scorable bending patterns. The RAPD profiles amplified using OPP-8 are presented vide Fig. 4 & 5.

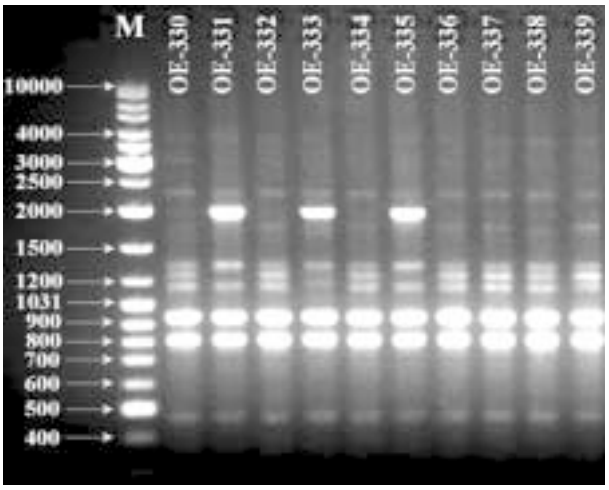


Fig. 4: RAPD profiles of *Calocybe indica* accessions using OPP-8 primer

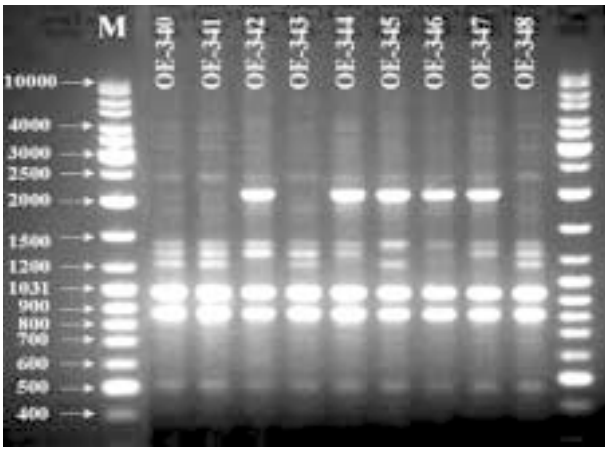


Fig. 5: RAPD profiles of *Calocybe indica* accessions using OPP-8 primer

The phylogenetic analysis of the RAPD scorable prominent bands exhibited both inter- and intra-specific polymorphism in *Calocybe* group of accessions All the six arbitrary decamer RAPD primers amplified the genomic scorable DNA fragments of all the 19 accessions of *Calocybe indica* and separated them into seven distinct phylogenetic sub-clades (Fig. 6). Group-1 included accessions OE (- 330, 334, 336, & 340), Group-2 OE (- 337, 338, 341, 343, 348), Group-3 (OE-339), Group-4 OE (- 331, 335 & 345), Group-5 OE (-342, 334 & 347), Group-6 (OE-346) and Group-7 (OE-333). Present study validates existence of intra-specific diversity in *Calocybe* accessions.

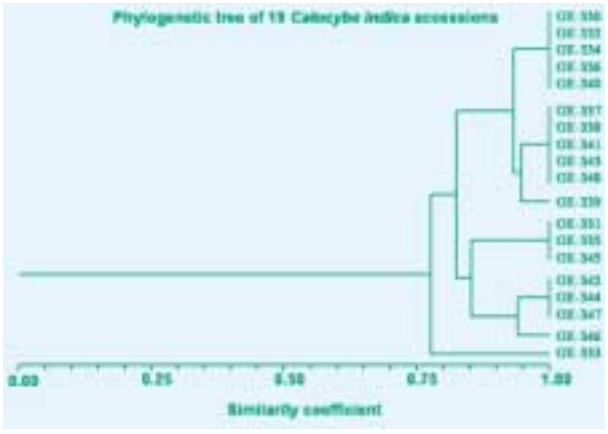


Fig. 6: Phylogenetic tree showing intra-species diversity in *Calocybe indica*

2. Genetic Improvement

Project–NCM-14: Genetic improvement of temperate and tropical mushroom

2.1 Breeding in white button mushrooms (PI: Dr. Mahesh C. Yadav)

2.1.1 Molecular markers assisted breeding

RAPD analysis: RAPD markers were used for the molecular characterization of genetic variation induced via meiotic recombination and chromosomal segregation in the single spore progenies of parents A-2, A-46, U-3 and A-21. Sixteen random primers with reproducible bands were used for RAPD analysis of 44 SSIs and 4 parental strains of *A. bisporus*. These primers amplified easily scorable bands, which ranged from 300 bp to 4000 bp in length. A total of 184 RAPD fragments were amplified with an average of 11.5 amplicons per primer. Genetic variability was detected among SSIs of the same parent. The similarity coefficients varied from 0.36 to 1.00 with the average being 0.67. The genetic diversity among progenies of parent A-2 was 15.82%, while it was 16.56% in SSIs of hybrid A-46, 12.27% in SSS of hybrid U-3 and 7.67% in SSIs of brown strain A-21.

The dendrogram based on UPGMA separated all the 44 SSIs except two U-3 progenies SSI-8107and SSI-8108 and grouped them into two major phylogenetic groups based on pileus colour i.e. white *vs.* brown. These two groups were separated at 0.48 similarity coefficient. Within the first major phylogenetic cluster, A-2 and its SSIs formed single sub-cluster, whereas, SSIs of A-46 and U-3 formed another sub-cluster. Parent A-21 and its single spore progenies formed another major cluster based on brown pileus colour. The single spore progenies were separated from parent A-21 showing intra-cluster variation.

2.1.2 Genetic Improvement in Button Mushroom, *Agaricus bisporus*

In view of genetic enhancement in the commercially most important button mushroom *A. bisporus*, single spore selection was exercised in a large number of single spore progenies isolated from parent hybrid U-3, A-2 and A-46. The progenies selected based on mycelium morphology and growth rate were evaluated for their yield potential and mushroom qualities. The profound variation was observed for spawn run, primordia initiation, days to first harvest and yielding abilities. The first harvest was recorded early in high yielding genotypes. Out of 21 single spore progenies, four single spore selections namely SSI-6301, SSI-6305 from strain A-2 and SSI-8107 and SSI-8109 from hybrid U-3 produced significantly higher yields of 17.5, 17.7, 19.2 and 20.2 kg, while, standard check hybrid U-3 yielded 15.0 kg/100kg (Fig. 7) pasteurized compost, respectively in 6 weeks of cropping under partially controlled environmental conditions.

Fig. 7: High yielding single spore selection from U-3 exhibiting nice white fruitbodies

2.1.3 Yield evaluation at farmer's field:

Four hybrids of *A.bisporus* were tested at farmer's field through HAIC, Murthal, (Haryana) using large scale trials. Two hybrids performed superiorly over the

standard check varieties. The mushroom yields of these hybrids will again be tested in 2006-07 season at farmer's field.

2.1.4 Induced mutagenesis: Seven EMS treated single spore progenies of parent U-3 and three tissue cultures of A-21 treated with EMS were characterized by colony morphology and RAPD technique. The slower growth rate and varied mycelium morphologies were observed in EMS treated SSPs. RAPD markers detected polymorphism among the EMS treated lines (32.95% distance from the parent) and EMS treated tissue cultures (45.27% distance from the parent). Two EMS treated lines produced significantly high yield than the parent.

2.1.5 Protoplast isolation and regeneration in *Agaricus* species: In all 45 protoplast regenerants (PRs) were isolated, some exhibited appressed type of colonies. RAPD genotyping of five randomly selected protoplast regenerants revealed that these lines are isogenic (homogenetic) with 100% similarity even after employing 18 polymorphic random primers in the analysis. However, the protoplast regenerants were found to be 5.8% genetically diverse from the parent U-3.

2.2 Breeding in *Pleurotus* spp. (PI: Dr. R.C. Upadhyay)

2.2.1 Developing Hybrid strains of *Pleurotus sajor-caju*

Spore print of *Pleurotus sajor-caju* strain Pl-1150 was used to isolate single spores on malt extract agar medium with Rose Bengal. Twenty seven single spore cultures were isolated out of which 2 were found dikaryotic and discarded. The single spores cultures showed wide variability and colonies could be differentiated as thin or thick, strandy or cottony, slow growing or fast growing. All the 25 isolates were hybridized for determining mating types. The mating system is bifactorial. The hybrids developed and their single spore parent cultures are mentioned in Table-3. Two strains H-26 and H-28 were very fast growing at 25ºC and daily radial growth of 14.4mm and 14.8mm, respectively was recorded. Three strains were very fast at 32ºC and gave 70-80% faster growth than parent culture. Preliminary cultivation trail using wheat straw gave fructifications in 35 strains while twenty two strains were very slow growing and contaminated during spawn run. Three strains namely H-8, H-12 and H-34 gave higher yield that parent strain. (Table 4).

2.2.2 Evaluation of high yielding strains of *Pleurotus florida* on pasteurized wheat and paddy straw

Six hybrid strain of *Pleurotus florida* developed earlier by hybridization of thirteen single spores were again evaluated for their yield performance on pasteurized wheat straw during winter. Five replications were kept for each hybrid strain. All the six strains namely H-16, H-18, H-24, H-25, H-29 and H-35 gave significantly higher yield than parent. However, strain H-16 and H-18 gave highest yield (72% and 69% B.E.). The detailed morphological characteristics of hybrid strains are mentioned in Table 5.

2.3 Breeding of Paddy straw mushroom (*Volvariella* spp)- (PI: Dr. O.P.Ahlawat)

2.3.1 Isolation and characterization of single spore isolates from parental strain OE-274 of *V. volvacea*

The promising strain OE-274, which produced higher mushroom yield and better quality fruiting bodies was used in

Table 3: Spore cultures used for developing hybrid strains

S. No.	Hybrid strains	Parent spore	Single culture	S. No.	Hybrid strains	Parent spore	Single culture
1	Strain No. 1	1	6	29	Strain No. 29	5	12
2	Strain No. 2	1		30	Strain No. 30	5	13
3	Strain No. 3	1	9	31	Strain No. 31	5	14
4	Strain No. 4	1	13	32	Strain No. 32	5	17
5	Strain No. 5	1	14	33	Strain No. 33	5	18
6	Strain No. 6	1	17	34	Strain No. 34	5	19
7	Strain No. 7	1	18	35	Strain No. 35	6	10
8	Strain No. 8	1	19	36	Strain No. 36	6	11
9	Strain No. 9	1	20	37	Strain No. 37	6	20
10	Strain No. 10	2	10	38	Strain No. 38	7	10
11	Strain No. 11	2	8	39	Strain No. 39	7	11
12	Strain No. 12	2	1	40	Strain No. 40	7	20
13	Strain No. 13	2	15	41	Strain No. 41	8	11
14	Strain No. 14	3	6	42	Strain No. 42	9	11
15	Strain No. 15	3	8	43	Strain No. 43	10	12
16	Strain No. 16	3	9	44	Strain No. 44	10	15
17	Strain No. 17	3	12	45	Strain No. 45	10	16
18	Strain No. 18	3	14	46	Strain No. 46	10	17
19	Strain No. 19	3	17	47	Strain No. 47	10	19
20	Strain No. 20	3	18	48	Strain No. 48	11	13
21	Strain No. 21	3	19	49	Strain No. 49	11	14
22	Strain No. 22	4		50	Strain No. 50	11	17
23	Strain No. 23	4	12	51	Strain No. 51	11	18
24	Strain No. 24	4	15	52	Strain No. 52	11	19
25	Strain No. 25	4	16	53	Strain No. 53	12	20
26	Strain No. 26	5	6	54	Strain No. 54	15	20
27	Strain No. 27	5	8	55	Strain No. 55	16	17
28	Strain No. 28	5	9	56	Strain No. 56	16	20
				57	Strain No. 57	19	20

the present study. A total of 42 single spore isolates of this strain were isolated on the succinic acid supplemented plain agar medium and re-grown on malt extract agar medium for their morphological characterization. The SSIs showed wide variations in their growth rate, type of mycelial thread, density of mycelial growth, presence of the aerial mycelia and the chlamydospores. Based upon these growth parameters the SSIs were found to belong to 4 major groups (Table 6).

2.3.2 Morphological and biochemical characterization of single spore isolates from parent strain OE-210 of *V. volvacea*

The promising parent strain, OE-210, which gave higher mushroom yield and better quality fruiting bodies was used in

Table 4: Radial growth of hybrid strains of *P. sajor-caju* at 25 and 30°C and biological efficiency on wheat straw substrate

S. No.	Hybrid	Radial growth at (mm/day) 25° C	32° C	BE (%)	S. No.	Hybrid	Radial growth at (mm/day) 25° C	32° C	BE (%)
1	H - 1	12.25	5.8	16.24	30	H -30	13.0	4.4	14.68
2	H -2	11.8	5.8	13.58	31	H -31	14.2	4.9	39.48
3	H -3	13.1	4.5	22.02	32	H -32	13.6	4.6	12.12
4	H -4	10.3	4.3	-	33	H -33	12.8	4.5	-
5	H -5	12.9	4.8	23.88	34	H -34	12.7	4.9	48.00
6	H -6	11.4	5.6	19.46	35	H -35	10.4	1.0	-
7	H -7	11.4	6.1	36.94	36	H -36	11.7	5.0	-
8	H -8	12.4	6.8	49.58	37	H -37	11.7	2.3	-
9	H -9	13.4	6.4	43.72	38	H -38	13.6	1.3	-
10	H -10	11.4	4.9	24.16	39	H -39	8.6	2.6	-
11	H -11	8.8	1.9	8.26	40	H -40	11.1	1.8	-
12	H -12	13.5	5.1	46.38	41	H -41	11.8	4.6	-
13	H -13	9.9	4.9	29.32	42	H -42	10.8	1.8	-
14	H -14	13.3	7.3	25.58	43	H -43	12.4	2.3	31.70
15	H -15	12.0	7.1	26.12	44	H -44	10.3	3.5	-
16	H -16	13.5	5.6	36.14	45	H -45	11.3	5.5	22.20
17	H -17	10.9	2.9	10.00	46	H -46	10.4	2.6	-
18	H -18	12.6	4.6	38.10	47	H -47	12.0	1.6	-
19	H -19	6.5	4.4	-	48	H -48	9.8	3.3	-
20	H -20	11.2	6.4	38.10	49	H -49	9.8	3.0	39.14
21	H -21	7.0	6.1	-	50	H -50	11.7	2.9	33.06
22	H -22	8.8	4.3	-	51	H -51	9.7	1.4	-
23	H -23	9.0	7.0	40.50	52	H -52	12.4	2.4	33.06
24	H -24	8.8	2.0	-	53	H -53	13.2	3.4	34.52
25	H -25	11.1	4.5	-	54	H -54	7.4	6.8	-
26	H -26	14.4	4.6	8.56	55	H -55	9.2	5.8	-
27	H -27	12.6	5.8	34.12	56	H -56	11.3	3.1	-
28	H -28	14.8	4.1	20.78	57	H -57	7.6	1.6	-
29	H -29	13.3	5.1	21.86	58	*P. Sajor-caju*	11.1	4.1	42.10

the present study. A total of 10 promising single spore isolates of this strain varying in their growth characteristics were used for studying variations in morphological and biochemical characteristics by growing on the grinded paddy straw substrate (Table 7).

2.3.3 Morphological characteristics of SSIs of strain OE-210 growing on grounded paddy straw substrate

The SSIs showed vide variations in their growth rate with highest in OE-210-30 followed by OE-210-4, OE-210-12, OE-

Table 5: Morphological characteristics of hybrid strains

Col No.	Pileus diam (cm)	Avg. diam (cm)	Stipe diam. (cm)	Avg. diam. (cm)	Colour of plieus	Spore print in mass
Pl-H-16	3.5-4.5	4.0	3-6 x 1.8-2	4.5 x 1.9	Light orange to pale orange (5A4-3), yellowish grey to yellowish white (3B2-2A2), velvety in the centre, white to orangish grey (5B2) fibrils	Brownish grey (6C2) to brownish orange (6C3); heavy
Pl-H-18	4.0-5.5	1.9	8-13 x 2-3	10.5 x 2.5	Pale orange (5A3) to light yellow (4A4), lighter outwards, velvety in the middle.	Orange grey (6B2); heavy
Pl-H-24	4.0-9.0	6.5	3-7.5 x 0.8-1.4	5.25 x 1.1	Yellowish grey (4B2) darker in the middle, brownish orange (5C3) to grayish beige (4C2), velutinous in the middle	
Pl-H-25	4.0-9.0	6.5	5-9 x 1.5-3	7 x 2.25	Grayish beige (4C2) to brownish orange (5C2), yellowish grey (4B2) outwards	Creamish white; moderate
Pl-H-29	4.5-6.5	5.5	7-10 x 1.8-2.5	8.5 x 2.15	Grayish orange (5B3) to grayish yellow (4C3), grayish yellow (2B2) outwards	Brownish grey (8D2); heavy
Pl-H-35	3.0-6.5	4.7	3.5-7 x 1-1.9	5.25 x 1.45	Yellowish grey (4B2), grayish beige (4C2) to brownish orange (5C3) in the milddle, whitish fibrils in the centre	Brownish grey (8D2); heavy

Table 6: Morphological characteristics of single spore isolates of strain OE-274 of *V. volvacea*

Broad grouping	Growth rate	Aerial mycelia	Mycelial growth density	Location and intensity of chlamydospores	No. of isolates
Group-I	Very slow	Negligible	Powdery growth	Nil/negligible	11
Group-II	Medium	++	Cottony well spread	Negligible	12
Group-III	Fast	+++	Thick/thin	Well spreaded	7
Group-IV	Very fast	+++++	Thick and on aerial mycelia at periphery	More in Center	12

++ = Good growth +++ = Very good growth +++++ = Excellent growth

210-23 and OE-210-29. The SSIs also varied in type of growth and presence of aerial mycelia on the surface of the substrate. Highly thick aerial mycelia growth along with presence of chlamydospores was recorded in SSI, OE-210-30. In rest of the SSIs no chlamydospores presence was recorded (Table 7). Aerial mycelia was absent in SSIs, OE-210-9, OE-210-22 and OE-210-28.

2.3.4 Ligno-cellulolytic enzymes assay of SSIs of strain OE-210 growing on grounded paddy straw substrate

Ten SSIs along with parent strain OE-210 were used for assaying their enzymes production potential by growing on sterilized paddy straw substrate. The enzymes assay was done after 8 days of growth of different SSIs and the parent strain. Not many SSIs showed much activity of the exoglucanase and endoglucanase enzymes and the endoglucanase activity was highest in parent strain, while, the exoglucanase activity was higher only in one SSI, OE-210-03. Xylanase activity was also negligible in majority of the SSIs. Several fold higher activities of laccase and polyphenol oxidase enzymes were recorded in SSIs OE-210-9 and OE-210-12 (Table 8) in comparison to parent strain.

2.3.5 Molecular characterization of single spore isolates of higher yielding strain, OE-210

A total of 10 single spore isolates and the parent strain OE-210 showing variations in their morphological growth characteristics and in lingo-cellulolytic enzymes activities were used in the study. The SSIs showed different growth patterns starting from powdery very slow growth to very fast growth with plenty of aerial mycelia and cluster of chlamydospores around the bit of inoculated mycelia (Fig. 8). The PCR – amplified product of the ITS region of 5.8S ribosomal gene by using two primers (ITS-1 and ITS-4) revealed that all the SSIs and the parent strain exhibited bands at nearly 720 bp length determined by running a parallel marker on the gel. The results proved that all the SSIs belong to the same species as of the parent strain and there was no variations at species level or contamination from other related mushroom mycelia (Fig. 9).

Table 7: Morphological growth characteristics of single spore isolates and the parent strain, OE-210

Strain/SSI	Extent of growth	Type of mycelia	Aerial	Chlamydospores
OE-210	+++	Equally distributed , thin	+++	-
OE-210-3	+++	Equally distributed , thin	+++	-
OE-210-4	++++	Very thin and fluffy	+++	-
OE-210-9	++	Very thin and fluffy	-	-
OE-210-12	++++	Equally distributed , thin	+++	-
OE-210-13	++++	Dense growth more pronounced on top	++	-
OE-210-22	+++	Dense poorly distributed	-	-
OE-210-23	++++	Dense and thick	++	-
OE-210-28	++	Dense equally distributed	-	-
OE-210-29	++++	Equally distributed , thin	+++	-
OE-210-30	+++++	Dense thick, equally distributed	++++	+++

++ = Good growth; ++++ = Very good growth; ++++ = Excellent growth; +++++ = Excellent dense growth

Table 8: Cellulolytic and lignolytic enzymes activities of single spore isolates of strain OE-210 of *V. volvacea*

Single spore isolate	Enzyme activity				
	Exoglucanase (mmole glucose /ml/hr)	Endoglucanase (mmole glucose /ml/hr)	Xylanase (mmole glucose /ml/hr)	Laccase (0.001Unit/ ml/min.)	Polyphenol oxidase (0.001Unit/ ml/min)
OE-210	0.096	1.102	0.0032	10.67	7.42
OE-210-3	0.354	0.129	0.0129	-	7.25
OE-210-4	0.042	0.256	-	33.25	17.00
OE-210-9	0.035	0.046	0.0560	76.67	13.92
OE-210-12	0.012	0.249	0.0220	94.00	12.83
OE-210-13	-	-	0.0370	5.42	2.17
OE-210-22	0.009	0.001	-	6.25	5.83
OE-210-23	0.006	-	0.0180	-	2.67
OE-210-28	0.080	0.054	0.0032	10.58	5.92
OE-210-29	0.050	0.050	0.4080	24.42	-
OE-210-30	0.009	0.053	0.0039	15.17	9.42

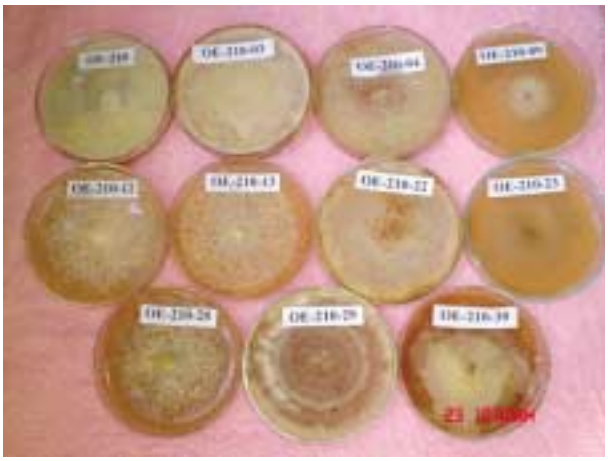


Fig. 8: Plates showing variations in growth characteristics of the SSIs and the parent strain OE-210

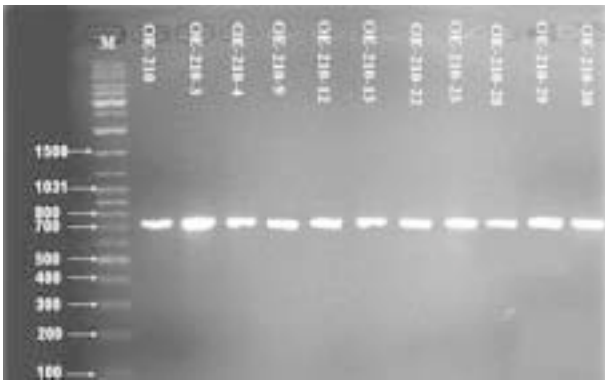


Fig. 9: PCR amplified products of ITS region of 5.8S ribosomal gene in SSIs of strain OE-210 of *V. volvacea*

2.3.6 Molecular characterization of single spore isolates and the parent strain OE-210 by using RAPD profiles obtained with different OPB series primers

The variations in all the single spore isolates and the parent strain OE-210 were studied by obtaining the RAPD profiles on using 5 different OPB series primers (OPB-1, OPB-2, OPB-3, OPB-4 and OPB-5). The profiles obtained by using different primers are presented in Figures 10 and 11. All the primers showed different banding pattern and OPB-1, OPB-3 and OPB-5 primers yielded the maximum number of bands in different strains, while OPB-2 and OPB-4 gave lesser numbers of bands. Primer OPB-1 showed very high similarity between different SSIs and the parent strain. However, primer OPB-3, OPB-4 and OPB-5 generated different discrete bands in different SSIs and the parent strain. The dendrogram generated by using 5 different primers showed that the 10 SSIs formed 7 different groups, out of which only one i.e. OE-210-4 showed absolute similarity

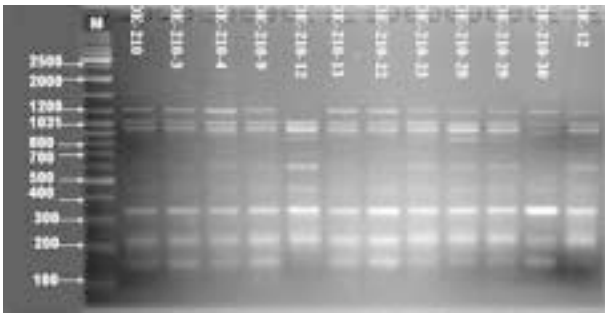


Fig. 10: RAPD profile of SSIs of parent strain OE-210 of *V. volvacea* by primer OPB-1

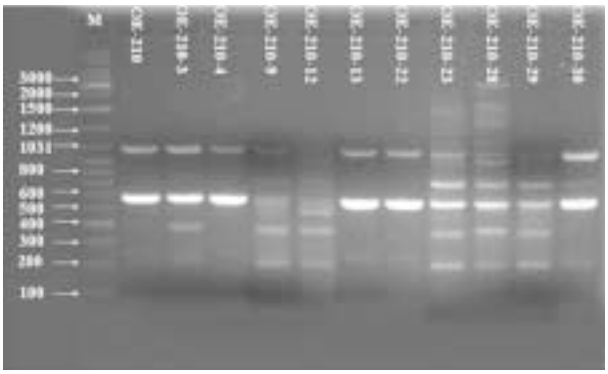


Fig. 11: RAPD profile of SSIs of parent strain OE-210 of *V. volvacea* by primer OPB-4

with the parent strain (Fig. 12). Highest level of dissimilarity (53% similarity) was exhibited by SSI, OE-210-12 which has also shown high lignolytic activity in the form of laccase and poly phenol oxidase enzymes activities. Other closely sharing SSIs were OE-210-03, OE-210-13 and OE-210-22 with similarity level of more than 80%.

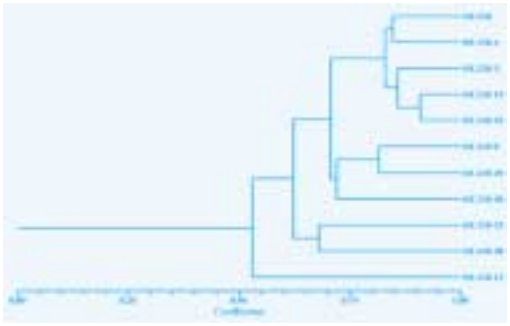


Fig. 12: Dendrogram of single spore isolates and parent strain OE-210 based upon five OPB series primers

2.4 Genetic improvement in Shiitake (*Lentinula edodes*) mushroom

Project: - NCM-33 - Molecular characterization and genetic improvement in Shiitake (*Lentinula edodes*) mushroom (PI: Dr S.K. Singh)

2.4.1 Collection/ procurement of *Lentinula edodes* germplasm

Twenty-one shiitake (*Lentinula edodes*) strains were procured from National Research Centre for mushroom Culture Bank and brought into fresh cultures on MGA (Malt extract 10 g; Glucose 5 g; Agar Agar 20 g; Distilled Water 1 Liter) at 25^{0}C. Six new Shiitake strains were collected during 2005-06. The details of the strains are given as under.

1. OE-329: RRL Jorhat.
2. OE-359: (MN-1) Imphal, Manipur.
3. OE-360: (MN-2) Imphal, Manipur.
4. OE-361: (MPT-1) Raipur, M.P.
5. OE-362: (MPT-2) Raipur, M.P.
6. OE-363: (MPT-3) Raipur, M.P.

All these new cultures have been deposited in NRCM culture bank and accession numbers assigned.

2.4.2 Assessment of genetic diversity and strain typing

Eleven Shiitake strains viz., OE (16, 21, 28, 38, 59, 329, 359, 360, 361, 362 & 363) were subjected to RAPD analysis and sequencing of 5.8S r RNA gene. The molecular analysis exhibited genetic variations and validated that all the strains are of *Lentinula edodes*.

2.4.3 Conservation and maintenance of *Lentinula edodes* germplasm

All the 27 shiitake strains were sub-cultured twice during 2005-06 for their use in breeding programme.

2

CROP PRODUCTION

1. Button mushroom, *A. bisporus*

Project: - NCM-16: Improved methods of composting for white button mushroom (*Agaricus bisporus*) (PI- Dr. B.Vijay)

1.1 Indoor composting

This experiment was conducted two times in the season taking wheat straw as the base material. Compost was prepared using following formulation.

Compost ingredients	Quantity
Wheat straw:	1.0 ton
Chicken manure:	400 kg
Wheat bran:	70 kg
Urea:	15 kg
Cotton seed cake:	20 kg
Gypsum:	30kg

Time schedule	Operation
-2 day:	Wetting and mixing of the ingredients out doors.
-1 day:	Turning, trampling by Bobcat and thorough mixing of the ingredients, addition of water.
0 day:	Filling in the phase-I tunnel.
+3 day:	Emptying the tunnel, turning and mixing of the ingredients, addition of water and filling the Phase-I tunnel.
+6 day:	Filling the phase-II tunnel.
+12 day:	Phase-II operation over.

Solid state fermentation

Ingredients were thoroughly mixed and properly wetted so as to achieve around 75% moisture. Run off water was regularly collected and sprinkled over the wetted straw. On the following day these wetted ingredients were than spread over the composting yard (around 8"-10" height) and were trampled hard by running Bobcat several times over the wetted ingredients so as to increase the bulk density of the ingredients and also to shred the straw. After two days of their thorough mixing and wetting, it was transferred to phase-I bunker for phase-I operation. This material weighed around 4 tons and height of the compost in the bunker was kept up to 2 meters. The compost mass was kept as such over night. A temperature between 65-73°C was recorded in the centre of the pile while top and sides showed temperature between 48-55°C. Blower fan was switched on for 5 minutes per hour. Full penetration of air was noticed in the compost. Further, no foul smell was noticed while performing phase -I in bunker. After 3 days of partial fermentation in phase-I tunnel, entire compost mass was taken out, remixed and filled in the same tunnel. After 3 days, this compost was transferred to phase-II tunnel for usual phase-II operations, thereafter, standard methodology was employed for compost production.

For check, compost was prepared by short method in 16-18 days using same ingredients mentioned above and standard procedure was followed for composting.

Physical parameters and total yield

Moisture of the compost at filling was 72% which came down to 67% at spawning compost. pH at filling was 8.2 while it was 7.7 at spawning. Nitrogen percentage (N%) was 1.74 at filling while it increased to 2.2 at spawning. Wheat straw to compost conversion ratio was 2.9 times (Table-1). With short method compost 2.4 times compost was obtained with one tonne straw. An average yield of 14.03Kg/ 100Kg compost was obtained from the trial in forty days of cropping as against 13.46 Kg in short method of compost.

Table 1: Physical parameters of compost prepared with indoor composting technique

Parameter	At filling	At spawning
Moisture %	72%	67%
pH	8.2	7.7
Nitrogen%	1.74	2.20
Conversion ratio	—	2.90

1.2 Isolation and identification of fungal flora of different composts

Mesophilic and thermophilic flora were isolated from the six compost piles prepared with different ingredients (Table-2) before filling and after pasteurization. A total numbers of eight mesophilic fungi were isolated viz., *Mucor* sp., *Aspergillus niger*, *Aspergillus* sp., *Penicillium oxalicum*., *Trichoderma viride*, *Scytalidium thermophilum*, *Humicola insolens* and an unidentified species (Table 2). Incidence of *T. viride* was very high in the piles where cotton linter was used as one of the ingredients. Only *Scytalidium thermophilum* and *Humicola insolens* were isolated from these composts after pasteurization. CFU of all these fungi after pasteurization were low as compared to phase one stage of composting. No true mesophilic fungi were isolated at this stage.

Thermophilic fungi were also isolated at different stages. At filling seven fungi namely *Mucor racemosus*, *Scytalidium thermophilum*, *H. insolens*, *Humicola grisea*, *Thermomyces lanuginosus*, *Talaromyces duponti* and *Aspergillus* sp. were isolated from different composts. Among all these fungi *S. thermophilum* followed by *H. insolens* were the most dominant fungi and were isolated from all the treatments. *T.duponti* and *Aspergillus* sp. were isolated in the initial stages of composting from the piles where cotton linter was added as one of the nitrogen source (Table-3). Only two fungi (*S. thermophilum* and *H. insolens*) were isolated after pasteurization and frequency of occurrence of former was more.

Table 2: Dominant mesophilic flora isolated from the different composts before pasteurization

Organisms	T-1	T-2	T-3	T-4	T-5	T-6
Mucor sp.	+	+	+	-	+	+
Aspergillus niger	++	+++	++	++	+	
Aspergillus sp.	-	-	++	++	-	-
Penicillum oxalicum	-	-	-	-	+	-
Trichoderma viride	-	+	-	-	+++	++
Scytalidium thermophilum	+	+	+	+	+	+
Humicola insolens	-	-	+	-	-	+
Unidentified sp.	-	-	+	++	-	-

(-) = Nil; + = max. 3 colonies; ++ = max. 5 colonies; +++ = more than 5 colonies

Table 3: Dominant thermophilc flora isolated from different composts before pasteurization

Organisms	T -1	T-2	T-3	T-4	T-5	T-6
Mucor racemosus	+	+	-	-	-	-
Scytalidium thermophilum	+++	+++	++	+++	+++	+++
Humicola insolens	+	+	++	++	+	+
Humicola grisea	-	+	+	-	+	-
Thermomyces lanuginosus	-	+	-	-	-	-
Talaromyces duponti	-	-	-	-	+	+
Aspergillus sp.	-	-	-	-	+	+

(-) = Nil; + = max. 3 colonies; ++ = max. 5 colonies; +++ = more than 5 colonies

1.3 Evaluation of different compost formulations for *A. bisporus* cultivation

Different formulations were used for preparing compost (Table-4) by short method. During phase-I highest average temperature was recorded in T- 4 treatment whereas lowest was recorded in T-1 treatment where wheat straw was supplemented with 80 % chicken manure as the nitrogen source (Table-5). Compost pH at spawning ranged between 7.15-7.60. Total Nitrogen % was in the range of 1.42-1.52. In the trial highest compost was produced in the treatment where 80 % chicken manure was used for compost production. Highest yield (12.34 kg/ 100kg compost) was obtained in treatment 5, where chicken manure and cotton linter were added as the organic supplements. Lowest yield was obtained in treatment 6 where 70% chicken manure was used as the supplement along with 5 % supplement of cotton seed cake and cotton linter (Table-5).

Table 4: Formulations used for preparing compost

Ingredients (kg)	Piles (Treatments)					
	1	2	3	4	5	6
Wheat straw	200.0	200.0	200.0	200.0	200.0	200.0
Chicken manure	160.0	140.0	-	80.0	80.0	140.0
Wheat bran	-	-	14.0	14.0	-	-
Urea	-	-	5.0	3.5	3.0	-
Cotton seed cake	-	14.0	-	-	-	10.0
Cotton seed meal	-	-	16.0	-	-	-
Cotton linter	-	-	-	-	40.0	10.0
Gypsum	15.0	15.0	15.0	15.0	15.0	15.0

Table 5: Physical parameters of different composts prepared with different ingredients

Temp (^{0}C) during phase 1	Moisture (%) at spawning	pH at spawning	Nitrogen (%) (cold)	Total compost produced(kg)	Yield (kg)/ 100kg compost
60.83	66.00	7.24	1.52	630	9.29
61.20	69.00	7.30	1.52	550	9.70
63.16	67.60	7.60	1.45	530	10.58
67.33	68.50	7.40	1.35	480	10.31
66.33	70.30	7.15	1.47	600	12.34
62.50	66.40	7.60	1.42	500	7.53

1.4 Total indoor compost production using thermophilic fungi

The experiment was conducted with a view to produce *A. bisporus* compost under total indoor condition in seven days time completely bypassing Phase-I condition of composting, with the help of thermophilic fungi. The study was conducted with the undermentioned formulation:

Ingredients	Quantity
Wheat straw	300 kg
Urea	4.7 kg
Chicken manure	125 kg
Gypsum	15 kg
Wheat bran	30 kg

This compounding mixture was thoroughly wetted so as to achieve around 74% moisture. After thorough wetting, mixture was kept as such in open in flat stacks (6" high) for one day so that it may not heated up. On the following day this mixture was inoculated (0.4%) with *S thermophilum* (7 Strains), *H insolens* (8 Strains) and *H grisea* (6 strains). 50 Kg compounding mixture was taken for each strain. Four control sets namely C-1 (no inoculum added), C-2 (mixed inoculum of above fungi), C-3 (compost inoculum added) and C-4 (steam sterilized compounding mixture) were also prepared. These inoculated lots were then placed in the peak heating room on racks in the form of heaps. Doors and shutters were closed and blower fan switched on. In the morning temperature of different piles stood around 45-48^{0}C. These heaps were kept in the peak heating room for seven days at a temperature regime of 45-58°C. Steam was released periodically to maintain the above temperature.

Data on physical parameters and mycoflora of the initial compounding mixture are presented in Table-6. Moisture % ranged between 67.4 – 72.0%, pH was in the range of 7.45 to 7.85 and N level between 1.6 to 1.91%. Cfu/g of this compounding mixture was 17.6. Dominant thermophilic fungal flora isolated from these mixtures included *Mucor* sp., *Aspergillus* Sp., *S thermophilum* and *H insolens*.

Physical parameters of the prepared compost after 7 days of conditioning and pasteurization are presented in Table-7. Apparently compost was ready and free from ammonia in 7 days time. There was large growth of thermophilic fungi in different piles. Weight loss of the compounding mixture in different treatments ranged between 36.2-52.6%. Highest being in *H grisea* (Starin-3). Control piles exhibited least weight loss. Moisture and pH were well within permissible limits for all the treatments including controls. N% ranged between 0.91-3.57 in different treatments. Highest being in the control, which was inoculated with mixed inoculum of the above fungal strains (C-2).

Table 6: Physical parameters of initial compounding mixtures

Sample	Physical Parameters				
	Moisture (%)	pH	N(%)	CFU/g of the compost	*Dominant Flora
F1	72.00	7.85	1.80	17.6	12, 11, 1
F1 Sterilized	67.40	7.45	1.60	10.0	11
Compost Inoculum	70.00	7.45	1.91	16.0	1,5,11,12

***Dominant flora** :1. *Scytalidium thermophilum*: Representative strain, 2. *Humicola insolens*: Representative strain, 3. *Humicola grisea*: Representative strain, 4. *Scytalidium thermophilum*-I, 5. *Scytalidium thermophilum*-II, 6. *Humicola insolens*-I, 7. *Humicola grisea*-I, 8. *Themomyces lanuginosus*, 9. *Thermoascus aurantiacus*, 10. *Chaetomium thermophile*, 11. *Aspergillus* sp., 12. *Mucor pussilus*, 13. *Mycelia sterilia*

Table 7: Physical parameters of different composts prepared with different thermophilic organisms

Strain	% wt. loss	pH	N (%)	Inoculum load (g^{-1})	cfu (g^{-1}) of compost	*Dominant flora
Scytalidium thermophilum (Strains)						
S-1	46.00	7.52	2.20	14.66	63.00	1(58), 4(2) 11(3)
S-2	44.00	7.26	1.71	12.33	40.60	1(36), 4(1), 6(2), 11(1)
S-3	43.26	7.36	1.98	3.33	39.60	1(35), 4(2), 5(2)
S-4	38.00	8.15	1.77	2.33	23.60	1(20), 4(1), 7(1) 12(1)
S-5	36.20	8.32	2.10	9.33	38.60	1(33), 4(2), 11(2), 12(1)
S-6	46.42	7.19	2.06	12.66	37.60	1(34), 4(1), 10(1), 12(1)
S-7	41.50	7.10	1.19	5.33	42.60	1(37), 11(3), 13(2)
Humicola insolens (Strains)						
S-1	44.00	7.85	1.61	11.66	40.30	2 (34), 4(1), 11(2) 12(2), 13(1)
S-2	42.70	7.37	1.89	10.66	44.85	2 (40), 4(1), 11(2), 13(1)
S-3	43.00	7.19	1.47	13.33	42.00	2 (40), 11(2)
S-4	46.40	7.83	1.89	17.66	42.85	2 (37), 13(5)
S-5	47.60	7.28	1.85	10.33	48.27	2 (39), 6(1), 10(1), 11(4), 12 (2), 13(1)
S-6	47.00	7.71	1.61	17.33	45.21	2 (40),4(1) 11(2), 12 (2)
S-7	43.40	7.10	1.89	15.00	31.30	2 (27), 5(1), 9(1), 11(2)
S-8	38.00	7.55	2.05	29.00	38.00	2 (34), 4(2), 13 (2)
Humicola grisea (Strains)						
S-1	45.00	7.48	2.03	11.66	110.24	3 (108), 4(2)
S-2	43.50	7.45	1.75	16.00	52.30	3 (49), 4(1), 5(1), 11(1)
S-3	52.26	7.17	1.62	15.33	42.30	3 (37), 4(2), 5(2), 11(1)
S-4	40.00	7.45	1.72	3.35	27.85	3 (25), 4(1), 12(1)
S-5	40.00	7.44	2.17	12.00	36.00	3 (34), 11(2)
S-6	44.40	7.85	1.89	14.00	37.60	3 (34), 4(1), 11(1), 13(1)
Control						
C-1	32.00	8.00	0.91	-	22.54	4(10), 5(8), 11(2), 13(2)
C-2	38.00	7.70	3.57	-	40.30	All representative strains
C-3	40.00	7.55	1.98	16.0	37.75	4(15), 5(12)
C-4	20.00	7.88	1.73	7.0	27.60	11(5), 12(10), 13(2)

Figures in parantheses represent no. of colonies

***Dominant flora** :1. *Scytalidium thermophilum*: Representative strain, 2. *Humicola insolens*: Representative strain, 3. *Humicola grisea*: Representative strain, 4. *Scytalidium thermophilum*-I, 5. *Scytalidium thermophilum*-II, 6. *Humicola insolens*-I, 7. *Humicola grisea*-I, 8. *Themomyces lanuginosus*, 9. *Thermoascus aurantiacus*, 10. *Chaetomium thermophile*, 11. *Aspergillus* sp., 12. *Mucor pussilus*, 13. *Mycelia sterilia*

Colony forming units in the prepared compost ranged between 22.54-110.24 in different treatments and a total of 13 different fungi were isolated from the different composts. Respective inoculated fungal strains were dominantly isolated from the respective composts, indicating that the final composts were prepared by these fungal strains.

Yield data (4 weeks) obtained in the trial for these composts are presented in Table-8. Condition of spawn run was rated as poor to excellent with most of the strains. Poor spawn run was noted in Strain S-3 of *H insolens*, S-4 strain of *H grisea* and in control treatments C-1 & C-4. (Table 8).Colour of the compost produced varied from deep yellow to black. Average fruit body weight ranged between 6.08 to 9.61 among the different treatments. Highest fruit body weight (9.61g) and highest yield of 10.712 Kg/100Kg compost was obtained with S-4 strain of *H grisea*. Among the *H insolens* and *S thermophilum* strains, strain S-4 and S-7, respectively gave the higher

Table 8: Yield obtained in different composts prepared with different thermophilic organisms

Strain	Condition of spawn run	Compost Colour	Days taken for pinning (After casing)	Av. Fruit body weight (g)	Yield (Kg/100Kg of compost)
Scytalidium thermophilum (Strains)					
S-1	++++	++++	15	6.86	6.375
S-2	++++	++++	15	7.50	4.500
S-3	+++	+++	15	7.53	6.375
S-4	+++	+++	15	8.28	2.850
S-5	+++	+++	15	7.07	5.450
S-6	++++	++++	14	6.48	6.825
S-7	++++	++++	15	7.53	6.825
Humicola insolens (Strains)					
S-1	++++	++++	14	7.0	5.000
S-2	+++	++	16	6.08	5.000
S-3	+	+	13	7.72	2.762
S-4	++++	+++	12	7.17	7.950
S-5	+++	+++	12	6.61	5.550
S-6	++++	++	13	7.13	3.337
S-7	++	+	13	9.06	4.487
S-8	++++	++	19	8.01	4.487
Humicola grisea (Strains)					
S-1	+++	+++	14	8.12	1.425
S-2	+++	++	13	7.72	6.650
S-3	++++	++++	14	6.73	5.800
S-4	+	+	14	9.61	10.712
S-5	+++	++	13	6.52	7.325
S-6	+++	+++	13	8.63	5.375
Control					
C1	+	++	16	5.25	3.200
C2	+++	+++	17	6.88	4.237
C3	++	++	17	6.42	4.062
C4	+	+	17	5.55	1.200
SM	-	-	-	-	6.437

+ = Poor; ++ = Good ; +++ = Very good; ++++ = Excellent

yields. All the control sets gave lower yield including short method compost compared to various treatments. Control set with mixed inoculum of above fungal strains also performed well.

Study conducted suggested that productive compost could be produced in as less in 7 days time completely bypassing the Phase-I condition of the compost. However more experiments are required for perfecting this technology

1.5 Project: - NCM-22: Casing and crop management in *Agaricus bisporus* (PI-Dr.B.L.Dhar)

1.5.1 Casing materials/mixtures and mushroom yield

Casing materials prepared out of agricultural waste easily available in India were selected for the experiment. The crop was raised on compost prepared by short method of composting. Standard package of practices were followed during cultivation. Different casing materials viz. Coirpith-1, Coirpith-2, Farm Yard Manure, Spent Mushroom Substrate, City Refuse Compost, SMS + Coir pith, FYM+Burnt Rice Husk, SMS + Burnt Rice Husk, Coir pith-I + Burnt Rice Husk and Press Mud + Burnt Rice Husk, SMS + coir pith-I (50:50 v/v), Farm Yard Manure + Burnt Rice Husk (75:25 v/v), Spent Mushroom Substrate + Burnt Rice Husk (75:25 v/v), Coir pith-I + Burnt Rice Husk (75:25 v/v), Press Mud + Burnt Rice Husk (75:25 v/v) of 1 inch thickness after steam pasteurization were applied on fully spawn run compost bags of 10 kg each, using 20 compost bags per treatment (200 kg compost). The case run was done at 24°C and cropping at 15-17°C (air temperature). The mushroom yield was recorded for a period of 6 weeks. Superiorly performing casing materials like SMS, CP and combination of SMS + CP yielded around 14-16 kg of fresh mushroom per 100 kg compost, closely followed by FYM/ FYM+CP.

1.5.2 Physical-chemical parameters of different casing materials: Physical and chemical parameters of different casing materials are presented in Table-9. The pH seemed to be in the desired range in all the treatments. The Electrical conductivity recorded was highest in Press Mud and city refuse compost, showing negative bearing

Table 9: Physical and chemical characteristics determined in various casing materials

Treatment	pH	BD (g/cm^3)	PD (g/cm^3)	Porosity (%)	Water holding capacity (%)	N_2 (%)	C (%)	EC (mS/cm)
Coir pith-I	6.61	0.25	1.37	53.60	20.00	0.50	1.59	40.4
Coir pith-II	6.50	0.34	2.48	24.40	33.39	0.53	1.01	48.61
FYM	7.01	0.43	0.96	74.62	42.18	0.91	1.10	125.5
SMS	6.93	0.39	0.68	72.62	50.00	1.30	1.01	164.5
Press Mud	7.81	0.29	9.50	6.80	21.00	2.45	4.19	660*
City compost	7.10	0.22	2.00	39.00	54.55	2.10	2.90	344*
CP-I + BRH	6.76	0.33	1.32	47.18	34.33	1.00	0.81	173.5
FYM + BRH	6.90	0.19	1.67	48.50	44.44	1.70	1.00	89.7
SMS + BRH	6.80	0.25	2.00	37.50	40.00	0.97	1.00	90.8
PM + BRH	6.66	0.28	2.50	28.80	20.00	1.70	2.17	718

BD = Bulk Density; PD = Particle density; N_2 = Nitrogen; C = Carbon; EC = Electrical conductivity
* Negative bearing

on mushroom yield directly. Bulk density was in the range of 0.19 to 0.43 (g/cm^3), which is lower as compared to black and brown peat (0.8 – 0.9 g/cm^3). Particle density was very high in Press Mud and addition of Burnt Rice Husk did not improve the situation as far as particle density is concerned. The porosity was minimum in Press Mud (6.80%) and it ranged between 24.40 to 74.62% in other treatments, showing some positive bearing on mushroom yield. The water holding capacity ranged between 20 to 54.55% in different treatments, indicating increased water application to be followed during crop raising as compared to peat . Nitrogen content was highest in Press Mud and city compost, again showing negative effect on mushroom yield. The carbon content was again highest in Press Mud and city compost, resulting in late pinhead formation, reduced pinhead formation and low mushroom yields. Carbon /nitrogen content seemed to be directly influencing the mushroom yield as can be seen from days taken to fruit from casing with reduced yield of mushrooms from these treatments.

All the casing materials were water leached and steam pasteurized at 65-70°C for 8 hours before use. Press Mud was washed repeatedly in flowing water to remove available sugars before steam pasteurization. Strain A-15 (Sylvan) of *Agaricus bisporus* was used in the trial. Wheat grain spawn was used for spawning of the compost at 0.5% spawning rate. Spawn run was done in environment controlled cropping rooms at 24°C, 95% RH and high CO_2 concentration. Uniform layer of different casing materials was applied over completely spawn run compost bags (1" depth) and water sprayed immediately over the casing. Case run was done at the same temperature, RH and CO_2 concentration as for spawn run, which took about 6-7 days. Fresh air was opened after complete case run and pinhead formation was observed within one week of opening of fresh air. First harvest of mushrooms was done 15-25 days after casing application in different treatments, and treatmentwise observations on "days taken to harvest after casing" are presented in the Table-10.

Table 10: Days taken to fruit after casing application

Treatment	Time taken to fruit (days)
Coir pith-I	17 days
Coir pith-II	18 days
FYM	16 days
SMS	15 days
Press Mud	19 days
City compost	18 days
CP-I + BRH	18 days
FYM + BRH	17 days
SMS + BRH	15 days
PM + BRH	25 days
SMS + CP-I	15 days

Mushrooms were harvested in shortest time of 15 days after casing in SMC + Coir pith, SMS + Burnt Rice Husk and Spent Mushroom Substrate casing materials. It was followed by FYM (16 days), Coir pith and FYM + Burnt Rice Husk (17 days) and Coir pith-II, City Compost and Coir pith-I + Burnt Rice Husk each taking 18 days for first harvest. Press Mud in combination with Burnt Rice Husk took maximum time of 25 days for first harvest.

Highest mushroom yields were recorded from treatmemts SMS , CP-II, CP-I followed by SMS+CP, SMS+BRH (Table-11). These treatments were at par with each other as far as mushroom yield is concerned, but significantly superior to rest of the treatments. SMS alone and in combination with CP/BRH also performed superiorly as can be seen from the yield data. BRH when mixed with coir pith resulted in yield reduction, when compared to CP alone. FYM alone and in combination

Table 11: Effect of different casing materials on the yield, number and weight of fruit bodies

Treatments	Average fruit body weight (g)	Average fruit bodies number	Yield (Kg/100Kg compost)
Coir pith-I	11.10	1412	15.715
Coir pith-II	11.00	1454	15.595
Press Mud+BRH	10.25	757	7.782
FYM	11.20	1147	12.814
SMS	11.10	1409	15.657
City Refuse compost	11.98	949	10.970
SMS+CP	10.82	1370	14.830
FYM + BRH	10.97	1165	12.770
SMS + BRH	11.93	1201	14.335
Coirpith + BRH	10.82	1243	13.443
Mean	13.39	1210.7	13.39
CD (0.05)	**1.69**	**150.95**	**1.69**

with BRH resulted in significant lower yields as compared to SMS and CP. Press Mud in combination with Burnt Rice Husk was found inferior casing material, while as FYM and City Compost were found to be medium quality materials on the basis of mushroom yield data. The increased mushroom yield in superior treatments was mainly due to more number of fruit body production, and lesser on individual fruit body weight. Press mud and city refuse compost as casing materials gave significantly lower yields as compared to all high yielding treatments. Spent Mushroom Substrate and Coir Pith as casing materials, both, alone and in combinations showed promise as a good casing layer for cultivation of button mushrooms in India. Addition of Burnt Rice Husk (BRH) in the superior performing treatment did not show any advantage. BRH addition had rather negative effect.

1.5.3 Fruit body quality as related to application of different casing materials: The fruit body measurable quality parameters are presented in Table-12. The whole mushroom weight in

Table 12: Quality parameters of button mushrooms harvested from different casing materials (Strain A–15 Sylvan)

Treatment	Whole		Pileus		Stipe			Whiteness %	Dry wt(g)
	Wt (g)	Length (mm)	Dia (mm)	Wt. (g)	length (mm)	dia (mm)	Wt. (g)		
Coir pith-I	13.94	35	33.6	4.65	22.6	16	1.96	90	8.05
Coir pith-II	14.12	33	35	4.79	17.6	15	1.49	83	9.40
FYM	15.66	34	35	6.06	23	15.6	2.40	80	10.10
SMS	15.53	35	36	6.36	20	15	1.95	78	9.15
Press Mud	12.08	30	32	4.79	17.6	15	1.49	66	13.00
City compost	15.74	46	110	5.78	30	14	1.93	76	9.60
CP + BRH	13.56	32	35	4.65	21.6	16.6	1.98	89	8.59
FYM + BRH	14.34	42	34	4.68	19	15.7	2.68	79	7.04
SMS + BRH	12.14	32	34	4.32	19	14	1.65	71	9.90
PM + BRH	8.36	26	19	3.29	16	16	1.13	68	14.10
SMS + CP-I	9.90	35	31	3.48	24	13	1.57	68	7.01

All readings are mean of 15 values

different treatments ranged between the lowest 8.36g in Press Mud + Burnt Rice Husk to the highest of 15.74g in City Compost. Whole mushroom length also varied in different treatments, with lowest of 26mm in Press Mud + Burnt Rice Husk and highest of 46 mm in City Compost. The other parameters also varied in different treatments with lowest pileus/stipe ratio of 2:1 in superior casing treatments like Coirpith and its combinations with SMS and Burnt Rice Husk. The dry matter content was observed highest in inferior casing treatment like Press Mud + Burnt Rice Husk. The superior mushroom yielding casing materials yielded mushrooms with 13.00 to 15.00g individual fruit body weight, 33-35mm length, optimal pileus / stipe ratio and 7.01 to 9.90 % dry matter content.

The casing materials derived from agro wastes mixed with coir pith as listed in Table-13 were also evaluated for crop yield and quality of fruit body of button mushroom.

The physico- chemical parameters of casing mixtures determined are presented in Table-14.

Table 13: Casing materials used

Treatment	Proportion
FYM : CP	70 : 30
SMS : CP	70 : 30
PM : CP	70 : 30
CRC : CP	70 : 30
FYM : CP	50 : 50
SMS : CP	50 : 50
PM : CP	50 : 50
CRC : CP	50 : 50
FYM : CP	30 : 70
SMS : CP	30 : 70
PM : CP	30 : 70
CRC : CP	30 : 70

FYM – Farm Yard Manure, SMS – Spent Mushroom Substrate, PM – Sugarcane Press Mud, CRC – City Refuse Compost, CP – Coir Pith (Industrial by product)

In this experiment mushroom yield recorded was on lower side due to fly infestation (Table-15). FYM and SMS in combination with CP in all ratios showed superiority on the basis of mushroom yield, highest in 70:30 ratio, followed by 50:50 and 30:70 ratios.

Table 14: Chemical analysis of various casing mixture

Treatment No.	Treatment	pH	Nitrogen (%)	Conductivity (µS)	TDS (ppm)
T- 1	FYM : CP/70 : 30	6.8	2.5	561.0	277.0
T- 2	SMS : CP/70 : 30	7.2	2.9	640.0	295.0
T- 3	PM : CP/70 : 30	6.4	2.9	3.91	2160.0
T- 4	CRC : CP/70 : 30	6.4	1.7	1509.0	756.0
T- 5	FYM : CP/50 : 50	7.0	2.1	939.0	448.0
T- 6	SMS : CP/50 : 50	6.4	1.3	2024.0	985.0
T- 7	PM : CP/50 : 50	6.2	2.2	2.73	1420.0
T- 8	CRC : CP/50 : 50	7.2	1.9	744.0	3665.0
T- 9	FYM : CP/30 : 70	6.8	2.3	464.0	225.0
T- 10	SMS : CP/30 : 70	6.1	1.9	1765.0	908.0
T- 11	PM : CP/30 : 70	6.8	2.7	745.0	363.0
T- 12	CRC : CP/30 : 70	6.2	2.1	4.03	2150.0

Table 15: Effect of various casing materials on the yield of white button mushroom

Treatment	Mushroom yield (kg/100 kg compost)
FYM : CP/70 : 30	11.0
SMS : CP/70 : 30	9.0
PM : CP/70 : 30	7.5
CRC : CP/70 : 30	7.0
FYM : CP/50 : 50	8.5
SMS : CP/50 : 50	8.0
PM : CP/50 : 50	6.5
CRC : CP/50 : 50	7.5
FYM : CP/30 : 70	7.0
SMS : CP/30 : 70	5.5
PM : CP/30 : 70	3.0
CRC : CP/30 : 70	6.7
CD (5%)	**1.18**

1.6 Determination of water regimes for *A. bisporus* mushroom during cropping

Compost for the trial was prepared following normal package of practices by short method, using wheat straw as base material supplemented with poultry manure. Spawn strain of A-15 of *A. bisporus* was used in the study. The spawn run was done at 24°C and steam pasteurized casing applied over fully spawn run compost. The experiment was done in 10 kg polythene bags and 2 kg casing material (FYM – standard recommendation) was applied over fully spawn run compost in each bag. The case run was done at 24°C and crop raised in environment controlled cropping rooms. Each treatment contained 30 bags (300 kg compost). Various water regimes as presented in Table-16 were evaluated.

Table 16: Water regimes tried

T-1	100 ml/bag/day x one application
T-2	150 ml/bag/day x one application
T-3	200 ml/bag/day x one application
T-4	200 ml/bag/ alternate day x one application
T-5	100 ml/bag/day x 2 application
T-6	Normal application of wetting of casing once /day x one application

The data (Table-17) revealed that the mushroom yield is on lower side in all the treatments due to insect/ pest infestation, but a clear trend can be observed in different watering regimes tried. Application at 200 ml of water per day per bag resulted in higher crop yields.

Table 17: Watering regimes and *A. bisporus* yield

Treatment	Yield* (kg per 100 kg compost)
100 ml/bag/day	6.5 kg
150 ml/bag/day	5.5 kg
200 ml/bag/day	7.0 kg
200 ml/bag/ alternate rday	9.0 kg
100 ml/bag/ twice a day (M/E)	8.5 kg
Normal spraying (Bed wetting/daily/once)	7.0 kg

* Lower mushroom yield was recorded due to heavy fly infestation

1.7 Project: - NCM-31: Organic mushroom production, quality produce and pesticide residue analysis (PI: Dr. B.L. Dhar)

1.7.1 Compost preparation: The composting ingredients used were crop residues / organic matter based supplements / no fertilizer used. The formulation was balanced with use of C/N rich supplements in the form of poultry manure, wheat bran, cotton seed cake, (deoiled), starting with 1.6-1.7 % nitrogen content at beginning of composting. Standard package of practices were followed to raise the crop. The mushrooms were harvested for 2 weeks of cropping, harvesting about 6 kg of mushroom from 100 kg compost. The cropping was discontinued after 2 weeks due to heavy fly infestation in the crop beds. Fly traps were used to bring down fly infestation in the room and were also helpful in monitoring the mushroom flies. No chemical was used for pest control.

1.7.2 Pesticide residue analysis : The dried powdered samples of all composting ingredients, compost , casing , spawn , fruitbody and water were sent to UHF, Deptt. Of Entomology, Nauni HP for pesticide residue analysis. Residue of commonly use insecticides like Organophosphates / Pyrethroides and fungicides like Carbendazim / Dithiocabamates were detected and tested for the quantities present . The residue analysis indicated elimination of most of the pesticides, detected before composting ingredients, from mushroom fruitbody to below detectable limits / no residue limits. This is in sharp contrast to presence of most of these pesticides within detectable limits after normal composting process consisting of three turnings outdoors during phase-I (earlier trials). Improved high temperature composting process outdoor was helpful in eliminating most of pesticide from the substrate.

2. Oyster mushroom, *Pleurotus* spp.

Project: - NCM-17: Studies on improved cultivation technology of *Pleurotus* spp. (PI: Dr. R.C. Upadhyay)

2.1 Effect of light during incubation on yield of *Pleurotus* spp.

Six different *Pleurotus* spp. namely *P. sajor-caju, P. florida, P. flabellatus, P. eryngii, P. fossulatus* and *P. djamor* were grown on pasteurized wheat straw. Spawned bags were kept in 24 hrs light and complete dark during incubation. The yield data are presented in Table-18.

The result indicated that light during incubation has negative influence on mycelial growth and yield. All the *Pleurotus* species incubated in dark gave better yield than the bags kept in light except *P. djamor* var. *roseus* light during incubation may be responsible for early production of fructification enzymes when the mycelium has not fully colonized the straw.

2.2 Effect of temperature shock treatment on various *Pleurotus* spp. for fructification

Five *Pleurotus* spp. namely *P. sajor-caju* (1140), *P. florida* (1), *P. flabellatus, P. sapidus* and *P. djamor* were selected for growth studies. Mycelial bits of 5mm size from 8days old cultures were inoculated in sterilized malt extract agar (20g/lit) with 1 gram per liter asperagine medium. Inoculated plates were incubated at 20ºC and 25ºC for 10days. When the medium was fully colonized with mycelium from 20ºC incubated treatment 3 plates each were kept at 20, 25 and 30ºC for fructifications. It was noticed that plates of *P. djamor* incubated at 15ºC temperature could not induce fructifications while all the plates incubated at 20, 25 and 30ºC gave fructification. It shows that *P. djamor* does not require low temperature shock for fructification. In case of *Pleurotus florida* all the plates kept at 15 and 20ºC gave fruiting. Similar observations were recorded in *P. sajor-caju, P. florida* and *P. flabellatus.*

Table 18: Effect of incubation conditions on yield of different *Pleurotus* spp.

Species	Bags incubated in light (BE%)	Bags incubated in dark (BE%)
Pleurotus sajor-caju	18.7	31.6
Pleurotus florida	34.2	67.6
Pleurotus flabellatus	25.73	41.33
Pleurotus eryngii	28.3	34.6
Pleurotus fossulatus	34.6	49.2
Pleurotus djamor	17.5	11.2
C.D. at 5%	**12.7**	

2.3 Effect of spawn rate on yield of *P. fossulatus*

An experiment was laid out to find out the optimum spawn rate in *Pleurotus fossulatus*. Five different spawn rates namely 2,4,6,8 and 10% of wheat grains were applied in wheat and paddy straw. It was observed that higher the spawn rate the mycelium growth was denser due to more nutrition in form of wheat grain from the spawn. However, there was no signification difference in number of days for mycelium spread on the substrate. Maximum yield was recorded in wheat straw bags spawned with 10% spawn rate followed 8%, 6%, 4% and 2%. In paddy straw there was no significant difference in yield from 6, 8 and 10% spawn rate, however, 2% and 4% were significantly less than 6, 8 and 10% spawn rate.

2.4 Effect of various organic nitrogen supplements on mycelial growth and yield in *Pleurotus fossulatus*

To study the the cumulative effect of different organic nitrogen supplements on mycelial growth and yield of *P. fossulatus*, 2 to 3 supplements were mixed and added in wheat and paddy straw at the time of spawning. Addition of high nitrogen in wheat straw gave less yield and highest yield was obtained with mixture of wheat bran (5%) and cotton seed cake (2%). Cotton seed cake (8%) also gave higher yield than other supplements.

3. Specialty mushrooms

Project- NCM-18: Standardization of cultivation technology of specialty mushrooms (PI-Dr.S.R.Sharma).

3.1 Effect of supplementation on the productivity of *Agrocybe aegerita*

Investigations on the effect of different supplements on the mycelial growth and yield of *Agrocybe aegerita* were conducted. Wheat bran at the rate of 10 per cent supported the fastest linear growth (129mm) of *Agrocybe aegerita* followed by 5 per cent rate (128mm) of the same supplement (Table-19). Other supplements also had positive impact on the linear growth, but all were inferior to wheat bran.

Addition of 10 per cent wheat bran in wheat straw resulted (Table-20) in quickest spawn run and highest (66.2%) biological efficiency (Fig. 1). Supplementation of the substrate with cotton seed cake resulted in poor spawn run and lower BE as compared to unsupplemented substrate. Heavy contamination of *Coprinus* sp. was recorded in cotton seed cake supplemented treatments.

Table 19: Average linear growth of *Agrocybe aegerita* in relation to different supplements

Supplement	Rate (%)	*Average linear growth after days		
		15	21	28
Wheat bran	5	31	60	128
	10	36	66	129
Cotton seed cake	5	29	52	108
	10	27	54	111
Soybean meal	5	31	59	115
	10	33	60	117
Deoiled soyabean	5	31	59	121
	10	34	62	126
Control		30.0	55.0	110
CD(0.05)		**1.8**	**2.8**	**3.3**

*Average of five determinations

Table 20: Effect of different supplements on the yield of *Agrocybe aegerita*

Supplement	Rate (%)	*Days taken for spawn run	Yield (g/400g dry substrate)	BE (%)
Wheat bran	5	27	240	60.0
	10	23	265	66.2
Cotton seed cake	5	Poor spawn run	140	35.0
	10	Poor pawn run	110	27.5
Soybean meal	5	27	215	53.7
	10	Poor spawn run	180	45.0
Deoiled soyabean	5	27	215	53.7
	10	26	223	55.7
Control		31	220	55.0
C.D. 0.05			**24.7**	

Fig. 1: Developing fruitbodies of *Agrocybe aegerita* on wheat bran supplemented substrate

3.2 Effect of supplementation and cultivation containers on the productivity of *Flammulina velutipes*

Wheat bran at the rate of 10 per cent supported the fastest linear growth (110mm) of *F. velutipes* followed by 5 per cent rate (99.8mm) of the same supplement (Table-21). Other supplements (soybean meal, cotton seed cake and deoiled soybean) resulted in reduced linear growth.

Addition of 10 per cent wheat bran in saw dust resulted (Table-22) in quickest spawn run and highest (37.5%) biological efficiency. No fruit body formation took place when the substrate was supplemented with either cotton seed cake or soybean meal or deoiled soybean.

Among the different containers (Table-23) viz. Polypropylene bags, Plantation pots, Glass specimen jars and Storage boxes tried (Fig. 2.) for the cultivation of *Flammulina velutipes*, Polypropylene bags proved to be the best resulting in highest yield (Fig. 3).

3.3 Comparative studies on the substrate treatment methods for the cultivation of *Calocybe indica*

It is clear from the results presented in Table-24 that initially hot water treated

Table 21: Average linear growth of *Flammulina velutipes* in relation to different supplements

Supplement	Rate (%)	*Average linear growth after days		
		7	14	21
Wheat bran	5	20.6	58.0	99.8
	10	22.4	66.0	110.0
Cotton seed cake	5	16.4	52.4	82.0
	10	17.2	52.4	80.8
Soya bean meal	5	15.6	52.8	86.0
	10	18.7	54.2	88.4
Deoiled soyabean	5	16.0	53.8	89.6
	10	18.0	55.7	96.8
Control		18.0	56.0	96.6
CD(0.05)		**2.9**	**2.2**	**1.8**

*Average of five determinations

Table 22: Effect of different supplements on the yield of *Flammulina velutipes*

Supplement	Rate (%)	*Days taken for spawn run	Yield (g/kg wet substrate)	BE (%)
Wheat bran	5	24	130	32.5
	10	22	150	37.5
Cotton seed cake	5	Poor spawn run	No fruit body formation	-
	10	Very poor pawn run	-do-	-
Soyabean meal	5	28	-do-	-
	10	No spawn run	-do-	-
Deoiled soyabean	5	Poor spawn run	-do-	-
	10	No spawn run	-do-	-
Control		30	116	29.0

* Average of ten determinations

Table 23: Effect of different containers on the yield of *Flammulina velutipes*

Type of container	Substrate/ container	*Days taken for spawn run	*Yield (g/kg wet substrate)
Polypropylene bags	1000g	22	152
Plantation pots	800g	28	No yield
Glass specimen jars	1000g	22	No yield
storage boxes	350g	20	26
CD 0.05			**6.87**

*Average of ten determinations

Fig. 2: Cultivation in different containers; 1.Polypropylene bags, 2. Storage boxes 3. Plantation pots, 4. Glass specimen jars

Fig. 3: Bumper crop of *F. velutipes* in polythene bags

substrate supported the fastest (16mm) growth of *C. indica* followed by pasteurized and autoclaved substrate. However, when the growth was measured after 15 days autoclaved substrate was fond to support maximum (56mm) mycelial growth followed by pasteurized (53mm) and hot water treated substrate. *C. indica* failed to resume any growth on chemically treated wheat straw or untreated substrate.

Among various methods of substrate treatment evaluated for the cultivation of milky mushroom, pasteurization method was found (Table-25) to be the best followed by hot water treatment and autoclaving. Chemical sterilization was not successful as no spawn run was observed.

Table 24: Linear growth of *Calocybe indica* on substrate treated with different methods

Fungus Substrate treatment method	*Linear growth (mm) of *Calocybe indica* on wheat straw after days		
	5	10	15
Pasteurized	11	27	53
Autoclaved	11	29	56
Chemically treated	NG	NG	NG
Hot water treated	16	28	53
Untreated	NG	NG	NG

*Average of three determinations; NG = No Growth

Table 25: Effect of different substrate treatment methods on the productivity of *Calocybe indica*

Substrate treatment method	Days required for spawn run	Number of fruit bodies	*Average Yield (g/5kg wet substrate)
Pasteurization	20	25	730
Autoclaving	24	28	755
Chemical treatment	No spawn run	-	0
Hot water treatment	18	23	520
Untreated	No spawn run	-	0

*Average of ten determinations

3.4 Activity of various enzymes in *Agrocybe aegerita* and *Flammulina velutipes* in relation to supplementation

Addition of wheat bran resulted in increased activity of cellulases and hemicellulases in *Agrocybe aegerita* whereas cotton seed cake resulted in reduced activity of cellulases. Similarly, addition of wheat bran resulted in increased activity of cellulases, hemicellulases and Peroxidases in *Flammulina velutipes* whereas cotton seed cake, soybean meal and deoiled soybean resulted in reduced activity of these enzymes.

4. Mushroom Farm Design

Project: - NCM-21: Development of mushroom farm designs suited to Indian conditions (PI-Dr.B.L. Dhar)

4.1 Mushroom growing in low cost huts

i) Button mushroom crop was raised seasonally in autumn of 2005 and early spring of 2006 on pasteurized compost and the early spring (2006) on long method compost. The cropping was done for 6 weeks time. It was possible to raise a crop of button mushrooms in bamboo and cloth hut seasonally with good yields, though long method compost yielded poorly.

ii) Oyster mushroom crop in early summer was raised on steam pasteurized wheat straw substrate with partial success and there was heavy infestation with mushroom flies & rampart growth of *Peziza* weed mould, possibly due to contaminated irrigation water.

iii) Paddy straw crop was raised in insulated cloth hut in summer months in 2005 with partial success, with production of healthy fruitbodies from the crop beds. The experiment had to discontinued early because of lower temperature prevalent in rainy season in July-August, 05.

5. Project: - NCM-25: Studies on development of evaporatively cooled mushroom growing room and low cost mechanization for mushroom industry (PI:Er. T.A. Nathan)

Renovation work has been completed (Fig 4) and the evaporative cooling system has been provided in the mud house. A cultivation trial on button mushroom using the compost prepared by long method was carried out in the mud house in the month of November, 2005 to February, 2006 and 10 % crop yield was obtained.

Fig. 4: Renovated mud house

3

CROP PROTECTION

1. Insect pests and diseases of mushrooms

Project: - NCM-20: Integrated pests and disease management in mushrooms (PI: Dr Satish Kumar)

1.1 Survey and surveillance of major pests and diseases

Survey of different mushroom farms revealed the widespread incidence of wet bubble, brown plaster mould, green moulds, ink caps at Kurukhstra, Sonepat and other adjoining area of Sonepat (Haryana) and Chambaghat, Vaknaghat, Deothi and adjoining area of Solan . Sciarid flies, phorid flies , mites and sprigtails were common in most of the farms visited.

1.2 Studies on *M. perniciosa*

1.2.1 Physiological studies

Out of 13 media evaluated against *M. perniciosa*, Walksmen agar (40.4 mm) proved to be the best followed by malt extract peptone dextrose agar (39.8 mm) and Martin rose bengal streptomycin agar. Least growth was recorded in case of dextrose nitrate agar (16.7 mm). Out of the 13 liquid media tested best growth was recorded in Walksmen medium (0.32 gm) followed by Czepakdox (0.29) medium. Least growth was recorded in case of Joffers broth (0.05 gm). Studies carried out on the effect of different pH levels revealed that maximum growth was recorded at pH 7.0 (6.0 cm) followed by pH 8.0 (5.6). Least growth was recorded at pH 4.0 and 10.0. Among the different temperature regimes tested, best growth (4.4 cm) was recorded at 25^0C followed by 20^0C (3.0 cm) . However, no growth was recorded at 10^0C. Assessment of carbon compounds revealed that mannintol supported maximum (0.25 g) growth followed by lactose (0.19 g). When nitrogen in the basal medium was replaced by different nitrogen sources it was observed that alanine was the best nitrogen source whereas, asparagine was least acceptable nitrogen source.

1.2.2 Evaluation of pesticides against *M. perniciosa*

Studies carried out on the effect of different fungicides on *M. perniciosa* revealed that maximum inhibition was recorded in case of chlorothalonil (58.0%) followed by anthracol (42%) and zineb (40%). No growth was recorded in case of bavistin due to bacterial contamination (Table-1).

1.2.3 Evaluation of plant products against *M. perniciosa*

Studies carried on different plant products revealed that none of the plant extract was able to cause inhibition of mycelial growth of *M. perniciosa* (Table-2). In every case growth was at par with the control treatment.

1.3 Physiological studies on *S. chrysospermum*

Out of 13 different solid media tested for the growth of *S. chrysospermum*

Table 1: Effect of fungicides against *M. perniciosa*

Fungicides (0.1%)	Mean radial growth (cm)	Per cent inhibition
Carbendazim	-	-
Chlorothalonil	1.2	58
Captafol	3.2	38
Thiopanate-Methyl	-	-
Metalaxyl +manacozeb	3.1	39
Zineb	2.8	40
Antracol	-	42
Sporgon	-	-
Control	7.0	-

Table 2: Effect of plant products against *M. perniciosa*

Plant Product (1%)	Mean (Growth in cm)	Per cent inhibition
Callistomon lanceolatus.	5.0	0
Ricinus cumminis	4.7	0
Cantharanthus sp	5.0	0
Gardenia spp.	4.6	0
Thuja compacta	5.0	0
Euclyptus spp	4.9	0
Control	4.6	

Czapekdox agar medium supported the maximum growth (64.4) mm followed by Subourands medium (59.6 mm). Walkesmen medium proved to be the least acceptable medium for this fungus.Out of the 13 different liquid media tested best growth was recorded in the Brown's medium (0.32 g) followed by malt extract peptone dextrose agar medium. Least growth was recorded in case of dextrose peptone yeast extract agar media (1.05 g). *Sepedonium* is able to grow at wide range of pH. However, the best growth was recorded at pH 7.0 (62.66 mm) followed by pH 8.0 (62.16 mm), pH 9.0 (60.16 mm) and pH 4.0 (48.66 mm). Least growth recorded at pH 5.0 (43.83 mm) and pH 6.0 (45.0 mm). Among the different temperature regimes tested best growth was recorded in 30^{0}C (72.8 mm) followed by 25 ^{0}C, (69.0mm). However, no growth was recorded at 10 ^{0}C. Studies carried out on effect of 5 nitrogen sources revealed that sodium nitrate was the best nitrogen source (0.58 g) followed by aspartic acid (0.50 g). Least growth was recorded in case of ammonium sulfate (0.12 mg). Out of 10 carbon sources the best carbon source for the growth of the test fungus was Maltose (0.57 g) followed by Starch (0.55 g). Least growth was recorded in the case of Galactose (0.15 g). Out of 4 trace element tested best growth was recorded in case of ammonium molebedate (0.53) at 2.0 ppm concentration followed by magnesium sulfate (0.34 gm) at 2 .0 ppm.

1.3.1 Evaluation of various fungicides against *S. chrysospermum*

Studies carried out on the effect of various fungicide (Table-3) against *S. chrysospermum* revealed that bavistin, captafol and sporgon proved to be most

Table 3: Effect of different fungicides against *S. chrysospermum*

Name of fungicides (100 ppm)	Mean redial growth in (mm)	Per cent inhibition over control
Ridomil	62.6	46.60
Bavistin	0.0	100.00
Indofil M-45	49.55	15.92
Captafol	0.0	100.00
Dithane Z -78	59.8	40.04
Chlorothalonil	28.0	34.11
Sporogon	0.0	100.00
Aanthracol	49.55	15.92
control	42.7	42.7

effective giving 100% mycelial inhibition. Ridomil caused 46.60% inhibition and dithane Z-78 caused 40.04 % inhibition at 100 ppm concentration.

1.3.2 Evaluation of various botanicals against *S.chrysospermum*

It is clear from the data (Table-4) that different plant product tested against the mycelial growth of *Sepedonium*, extract of castor caused maximum inhibition (24%) followed by bottlebrush (14.9%). *Gardenia* spp. resulted in 8% growth promotion of the test fungus.

2. Insect- pests

2.1 Effect of various insecticides against edible fungi and sciarid fly (*Bradysia* spp.) larvae

Effect of six insecticides has been studied on seven edible fungi under *in-vitro* conditions by food poisoned technique and also on sciarid larvae under *in-vivo* conditions during *Agaricus bisporus* cultivation by giving 4 sprays starting at casing. Under *in-vitro* studies dichlorvos (0.1%) and chlorpyriphos (0.1%) completely inhibited the growth of all edible fungi and cyromazin was highly toxic to *Lentinula edodes* and *Pleutotus ostreatus*. Decamethrin was not toxic to *Lentinula edodes* and *Pleutotus ostreatus*. Malathion for *A. bisporus* and Neemax (1.0%) was least toxic to all the edible fungi except *L. edodes*. Tunneling index was nil in mushroom fruit bodies when malathion was sprayed but yield was also marginally reduced over control. Highest yield (16.36Kg) was recorded in case of decamethrin. Highest tunneling index (4) was recorded in case of neemax and lowest yield in chlorpyriphos.

Table 4: Evaluation of growth of *S.chrysospermum* on different fungicides

Plant product (1%)	Mean redial growth in (mm)	Percentage of inhibition/promotion (+)
Eucalyptus spp.	35	6.6
Gardenia spp.	40.5	+8.0
Tooja compacta	34.4	8.2
Bottle brush	31.9	14.9
Castor	28.5	24.1
Tooni	37.6	2.4
Control	37.5	

2.2 Screening of different oyster species against sciarid (*Bradysia* spp.) flies

Screening of different *Pleurotus* spp. against sciarid larvae revealed that under laboratory conditions, *P. eryngii* proved most susceptible to sciarids followed by *P. ostreatus* and *P. sajor-caju*. However, no feeding was observed on *P. sapidus*. Under *in-vivo* conditions, *P. eous* proved to be most susceptible. Larvae bored in to the fruit body adjacent to stipe almost the same way as they entered in button mushroom.

2.3 Studies on persistence of malathion on white button mushroom

Studies on persistence of malathion on white button mushroom revealed that when five sprays of 0.01% concentration were given during different growth stages of crop, residue of malathion ranged from 0.172ppm –0.011ppm, 0.254 ppm – 0.083 ppm and 0.0189 ppm – 0.062 ppm in first, second and third flushes , respectively. When 0.05% concentration was sprayed, residue in first, second and third flush ranged from 0.0624ppm-0.316, 0.066ppm-0.141ppm and 0.874ppm-0.004ppm, respectively. When 0.07% concentration was sprayed, residue in first, second and third flush ranged from 0.064ppm-0.264, 0.162ppm-0.118ppm and 0.132ppm-0.282 ppm, respectively. When 0.1% concentration was sprayed, residue in first, second and third flush ranged from 0.698ppm-0.091, 0.102ppm-0.429ppm and 0.167ppm-0.132 ppm, respectively.

2.4 Studies on persistence of phorate on white button mushroom

Residue studies of phorate on white button mushroom revealed that in long method compost when 600 g phorate/ 300 q of compost was added, residue of phorate in different samples of mushrooms ranged from 0.592ppm- 1.678ppm. In the first flush residue level of 1.678 ppm was detected which was much higher than the maximum permissible level of 1 ppm. When 300g phorate / 300 q compost was added, residue in the fruit bodies in different samples ranged from 0.535ppm – 0.835 ppm. However, no residue was detected when 100g phorate was added/ 300q of compost.

3. Molecular characterization of moulds

Project: - NCM-32: Molecular and physiological characterization of moulds associated with mushrooms (PI: Dr. V.P. Sharma)

3.1 Samples collection and raising of pure cultures

Samples of different moulds/ mycoparasites infecting button mushroom were collected from different mushroom units located in Solan, Shimla, Mornihills and Sonepat. In all eighty nine samples were collected . Moulds/ mycoparasites were isolated and pure cultures were raised. Different fungi namely, *Sepedonium, Trichoderma , Mycogone, Verticillium* and *Cladobotryum* were found to be associated with button mushroom. *Cladobotryum* spp. were isolated from *Pleurotus* spp and *Calocybe*. Cultures of different moulds/ mycoparsites were also procured from different AICMIP, Centres. Twelve samples of *Cladoboytryum / Dactylium* causing cob web disease in different mushrooms were collected from *Agaricus bisporus, Pleurotus* spp. and *Calocybe indica*. Eight samples of *Trichoderma* were also collected from *Pleurotus*, *Calocybe*, *Lentinula* and pure culture were raised and four were procured from Ludhiana, Coimbatore, Vellayani and Ranchi centres.

3.2 Molecular characterization of *Mycogone, Cladobotryum* and *Trichoderma* species associated with mushrooms

Ten *Mycogone* isolates collected from different location namely, NRCM, Chambaghat, Oachghat, Morni hills Samlech, Murthal (Haryana) and Fagu (Shimla) were identified as *Mycogone perniciosa* by ITS sequencing of 5.8S r RNA gene (Fig.1). RAPD profile studies of ten *Mycogone* isolates exhibited no genetic variability (Fig.2 & 3) by using OPA-1 and OPA-10 primers.

Eight *Trichoderma* isolates, isolated from various mushrooms namely, *Lentinula edodes*, , *Pleurotus sajor-caju* and *Calocybe indica* and four procured from different centre Ludhiana, Coimbatore, Vellayani and Ranchi were identified as *Trichoderma asperellum*, *T. harzianum* *T. longibrachiatum* and *T. virens* by ITS sequencing of 5.8S r RNA gene. Phylogenetic analysis of 12 *Trichoderma* isolates exhibited seven phylogenetic groups.

Six isolates of *Cladobotryum* were collected from *Pleurotus*, *Calocybe* and *Agaricus bisporus*. Molecular characterization of these isolates revealed their identities as *Cladobotryum dendroides* and *C. asterophorum* by ITS (Fig.4) sequencing of 5.8S r RNA gene. RAPD primers amplied the genomic scorable DNA fragments and exhibited both inter and intra-specific variations (Fig. 5) among the test isolates and separated them into four distinct phylogenetic sub- clades.

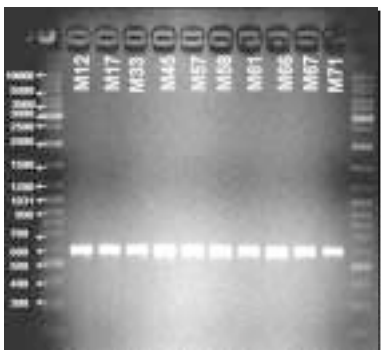


Fig. 1: ITS lengths of 5.8Sr gene regions of *Mycogone* isolates

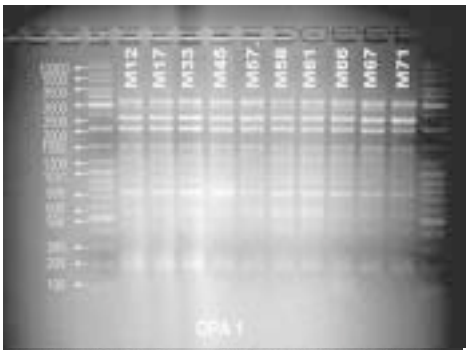


Fig. 2: RAPD patterns of ten *Mycogone* isolates

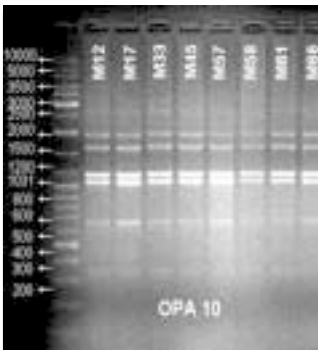


Fig. 3: RAPD profiles of ten *Mycogone* isolates

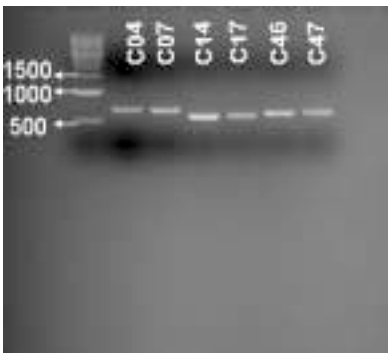


Fig. 4: ITS lengths of 5.8Sr gene regions of *Cladobotryuma* isolates

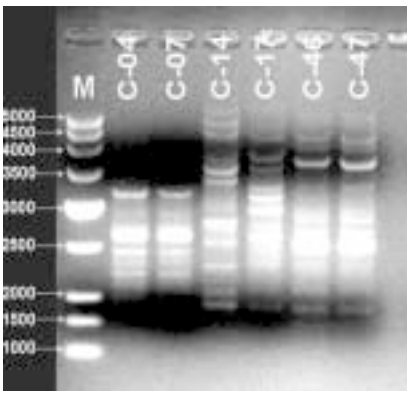


Fig. 5: RAPD profiles of six *Clodobotryum* isolates

3.3 Extracellular enzyme profile of *Mycogone* and *Cladobotryum* species

Extracellular enzyme profile of four groups of *Mycogone* was studied (Table-5) which revealed that M36 and M38 isolates have the highest activity of pectinase, chitinase whereas M3 isolate have greater activity of endo, exo-glucanse, xylanase and β-glucosidase. All the isolates of *Mycogone* did not show any activity of peroxidases.

On the basis of RAPD profiles all the four isolates of *Cladobotryum* were grouped in to four groups belonging to two species i.e., *C. dendroides* and *C. asterophorum*. Extracellular enzyme profile of all the four groups was studied (Table-6) which revealed that none of the isolates have any activity of PPO and peroxidases. Isolate C14 has higher activity of endo-glucanse and xylanase whereas C46 has greater activity of β-glucosidase and xylanase. Among all the isolates of *Cladobotryum* C17 showed highest activity of pectinase and chitinase.

3.4 Studies on yield loss by different isolates of *Trichoderma* in Oyster, Milky and button mushrooms

T1-1 (*Trichoderma virens*) and T21 (*T. virens*) isolates resulted in maximum yield loss (Table-7) in *Agaricus bisporus* followed by T16 *(T. harzianum).* T-18 *(T. harzianum)* isolates resulted in maximum yield loss in *Pleurotus sajor-caju* and *Calocybe indica* followed by T16. Irrespective of isolates and mushrooms the yield loss was more when inoculation was done at spawning stage.

3.5 Physiological studies on *Cladobotryum dendroides*

Out of 10 solid media evaluated for the growth of *Cladobotryum dendroides* , dextrose nitrate agar medium was proved to be the best (74.7mm). *C. dendroides* was able to grow at wide range of pH, however, the best growth was recorded at pH 8.0 (79mm).Out of six temperature regimes

Table 5: Extracellular enzyme production by *Mycogone* isolates

Isolate	Endo-glucanase	Exo-glucanase	â-glucosidase	Xylanase	Laminarinase	Laccase	PPO	Pectinase	Chitinase
M-3	31.0	64.2	53.3	53.3	0.0	2.44	2.7	15.4	0..3
M-13	0.0	47.7	18.0	18.5	2.0	0.38	1.5	20.3	0..3
M-36	0.0	24.6	18.86	0.0	0.0	0.88	1.8	40.2	0..2
M-38	11.9	21.5	26.55	10.6	0.0	1.72	0.0	40.9	0..2

Cellulases and hemicellulases: Unit = µ mole glucose release ml^{-1} h^{-1}
Laccase and PPO: Unit = change in OD by 0.001 ml^{-1} min^{-1}
Chitinase: µ mole N-acetylglucosamine release ml^{-1} h^{-1}

Table 6: Extracellular enzyme production by *Cladobotrum* isolates

Isolate	Endo-glucanase	Exo-glucanase	â-glucosidase	Xylanase	Laminarinase	Laccase	PPO	Pectinase	Chitinase
C-4	6.28	28.45	40.32	18.42	0.0	1.96	0.00	82.21	0.4
C-14	11.92	28.50	14.63	48.78	0.0	1.78	0.00	75.82	0.2
C-17	12.38	31.45	21.24	17.23	0.0	2.10	0.00	86.72	0.4
C-47	25.36	20.37	40.32	10.67	0.0	0.40	0.00	71.59	0.3

Cellulases and hemicellulases: Unit = µ mole glucose release ml^{-1} h^{-1}
Laccase and PPO: Unit = change in OD by 0.001 ml^{-1} min^{-1}
Chitinase: Unit= µ mole N-acetylglucosamine release ml^{-1} h^{-1}

Table 7: Yield loss due to *Trichoderma* isolates in button, oyster and milky mushrooms

Trichoderma isolate	Yield (g) of *P. sajor-caju*/ 5 kg wet substrate	Yield (g) of *C. indica*/ 5kg wet substrate	Yield (kg) of *A. bisporus*/ 10kg compost
T1	500	550	
T1-1	560	510	1.05
T6	525	510	1.2
T12	550	540	1.3
T16	400	575	1.1
T18	350	450	1.4
T21	575	570	0.95
T25	600	590	1.2
Control	700	650	1.57

tested for the growth of *C. dendroides*, the best growth was recorded at temperature 25°C (74.5mm).Out of ten carbon sources evaluated for the growth of *C. dendroides* dextrose supported the maximum (0.19 mg/ 20ml) mycelial growth.Out of 7 nitrogen sources best mycelial growth was supported by aspartic acid (0.06mg/20ml).

4

CROP NUTRITION AND UTILIZATION

Project-NCM-19: Medicinal mushrooms, their evaluation and utilization (PI: Dr. R.D.Rai)

1. Germplasm Characterization and Evaluation

One exotic culture (WC-872) of *Ganoderma lucidum* was obtained from the culture bank of the Pennsylvania State University, USA. All the cultures deposited in the Gene Bank of the NRCM as *G.lucidum* were subjected to molecular characterization by RAPD and RFLP and sequencing of 5.8S r RNA gene. Five local collections and five exotic strains were DNA fingerprinted by ITS amplifications and all were found true-to-the type *G. lucidum* (Fig.1) when compared with the ITS of 5.8S rDNA of sequenced ones. Four exotic cultures of the medicinal mushroom Reishi, were evaluated for yield and quality and Thai cultures gave the highest yield followed by Korean OE-53 (Fig.2,3,4). Fruit bodies of the American culture WC-872 had unusual long stem – may be cultural conditions might be different for this strain.

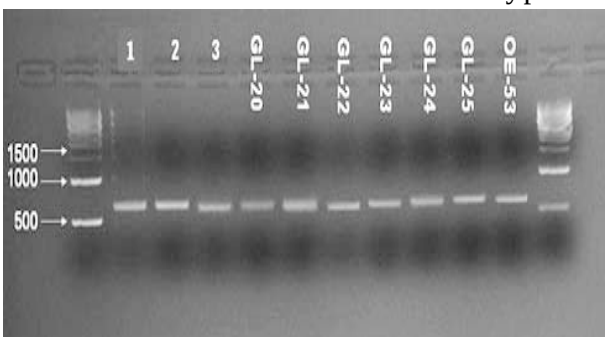


Fig. 1: ITS amplification of five exotic and four local collections of *Ganoderma lucidum*

2. Refinement in cultivation technology

In the study on the quantity of substrate per bag, it was found that 2.2 kg (700 gram dry) bag size was optimum. *G.lucidum* needed more than five hundred lux illumination for not only fruiting but also for cap development. There is very strong effect of light on pinhead formation and development of the fruitbody. *G.lucidum* was observed to produce an array of degradative enzymes namely; ligninase, all cellulases, xylanase, laccase, polyphenoloxidase, protease, pectinase and amylase which shows that it is capable of degrading lignin, cellulose, hemicellulose, starch, protein and pectin available in saw dust+wheat bran mixture.

Fig. 2: Korean strain OE 53

Fig. 3: Thai strain G-45

Fig. 4: American strain WC-872

3. Post harvest Technology of mushrooms

The colour values in terms of three-dimensional space L, a, b system was adopted for the measurement of colour of button mushroom. L, the whiteness; a represents the redness or greenness and b represents the yellowness or blueness of the button mushroom. The colour of the mushroom samples was measured using a Hunter lab model D-25 colour difference meter fitted with a five cm diameter aperture.

Experiments were conducted on the modified atmospheric packaging (MAP) of button mushroom in polythene and polypropylene bags and in the cardboard punnets over wrapped with PVC film. The variation in the gas composition was measured using the CO_2/O_2 meter. The various quality analysis conducted for the packed button mushrooms were weight loss, Gill opening, enzymatic browning, non-enzymatic browning, protein, protease, phenols, poly phenol oxidase, total sugars, vitamin C and free amino acids.

5

DEVELOPMENT OF INDIGENOUS MACHINERY

Project: ICAR - Network project on development of indigenous machinery for spawn and mushroom production (PI: Dr. R.P.Tewari)

1. Setting up of work shop

A work shop was established for the first time in the history of NRCM with the following workshop machineries. All the machineries (Fig. 1) purchased were installed with all the electrical connections and are in working conditions.

- Lathe machine (4 ½ ft)
- 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
- Genset (10 KV)

2. Preparation of compost manually by long method and its quality analysis

In order to compare the compost qualities by traditional composting method

Lathe machine

Shaper

Bench grinder

Hydraulic press

Bench drill

Sheet Bending Machine

Power Hacksaw

Fig. 1: Various machineries installed

and by semiautomatic compost turner, the compost was prepared manually by traditional long method using wheat straw and wheat straw + paddy straw and all the quality attributes of both the compost were analyzed such as pH, electrical conductivity, moisture, temperature profile of the pile, bulk density, particle density, porosity, water holding capacity, total dissolved solids, total dissolved oxygen, nitrogen content, carbon content, C:N ratio, sodium ion, calcium ion, lead ion, potassium ion, nitrate ions, chloride ions, heat evolution, microbial load, and colour value of compost.

3. Design and fabrication of semi-automatic compost turner

The design of semi-automatic compost turner of 5 tonnes/ hour capacity has been finalized (Fig. 2) and the fabrication work of the machine is under progress (Fig. 3).

It consists (Table-1) of MS angle 1 ½" and MS channel 3" frame having dimensions 5' 4" wide, 14' long and 5' 4" high as our compost pile is of 5' wide and 5' height. It comprises of one compost lifting drum of 2' diameter having 2" protrusions of MS angle and a conveyor of 5' length

Fig. 2: Proposed design for the semi-automatic compost mixer and turner of 5 tonnes/hr capacity

Fig. 3: Fabrication work of semi-automatic compost turner under progress

Table 1: Parts Detail

Sr. No.	Letter	Part description	Nos
1	A	MS channel 3"	10 Nos
2	B	Pulley 100 rpm	2 Nos
3	C	Compost picking drum	1 No
4	D	MS Angle 1 ½"	17 Nos
5	E	Rubber belt 5 mm	1 No
6	F	Conveyor 350 rpm	1 No
7	G	Gear box 1.10	1 No
8	H	Pulley 8"	2 Nos
9	I	Wheel 20"	2 Nos
10	J	Pulley 4"	2 Nos
11	K	Pulley 12"	2 Nos
12	L	Motor 2 HP, 3" pulley	2 Nos
13	M	Pulley 4"	2 Nos
14	N	MS wheel 8"	2 Nos
15	O	Ground level	

which will carry the compost lifted by the lifting drum to the mixer rollers placed after the conveyor to properly mix the compost for uniform turning. The RPM of the lifting drum is 100 rpm, which is achieved with the help of pulley and belt mechanism. The drive motor is of 2 HP power and 1440 rpm. The rpm of the conveyor is 350 and is achieved with the help of pulley and belt mechanism having drive motor 2 HP and 1440 rpm. Mixing rollers are of 100 and 350 rpm, which is used for the conveyed compost to be mixed properly. 4 wheels carry the compost turner. Two 20" rubber wheels and two 8" wheels having turning mechanism and of drive 1 rpm.

4. Design of compost conveyor

Design of compost conveyor has been prepared and finalized. The proposed design is given in Fig. 4.

A compost conveyor is designed to carry compost to the bunker or elsewhere saving the labour and time. The proposed conveyor is of 15' length and 2' width and is carried on four wheels of 8" dia out of

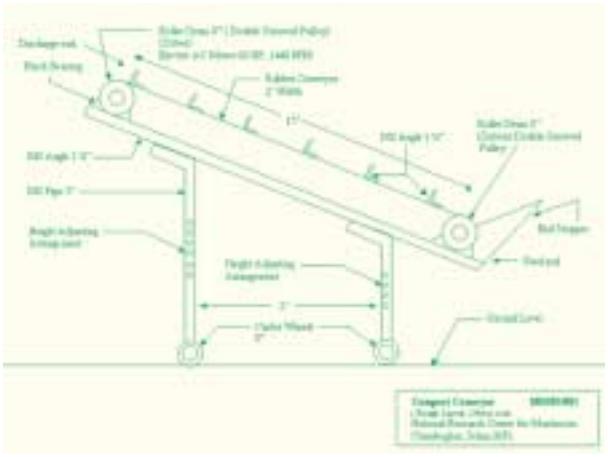


Fig. 4: Proposed design of compost conveyor

which two front wheels are caster wheels to facilitate easy turning. The conveyor belt is housed in 1 ½" MS angle frame driven by 2 HP motor with variable speed pulley and belt mechanism on to 8" roller drums of 2'6" width. The compost conveyor is legged by four MS pipes 3" dia with height and elevation adjusting mechanism. MS angle 1 ½" pieces are fixed on conveyor belt width wise at a distance of 12" to facilitate efficient picking of compost. There is end stopper at the picking side of conveyor to increase the compost carrying efficiency.

6

TRANSFER OF TECHNOLOGY

Project: - NCM-30: Collection, documentation and validation of indigenous technical knowledge about mushrooms cultivation (PI: Dr. M.P. Sagar)

1. Verification of indigenous technical knowledge

Under this project the ITKs collected last year were verified through experimental trials.Vermicompost is being used as medium for button mushroom cultivation by few mushroom growers in Punjab. In order to verify this ITK, vermicompost prepared from FYM was spawned with button mushroom spawn after treating it with malathion(1ml/lit). A total number of 23 bags each having 8 kg spawned vermicompost were prepared and placed on racks in cropping room. The required temperature for spawn run (22-25^0 C) was maintained. Vermi compost was found unsuitable for growing white button mushroom.

The another I.T.K. burnt rice husk mixed with F.Y.M. & soil in different ratio is being used as casing material in button mushroom by mushroom growers of Haryana, Himachal Pradesh & Punjab. Experimental trial was laid out at the Centre to verify and refine this ITK. The different formulations of casing soil mixture made of burnt rice husk, FYM and soil were applied on spawn run compost and required conditions were maintained in the cropping room. Case run was excellent in all the combination but time taken in case run was more than standard. It took about 20 days. Pin heads appearance was noticed in a week in all the treatments except treatment No. –1, where pinheads appeared one week later. The data on yield in various combinations show that burnt rice husk mixed with F.Y.M. and soil in different ratio may be used as casing material. The quality of mushroom was also found superior in terms of whiteness.

2. Refinement of I.T.Ks on the use of mushroom spent compost

1. Under AP-Cess adhoc project entitled "Refinement in Recycling Technologies of Spent Mushrooms Substrate for Soil Amelioration and Bioremediation", the indigenous technical knowledge about use of spent mushroom substrate, collected through mailed questionnaire were verified and refined through experimental trials at the Centre. Spent mushroom substrate obtained from white button mushroom cultivation and recomposted through various methods was used as organic manure in the agricultural & horticultural crops viz., wheat, tomato, ginger, capsicum, peas, cauliflower and onion . The major findings are given below:

i) Twelve months old aerobically recomposted SMS and 6-24 months old naturally weathered SMS application @ 250q/ha gave higher yield of tomato. Lower incidence of blossom end rot and buck eye rot diseases was noticed.

ii) The 6-18 months old naturally weathered SMS and 12 months old

anaerobically recomposted SMS enhanced the yield of capsicum along with better quality of fruits and restricted incidence of fruit rot disease.

iii) The chemical fertilizer supplemented anaerobically recomposted SMS gave superior yield in cauliflower, ginger and wheat, with better fruit quality however, lower incidence of diseases was recorded in non supplemented anaerobically recomposted SMS treatment.

iv) The 18 months old naturally weathered and anaerobically recomposted SMS gave better yield and quality of pea along with lower incidence of *Fusarium* wilt and powdery mildew diseases.

3. Routine extension research work

Apart from the research work under the projects, research on routine extension work related to training programmes was also conducted. The data on training needs assessment and their fulfillment of the trainees under various training programmes conducted during the year 2005-06 was collected. The Centre has conducted a number of training programmes sponsored by various departments/ agencies. Study on impact assessment of sponsored training programmes in terms of adoption of mushroom cultivation was conducted in HP. The data obtained show 12.08 and 18.9 % adoption of mushroom cultivation in Hamirpur and Chamba districts of H.P., respectively. It indicates that sponsored training programmes are more effective in mobilizing the SHGs to choose mushroom cultivation as source of income.

4. Horticulture technology mission

Under the Central Sector Scheme "Integrated Development of Horticulture in North- Eastern States under Technology Mission (Mini Mission–I)", the Centre has planned to develop mushroom cultivation in all the NE states. During the year under report, a one week training programme was organized for horticulture/ agriculture officers and field level workers at NRCM,Solan.

Under this scheme, 3 days off-campus training programmes were also organized at Gangtoke (Sikkim), Guwahati (Assam), Imphal (Imphal) and Agartala (Tripura). The data on training needs assessment were collected before starting all these off-campus training programmes.

5. Transfer of Technology

5.1 Training programmes Conducted

During the year under report, the Centre has organised a total number of 14 on&off-campus training programmes for farmers, entrepreneurs & Agril/Hort Officers. In all total numbur of 544 persons were trained on various aspects of mushroom cultivation (Fig. 1). Out of which 11 programmes have been coordinated by Extention & TOT Section.

Fig. 1: Spawning by trainees during farmers training at NRCM

5.2 Mushroom Mela- 2005

One day Mushroom Mela was organised on 10th September, 2005 – the day on which Solan was declared as Mushroom City of India. It was inaugurated by Dr. Jagmohan Singh, Hon'ble Vice chancellor (Fig. 2) Dr. Y.S. Parmar University of Hort. and Forestry, Nauni, Solan (H.P.) in the presence of Ex-Director, NRCM, Dr.H.S. Sohi and other dignitaries.

Fig. 2: Dr. Jagmohan Singh Hon'ble Vice-Chancellor, UHF Nauni visiting the exhibition during mushroom mela

It was attended by about 650 farmers, farm women, mushroom growers, researchers, extension workers and businessmen from various States viz; Himachal Pradesh, Haryana, Punjab, Uttar Pradesh, Bihar, Maharashtra, Rajasthan, Delhi, Sikkim, Kerala and Uttranchal.

An exhibition on improved mushroom cultivation technologies and other related aspects was organised in which twelve Govt. Organisation, ICAR Institutes/ University, Govt. financial organisation, compost and spawn producers, mushroom product manufacturers, seed, pesticides and chemicals producers and NGOs displayed their valuable information/ technologies/products and provided their services to the participants of Mushroom Mela.

Apart from this, participants purchased mushroom spawn, seed and pesticides, horticultural implements, literature on mushroom and mushroom products.

In order to make aware the participants with various improved technologies/ practices of mushroom cultivation, farm visit of the Centre,s growing unit was conducted and demonstrations on improved technologies were given in front of participants of Mushroom Mela.

In the afternoon session of Mushroom Mela, a Kisan Goshthi was organised to solve the problems in mushroom cultivation faced by mushroom growers. The problems raised by farmers and mushroom growers were replied by experts in a very systematic manner.

During the Mushroom Mela, the Centre felicitated a progressive mushroom grower -Mr. Vikash Benal, (Fig. 3) R/O village Samlach, Solan(H.P) for adopting innovative practices in mushroom cultivation on larger scale.

Fig. 3: Mr. Vikas Benal, A progressive mushroom grower being facilitated on the occasion of Mushroom Mela

5.3 Popularization of milky mushroom in H.P.

Keeping in mind the need of diversification in mushroom cultivation,

milky mushroom crop was raised at the Centre during the period April to July, 2005. Substrate was prepared through pasteurization techniques. This crop was shown to the visitors at the Centre. Milky mushroom cultivation has been started by farmers and mushroom growers in Hamirpur, Bilaspur, Mandi, and Una districts of H.P. as climate of these districts is conducive for milky mushroom cultivation. Farmers of Solan district (Fig. 5) were also motivated to grow milky mushroom in summer season.

Fig. 4: On farm demonstratin on milky mushrooms at Village Tope Ki Ber, Solan

On-farm trials were also laid out at three farmers farm in a near by village- Top Ki Ber. As a result, one farmer (Fig. 4) has adopted mushroom cultivation and he has taken two crops of button mushroom in the current year after milky mushroom crop.

5.4 Participation in National/ State level Kisan Melas and Exhibition

In order to create awareness about mushroom cultivation, the Centre participates in the national & state level exhibitions in India. The centre participated in the exhibitions organized by IVRI, Izatnagar(U.P.) from 18th –20th Oct.,05 and Krishi Expo-2006 at Pragati Maidan, New Delhi From 8-12th March., 2006.

5.5 Advisory service to farmers / Mushroom growers /businessman / unemployed youths

Advisory services through postal extension letters on various aspects of mushroom cultivation, training and marketing were also provided. Queries on mushroom cultivation were also replied on telephone and e-mail. The extention section has alone provided advisory services through face to face inter-action to 700 persons.

5.6 Preparation of extension literature

Three multicoloured folders viz. cultivation of milky mushroom, cultivation of paddy straw mushroom, and round the year cultivation of mushrooms were prepared and got printed in Hindi for distribution at various occasions.

Fig. 5: Scientist motivating villagers during meeting at Nehru Yuva Kendra, Manlog, Solan (H.P.)

7

MUSHROOM INFORMATION TECHNOLOGY

Project - NCM - 26: Database on different aspects of mushroom cultivation (PI.: Sh. Yogesh Gautam)

1. Data collection for mushroom growers and mushroom production of India

Different agencies have been requested to provide information relating to the mushroom production scenario in their respective states. A proforma has been designed to collect information related to the mushroom growers, mushroom production status and the agricultural waste available in the state. According to the information received, the total mushroom production in India was 72,000 tons during the year 2005-06. Punjab leads the production figures with around 40,000 tons per annum.

2. Digital training compendium of mushroom production

The Compendium of Lectures (SMS Training) has been prepared in a digital form where the titles of different lectures are available on the main screen and various lectures of the experts can be accessed by simply clicking on the respective links. It would present information related to mushroom production in a more user-friendly manner where a user can straight away go to the information desired.

3. Institute (NRCM) Profile

The Digital Institute Profile has been prepared wherein the different activities of the Centre have been presented in a digital form. It includes information relating to different Sections, Infrastructure etc. in text as well as in pictorial form.

4. Crop (Mushroom) Profile

The digital Mushroom Profile includes information relating to the cultivation technology of different mushrooms, their economic analysis, medicinal value etc. Information relating to button, oyster, paddy straw, milky, shiitake and black ear mushrooms can be accessed by clicking on the appropriate links.

8

TRAINING COURSES ORGANISED

S. No.	Name of Training Programme	Sponsored by	No. of Trainees	CD &CC
1.	Ten days training programme on mushroom production technology for Entrepreneurs w.e.f. 25th April, to 4th May, 2005.	Paid training programme of the Centre.	39	Dr. R.P.Tewari Dr. V.P.Sharma
2.	Seven days training on mushroom production for farm women of Shimla (H.P.) w.e.f. 4th to 11th April, 2005.	Dept. of Agril., Shimla	48	Dr. B.Vijay Dr. M.P.Sagar
3.	Seven days training on mushroom production for farm women of Shimla (H.P.) w.e.f. 13th to 19th April, 2005.	Dept. of Agril., Shimla	45	Dr. S.R.Sharma Dr. Satish Kumar
4.	Three days off campus training programme on mushroom production technology for mushroom growers/ farmers & officers of Jorhat (Assam), at AAU, Jorhat, w.e.f.8th – 10th June, 2005.	MM-I Scheme	31	Dr. B.Vijay Dr. M.P.Sagar
5.	Seven days training on mushroom production for farmers and unemployed youths w.e.f. 3rd to 9th August, 2005.	NRCM, Solan	55	Dr B. Vijay Dr. M.P.Sagar
6.	Seven days training on mushroom production for farmers and unemployed youths w.e.f. 20th to 26th September, 2005.	NRCM, Solan	49	Dr R.C.Upadhyay Dr. M.C.Yadav
7.	Five days training on mushroom production for supervisors & mushroom growers sponsored by Dept. of Hort. Ranikhet (UA) and SASD, Jammu w.e.f. 3rd to 7st November, 2005.	Dept. of Horti. (UA) & SASD, Jammu	9+5	Dr. M.P.Sagar
8.	Seven days training on mushroom production for farmers of Kinnaur (H.P.) sponsored by DDP Pooh (H.P.) w.e.f. 15th to 21st November, 2005.	Desert Dev. Proj. Pooh	28	Dr. B.Vijay Dr. M.P.Sagar
9.	Ten days training programme on mushroom production technology for Entrepreneurs sponsored by HP-STEP, Shimla w.e.f. 20th – 28th Dec.,05 & 7th Jan, 2006.	HP-STEP, Shimla	18	Dr R.C.Upadhyay Dr. M.P. Sagar

10.	Seven days training programme on msuhroom production technology for Agril & Hort. Officers of NEH region, w.e.f. 17th to 23rd January, 2006.	MM-I Scheme	7	Dr. B.Vijay Dr. M.P.Sagar
11.	Three days off-campus training programme on mushroom production technology for progressive farmers & officers of Imphal (Manipur), w.e.f 20th - 22nd Dec., 2005.	MM-I Scheme	40	Dr. B.Vijay Dr. M.P.Sagar
12.	Three days off-campus training programme on mushroom production technology for mushroom growers/ farmers & officers of Guwhati (Assam), at Guwhati, w.e.f.18th - 20th Feb, 2006.	MM-I Scheme	40	Dr. B.Vijay Dr. M.P.Sagar
13.	Three days off-campus training programme on mushroom production technology for mushroom growers/ farmers at Gangtoke (Sikkim), w.e.f.22nd - 24th Feb, 2006.	MM-I Scheme	89	Dr. B.Vijay Dr. M.P.Sagar
14.	Three days off-campus training programme on mushroom production technology for mushroom growers/ farmers at Agartala (Tripura), w.e.f. 4 - 6th April, 2006.	MM-I Scheme	50	Dr. B.Vijay Dr. M.P.Sagar

Fig. 1: Off campus training at AAU, Jorhat

Fig. 2: Entrepreneurs learning post harvest technology at NRCM Solan

Fig. 3: Practical demonstration of oyster mushroom cultivation to the farmers

9

EDUCATION AND TRAINING

Training of Scientists

1. **Dr. M.C. Yadav** attended 3 days training programme on "Bioinformatics and Plant Genomics" at Bioinformatics Centre of CSK HPKV, Palampur, from 9-11th June, 2005.

2. **Dr. R.C. Upadhayay** attended 21 days training on "Advanced Biochemical and Molecular Biology Techniques" at CAS in Biochemistry, IARI, New Delhi from 1st to 21st March, 2006.

Summer Training of Students

1. **Sh. B. Rajesh,** Deptt. of Microbiology, Andhra University Vishakhapatnam – 03 (AP), underwent summer training/ dissertation on " Physiological studies on *Mycogone perniciosa*" at NRCM from 09.05.2005-09.07.2005 under the guidance of Dr Satish Kumar.

2. **Ms. Ranjana Kumari,** Deptt. of Microbiology, Chanakya Mahavidyalaya, Jawahar Chowk, Bhopal (MP) underwent summer training/ dissertation on " Studies on cob web (*Cladobotryum dendroides*) disease of *Pleurotus* spp. at NRCM from 25.07.2005-25.08.2005 under the guidance of Dr S.R.Sharma.

3. **Ms Sonali Mahajan,** Department of Biotechnology, Punjab Technical University Jalandhar underwent summer training/ dissertation on **"** Studies on brown mould (*Oedocephalum* sp), a competitor mould of *Calocybe indica*" at NRCM from 17.07.2005-03.09.2005 under the guidance of Dr. V.P. Sharma.

4. **Sh. Ashfaq Khan**, Extol Institute of Management, Extol Campus, Extol Square, Bhopal – 462 008 (MP) underwent summer training/ dissertation on "Physiological studies on *Sepedonium chrysospermum"* at NRCM from 05.09.2005-05.12.2005 under the guidance of Dr. Satish Kumar

5. **Sh. Vijendra Pawar**, Extol Institute of Management, Extol Campus, Extol Square,Bhopal – 462 008 (MP), underwent summer training/ dissertation on "Post harvest technology of mushrooms" at NRCM w.e.f. 05.09.2005 - 05.12.2005 under the guidance of Dr. R.D. Rai.

6. **Sh. Deepak Janghel** M.Sc student of Extol College, Bhopal (M.P) underwent summer training on "Post harvest technology of mushrooms" at NRCM w.e.f. 05.09.2005 to 05.12.2005 under the guidance of Er. T. Arumuganathan.

7. **Sh. Ahfaz Khan,** Extol Institute of Management, Extol Campus, Extol Square, Bhopal – 462 008 (MP) underwent summer training/ dissertation on " Biochemical and genetic characterization of single spore isolates of paddy straw mushroom (*Volvariella volvacea*)" at NRCM from 05.09.2005-05.12.2005 under the guidance Dr. O.P. Ahlawat.

8. **Mr. Balwant Kumar,** Extol Institute of Management, Extol Campus, Extol Square, Bhopal – 462 008 (MP) underwent summer training/ dissertation on "Molecular Characterization of *Agaricus bisporus* Germplasm using RAPD Markers" at NRCM from 09.11.2005-08.02.2006 under the guidance Dr. M.C.Yadav.

9. **Ms. Savita Sharma**, Guru Nanak Dev Engineering College, Ludhiana (Punjab) underwent summer training on "Effects of various pretreatments on quality attributes on osmo-air dried white button mushroom *(Agaricus bisporus*)" w.e.f. 10.11.2005 - 09.12.2005 under the guidance of Dr R.D. Rai.

10. **Mr. Sahil Mahfooz,** Department of Biotechnology, Barkatullah University, Bhopal has submitted Ph. D. thesis entitled "Induction and molecular characterization of genetic variation in *Agaricus bisporus"* under the co-guidance of Dr M.C. Yadav.

10

AWARDS , RECOGNITION, PATENTS AND FOREIGN VISITS

1. **Dr R.P. Tewari,** Director visited Bangladesh as FAO consultant for two months w.e.f. Dec, 2005 to Feb., 2006 to provide consultancy on mushroom in the project "Integrated Horticulture and Nutrition Development Project".

2. **Dr. B.L. Dhar,** Principal scientist conferred as Honorary Fellow of Indian Mycological Society (for contribution in Mushroom Science) by University of Calcutta, Deptt. of Botany, Ballaey Ganj, Calcutta, West Bengal.

3. **Dr. O.P. Ahlawat** received "Scientist of the year Award 2004" for Natural Resource Management for Optimum Utilization from National Environmental Science Academy, India during its XVIIIth Annual Conference at Hyderabad on October 25, 2005.

PATENT GRANTED

Patent on "A method for preparing a mushroom growth promoting agent was granted to Dr. O.P. Ahlawat vide Indian Patent Office No. 193331 dated 16th Feb., 2006 with effect from 04-04-2001.

11

AICMIP CENTRES

The All India Coordinated Mushroom Improvement Project (AICMIP) came into existence during VIth Five-Year Plan on 01.04.1983 with its Headquarters at National Research Centre for Mushroom, Solan (HP). The Director of NRC for Mushroom, Solan (HP) also functions as the Project Co-ordinator of the project. Initially the AICMIP started with six Centres at Punjab Agricultural University, Ludhiana (Punjab), G.B.Pant University of Agriculture and Technology, Pantnagar (UP), C.S. Azad University of Agriculture and Technology, Kanpur (UP), Bidhan Chandra Krishi Vishwa Vidyalaya, Kalyani (West Bengal), Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu) and Mahatma Phule Agricultural University, Pune (Maharashtra). At a later stage during VIIth Plan one new Centre at Indira Gandhi Krishi Vishwa Vidyalaya, Raipur (MP) was added and two existing Centres at Kanpur (UP) and Kalyani (West Bengal) were dropped. However, three new Centres during VIIIth Five Year Plan and 3 Co-ordinating and one co-operating Centres during IXth Five Year Plan have been added to the existing list of Centres by dropping one at Goa. At present, 10 Co-ordinating and one co-operating Centres are working under AICMIP programme with its Headquarters at NRCM, Solan. The centres are:

- Punjab Agricultural University, Ludhiana (Punjab).
- Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu).
- G.B. Pant University of Agriculture and Technology, Pantnagar (Uttranchal).
- Mahatma Phule Agricultural University, Pune (Maharashtra).
- N.D.University of Agriculture and Technology, Faizabad (UP).
- Indira Gandhi Krishi Vishwa Vidyalaya, Raipur (MP).
- Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan).
- Kerala Agricultural University, Thrissur (Kerala).
- ICAR Research Complex for NEH Region, Barapani, (Shillong), (Meghalya).
- Horticulture and Agroforestry Research Programme (ICAR Research Complex for Eastern Region), Ranchi (Jharkhand).
- Dr.Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan – Co-operating Centre.

12

PUBLICATIONS

A. Research Papers

1. Ahlawat, O.P., Gupta, P., Rai, R.D. and Tewari, R.P. 2005. Mechanism of fruiting body liquefaction and mycelial culture inactivation in *Volvariella volvacea* (Bull.: Fr.) Sing. during cold storage conditions. *Indian Journal of Microbiology* **46(1):** 39-45.

2. Arumuganathan, T., Rai, R.D. and Hemakar, Anil Kumar. 2005. Effect of blanching time, concentration of sugar syrup and citric acid concentration on the quality of mushroom murabba (preserve). *Beverage and food world* **32(11):** 84-85.

3. 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.

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

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

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

7. Semwal, K.C., Bhatt, R.P. and Upadhyay, R.C**.** 2005. The genus *Amanita* from Garhwal Himalaya, India. *Mushroom Research*, **12(2):** 50-55.

8. Sharma, V.P., Kumar, S. and Sharma, S.R. 2005. Studies on chemical sterilization of substrate for the cultivation of some specialty mushrooms. *Mushroom Res.* **14(1):** 41-45.

9. 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.

10. Sharma, V.P. 2005. *Trichoderma*, the most common mould associated with mushroom cultivation. *Plant Disease Research* **20:** 72-73.

11. 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(2):** 68-71.

12. Sharma, V.P. and Kumar, R. 2005. Use of botanicals to manage *Sepedonium* yellow mould and obtain higher yield in button mushroom. *J. Mycol. and Plant Pathology* **35:** 257-259.

13. Singh, S.K., Sharma, V.P., Sharma, S.R., Kumar, S. and Mugdha, T. 2006. Molecular characterization of *Trichoderma* taxa causing green mould disease in edible mushrooms. *Curr. Sci.* **90(3):** 427-431.

14. 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*, **7(4):** 587-594.

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

16. Tandon, G., Sharma, V.P. and Guleria, D.S. 2006. Studies on spawn production technology of *Calocybe indica* P & C. *Indian J. Mush*. **XXII:** 64-67.

17. 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:** 106-116.

Book/ Book Chapter

1. Ahlawat, O.P., Indu Rani, C. and Sagar, M.P. 2005. Spent mushroom substrate-properties and recycling for beneficial purposes. In: *Frontiers in Mushroom Biotechnology* (R.D. Rai, R.C. Upadhyay and S.R. Sharma eds.). Pp. 314-334, NRCM, Solan.

2. Ahlawat, O.P. and Kumar, S. 2005. Traditional and modern cultivation technologies for the paddy mushroom (*Volveriella* spp.) In: *Frontiers in Mushroom Biotechnology* (R.D. Rai, R.C. Upadhyay and S.R. Sharma eds). 157-164, NRCM, Solan.

3. Arumuganathan, T., Dhar, B.L. and Rai, R.D. 2005. Low-cost structures for the seasonal production of mushrooms. In: *Frontiers in Mushroom Biotechnology*. (R.D. Rai, R.C. Upadhyay and S.R. Sharma eds.). Pp. 294-300, NRCM, Solan.

4. Arumuganathan, T., and Rai, R.D. 2005. Machinery, equipments and instrument in mushroom production and processing. In: *Frontiers in Mushroom Biotechnology*. (R.D. Rai, R.C. Upadhyay and S.R. Sharma eds.). Pp. 343-359, NRCM, Solan.

5. Rai, R.D. and Arumuganathan, T. 2005. Nutritive value of mushrooms. In: *Frontiers in Mushroom Biotechnology*. (R.D. Rai, R.C. Upadhyay and S.R. Sharma eds.). Pp. 27-36, NRCM, Solan.

6. Rai, R.D. and Arumuganathan, T. 2005. Post harvest handling of the fresh mushrooms. In: *Frontiers in Mushroom Biotechnology*. (R.D. Rai, R.C. Upadhyay and S.R. Sharma eds.). Pp. 365-375, NRCM, Solan.

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8. Sagar, M.P. 2005. Sources of information for various inputs and guidance on mushroom cultivation In: *Frontiers in Mushroom Biotechnology* (R.D. Rai, R.C. Upadhyay and S.R. Sharma eds.). Pp. 411-425, NRCM, Solan.

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10. Sharma,V.P. and Suman, B.C. 2006. Diseases and Pests of Mushrooms. Agribios (India) 212p.

11. Sharma, V.P., Sharma, S.R. and Kumar, S. 2005. Insects and Mite Pests in the cultivation of Edible Mushrooms and their Management. In: *Frontiers in Mushroom Biotechnology* (R.D. Rai, R.C. Upadhyay and S.R. Sharma, eds.), Pp. 244-258, NRCM, Solan.

12. Vijay, B. 2005. Formulations for white button mushroom. In: *Frontiers of Mushroom Biotechnology* (R.D. Rai, R.C. Updhyay and S.R. Sharma eds.). Pp. 80-87, NRCM, Solan.

13. Vijay, B. 2005. Recent advances for compost preparation for white button mushroom . In: *Frontiers of Mushroom Biotechnology* (R.D. Rai, R.C. Updhyay and S.R. Sharma eds.). Pp. 88-107, NRCM, Solan.

14. Vijay, B. 2005. Thermophilic fungi and their significance in compost preparation. In: *Frontiers of Mushroom Biotechnology* (R.D. Rai, R.C. Updhyay and S.R. Sharma eds.). Pp. 108-116, NRCM, Solan.

15. Vijay, B. 2005. Economics of modern and seasonal production of mushrooms. In: *Frontiers of Mushroom Biotechnology* (R.D. Rai, R.C. Updhyay and S.R. Sharma eds.). Pp. 301-313, NRCM, Solan.

16. Gautam, Y. 2005. Application of electronics in mushroom production system. In: *Frontiers in Mushroom Biotechnology* (R.D. Rai, R.C. Upadhyay and S.R. Sharma (eds.) Pp. 335-342, NRCM, Solan.

17. Gautam, Y. 2005. Mushroom informatics on the NET- its importance in research, production and trade. In: *Frontiers in Mushroom Biotechnology* (R.D. Rai, R.C. Upadhyay and S.R. Sharma eds.), Pp. 360-364, NRCM, Solan.

B. Technical Bulletins

1. Dhar, B.L. and Arumuanathan, T. 2005. Farm Design for White Button Mushroom Cultivation. *NRCM-Technical Bulletin No.6.* (Revised 2005): Pp. 32.

2. Dhar, B.L. and Tewari, R.P. 2005. Cultivation Technology of High Temperature Tolerant White Button Mushroom *Agaricus bitorquis*. *NRCM, Tech. Bulletin No.8* (Revised 2005); Pp. 29.

Reports

1. Ahlawat, O.P., Kumar, Satish and Gautam, Yogesh. 2005. Compiled and edited NRCM Mushroom Newsletter 11(1), Pp: 1-8.

2. Ahlawat, O.P., Kumar, Satish and Gautam, Yogesh. 2005. Compiled and edited NRCM Mushroom Newsletter 11(2), Pp: 1-8.

3. Ahlawat, O.P. and Kumar, Satish. 2005. Compiled and edited AICMIP Annual Report 2004-05, NRCM, Solan Pp. 1-52.

4. Singh, S.K. Yadav, M.C. and Verma, Shailja. 2005. Compiled and edited NRCM Annual Report 2004-2005, pp. 83 + XV, NRCM, Solan.

Popular/ Technical Articles

1. Arumuganathan, T., Ramanathan, M. Narayanan, L., Anandakumar, S. Indurani, C. 2005. Quick freezing preservation of fruits & vegetables. *Food & Pack*. **5(8):** 34-39.

2. Gautam, Y. and Kumar, S. 2006. Internet application for mushroom research and development. *Indian J. Mush*. **XXII (1&2):** 31-36

3. Gautam, Y. 2005. Multimedia ka khumb prasar mein ek shaktishali madhyam ke rup mein upyog, *Shoolini Samachar*, September' 2005.

4. Gautam, Y. 2005. Kahan kitni khumb prayog hoti hai, *Shoolini Samachar*, September' 2005.

5. Kumar, S. and Sharma, S.R. 2006. Persistence of pesticide residue in edible mushrooms- present status and future perspective . *Indian. J. Mush*. **XXII (1&2):** 10-17

6. Sagar, M.P. and Verma, R.N. 2005. Mushroom utpadan vevsai me safalta-ek kahani, kisan ki jubani, *Unnat Krishi*. **44(3)**, May-June.

7. Sagar, M.P. 2005. Sahkarita Aur Mushroom Utpadan. *Amar Ujala*, 20th Nov., 2005.

8. Sagar, M.P. 2006. Mushroom utpadan dwara mahilaon ka sashaktikaran. *Unnat Krishi*, **45(2):** 22-24.

9. Rani C., Indu and Arumuganathan, T. 2005. Nutritional value of bamboo and its value addition. *Food & Pack*. **6(4) :** 15-16.

Abstracts/Invited articles

1. Ahlawat, O.P., Indurani, C, Gupta, Pradeep and Rai, R.D. 2005. Variation in low temperature sensitivity in different strains of paddy straw mushroom, *Volvariella volvacea*. International Conference on Microbial Diversity: Current Perspective and Potential Application held on April 16-18, 2005 at University of Delhi South Campus, New Delhi.

2. Ahlawat, O.P., Indurani, C, Gupta, Pradeep and Rai, R.D. 2005. Variation at morphological, biochemical and yield potential levels in strains of paddy straw mushroom, *Volvariella volvacea*. International Conference on Microbial Diversity: Current Perspective and Potential Application held on April 16-18, 2005 at University of Delhi South Campus, New Delhi.

3. Arumuganathan, T., Ramanathan, M. Narayanan, L., Indurani, C. and Anandakumar, S. 2005. Post harvest hot water treatment for fruits & vegetables, A review. Souvenir & Proceedings of 18th National Conference on Recent Trends in Environmental Sciences organized by J.B. Institute of Engineering & Technology at JBIET, Hyderabad on 25-27th October, 2005, Pp:102.

4. Arumuganathan, T., Tewari, R.P., Kumar, Rajesh and Kamal, Shwet. 2006. Status and scope of mechanization in Indian Mushroom Industry. Souvenir on "40th Annual Convention and Symposium of Indian Society of Agricultural Engineers" organized by Indian Society of Agricultural Engineers, New Delhi and Agricultural Engineering College & Research Institute, TNAU, Coimbatore at TNAU, Coimbatore on 19-21st January, 2006, Pp: 254.

5. Arumuganathan, T., Rai, R.D. and Hemakar, Anil Kumar. 2006. Development of value added products from dried white button mushroom. Souvenir on "40th Annual Convention and Symposium of Indian Society of Agricultural Engineers" organized by Indian Society of Agricultural

Engineers, New Delhi and Agricultural Engineering College & Research Institute, TNAU, Coimbatore at TNAU, Coimbatore on 19-21st January, 2006, Pp. 3.24.

6. Arumuganathan, T., and Rai, R.D. 2006. Processing, Product development and value addition in mushrooms. Paper presented in the Brain storming session on "Status and Future Strategies for Research & Development on Mushroom in India" organized by National Research Centre for Mushroom, Solan held at NRCM, Solan on 18-19th March, 2006.

7. Arumuganathan, T. and Rai, R.D. 2006. Appropriate rural seasonal structures for optimum production of mushrooms. Paper presented in the Brain storming session on "Status and Future Strategies for Research & Development on Mushroom in India" organized by National Research Centre for Mushroom, Solan held at NRCM, Solan on 18-19th March, 2006.

8. Dhar, B.L. 2006. Organic mushroom production, pesticide residue analysis and quality produce. Brain Storming Session on "Status and Future Strategies for R&D on Mushroom in India", NRCM, Solan, HP (18-19 March, 06). (Invited Presentation).

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12. Gautam, A., Gautam, Y. and Kumar, S. 2005. Exploiting ayurveda and naturopathy for promoting agro-eco tourism in India. In : *Agro-Eco Tourism* (VS Korikanthimath & SB Barbudohe eds) Pp. 86-91. Proceedings of the national seminar on agro-eco tourism held on 19-20 Jan, 2006 at ICAR Res complex Goa.

13. Gautam, Y., Kumar, S, and Chauhan, A. 2005. Role of government and non-government organizations in agro –eco tourism. In : *Agro-Eco Tourism* (VS Korikanthimath & SB barbudohe eds) : 181-184. Proceedings of the national seminar on agro-eco tourism held on 19-20 Jan at ICAR Res complex Goa.

14. Gautam, Y., Dhar, B.L. and Kumar, S. 2006. Mushroom information centre in India - a new dimension in dissemination of agro based technology. International Conference on Social Science Perspective in Agricultural Research and Development. Feb. 15-18 , 2006. organized by VARDAN in collaboration with IFPRI, Washington DC (USA) and ISEE, New Delhi.

15. Indurani, C., Ahlawat, O.P., Sagar, M.P., Gupta, Pardeep, Vijay, B. and Dhar, B.L. 2005. Effect of button mushroom spent substrate of different age on yield

and quality of *Capsicum annuum*. National Conference on "Recent Trends and Environmental Science" held on 25-27 Oct, 2005 at JB Institute of Engineering and Technology, Hyderabad (AP).

16. Indurani, C., Sagar, M.P., Ahlawat, O.P. Gupta, Pardeep, Vijay, B. and Dhar, B.L. 2005. Effect of button mushroom spent substrate of different age on yield and quality of tomato (*Lycopersicom esculentum*). National conference on "Recent Trends in Environmental Science" held on 25-27 Oct, 2005 at JB Institute of Engineering and Technology, Hyderabad (AP).

17. Sagar, M.P., Ahlawat, O.P., Vijay, B., Raj, Dev and Gupta, Pradeep. 2006. Development of mushroom based integrated farming systems for resource poor farmer and farm women. International Conference on Social Science Perspectives in agricultural Research and Development held at IARI, New Delhi from 15th –18th Feb., 2006

18. Sagar, M.P. and Vijay, B. 2005. Training needs assessment and satisfaction about mushroom cultivation among entrepreneurs. Third National Extension Education Congress on " Revitalization of Extension System in New Economic Order" held at NDRI, Karnal from 27th to 29th April, 2005.

19. Sharma, S.R. and Kumar, S. 2006. Cultivation technology of milky mushroom (*Calocybe indica*) Invited lecture. Seminar on Innovations in Bio-sciences as applied to Biotechnology. 17-19 Feb.2006 at Sri satya Sai Institute of Higher Learning, Prasanthinilagam (AP).

20. Yadav, M.C. 2005. DNA markers in genetic improvement of mushrooms. Compendium of ICAR sponsored short course on "Emerging areas in mushroom diversity and post-harvest developments" organised by IGAU, Raipur, from 9-18 Jan., 2006, pp. 134-144.

21. Yadav, M.C. 2006. DNA markers in genetic analysis and genotyping of mushrooms. National Conference on Agrobiodiversity, organized by National Biodiversity Authority, held from 12-15 Feb., 2006, at Chennai.

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APPROVED ONGOING RESEARCH PROJECTS

Institute	Title	Researchers	Period	Code
NCM-14	Genetic improvement of temperate and tropical mushrooms:			
	Sub Projects:			
	a) Genetics and Breeding of white button mushroom (*A. bisporus* and *A. bitorquis*)	Dr. M.C. Yadav	Principal Investigator	Jan., 1988–Dec. 07
	b) Genetics and Breeding of *Pleurotus* spp.	Dr. R.C.Upadhyay Dr. M.C. Yadav	Principal Investigator Co-Investigator	Jan., 1988–Dec. 07
	c) Breeding of paddy straw mushroom (*Volvariella* spp.)	Dr. O.P. Ahlawat	Principal Investigator	April 2001–March 06
NCM-15	Survey, collection and identification of fleshy fungi	Dr. R.C.Upadhyay	Principal Investigator	Jan., 98–Dec. 03 (contd).
NCM-16	Improved methods of composting for button mushroom	Dr. B. Vijay Dr. O.P. Ahlawat Dr. R.P.Tewari	Principal Investigator Co-Investigator Co-investigator	Sept.,98-August,04 (continuing)
NCM-17	Studies on improved cultivation technology of *Pleurotus*	Dr. R.C.Upadhyay Dr. R.P. Tewari	Principal Investigator Co-Investigator	Jan., 98–Dec. 06
NCM-18	Standardization of cultivation technology of specialty mushrooms	Dr. S.R. Sharma Dr. V.P. Sharma Dr. Satish Kumar Dr. R.P.Tewari	Principal Investigator Co-investigator Co-investigator Co-Investigator	Dec., 97–Dec. 06
NCM-19	Medicinal Mushrooms - their evaluation and cultivation	Dr. R.D. Rai	Principal Investigator	Sept., 97–March, 06
NCM-20	Integrated diseases and pests management in mushrooms	Dr. Satish Kumar Dr. S.R. Sharma Dr. V.P. Sharma Sh. Y. Gautam	Principal Investigator Co-Investigator Co-Investigator Co-Investigator	Dec., 97–March, 06
NCM-21	Development of mushroom farm designs suited to Indian Conditions	Dr. B.L. Dhar T.Arumuganathan Sh. Y. Gautam	Principal Investigator Co-investigator Co-Investigator	Jan., 98–March, 06
NCM-22	Casing and crop management in *Agaricus bisporus*	Dr. B.L. Dhar Dr. O.P. Ahlawat	Principal Investigator Co-Investigator	Jan., 98–March, 06
NCM-25.	Studies on development of evaporatively cooled mushroom growing rooms and low cost mechanization for mushroom industry	T. Arumuganathan Dr. R.P. Tewari	Principal Investigator Co-Investigator	July, 99–July, 07
NCM-26	Database on mushroom growers of India	Sh. Y. Gautam Dr. M.P. Sagar	Principal Investigator Co-Investigator	Jan., 2001–Dec., 06
NCM-27	Improved cultural practices for high productivity of paddy straw mushroom, *Volvariella* spp.	Dr. O.P. Ahlawat	Principal Investigator	April, 2001–March, 06

Institute	Title	Researchers	Period	Code
NCM-29	Genetic characterization of mushroom germplasm of NRCM, Gene Bank	Dr. M.C. Yadav Dr. R.C. Upadhyay Dr. S.K. Singh	Principal Investigator Co-Investigator Co-investigator	Aug., 02–July, 06
NCM-30	Collection, documentation and validation of indigenous technical knowledge about mushroom cultivation	Dr. M.P. Sagar Dr. B. Vijay	Principal Investigator Co-Investigator	February, 04–July, 07
NCM-31	Organic mushroom production and quality produce	Dr. B.L. Dhar Dr. O.P. Ahlawat, Dr. J.K. Dubey, UHF Dr. Amit Nath, UHF	Principal Investigator Co-Investigator Co-investigator Co-Investigator	March, 02–March, 07
NCM-32	Molecular and physiological characterization of moulds associated with mushrooms	Dr. V.P. Sharma Dr. S.R. Sharma Dr. Satish Kumar Dr. S.K. Singh	Principal Investigator Co-Investigator Co-Investigator Co-Investigator	July,04–June, 09
NCM-33	Molecular characterization and genetic improvement in medicinal mushroom shiitake (*Lentinula edodes*)	Dr. S.K. Singh Dr. M.C. Yadav	Principal Investigator Co-Investigator	July, 2005–June, 09

Externally Funded Projects

Title of the Project	PI/Co-PI of the Project	Duration	Funding Agency
1. Collection, identification and culturing of Agricoid and Polyphorid fungi from North Western Himalayas for new drug discovery	PI: Dr. R.C.Upadhyay	01.07.2004 to 30.06.2007	CSIR
2. Refinement in Recycling technologies of spent mushroom substrate for soil amelioration and bioremediation	PI: Dr. O.P. Ahlawat	April, 2003 to June, 2006	AP-Css, ICAR
3. Development of Indigenous Machinery for Spawn and Mushroom Production	PI: Dr. R.P. Tewari	Nov.,2004 to Nov., 2007	Network Project

Consultancy Provided by the Scientists of NRCM

National:

1. Mr. C. Anand David, Director, M/s. Ontogino Flora (P) Limited, 13, Institutional Area, Lodi Road, New Delhi. Technology Economic Feasibility Report was prepared.
2. Sh. Anup Kumar Saha, S/o Late Sh. Amiya Kumar Saha, 32, Garia, Govt. Colony, Kolkata – 700 089 (W.B.) Training on Spawn Production Technology.
3. Sh. Subhash Chandra Gupta, S/o Late Sh. R.N. Gupta, 169, M.N.K. Road (N) Post Alam Bazar, Kolkata – 700 035 (W.B.) Training on Spawn Production Technology.
4. Sh. M.S. Chohan, Director (Technical), Chohan Huktamaki (India) Pvt. Ltd., Chambaghat, Solan (H.P.) Technology Economic Feasibility Report was prepared.
5. Director, M/s. Ambrosia Organoceuticals Pvt. Ltd., Lakshmi Towers, Saproon, Solan (H.P.) Technology Economic Feasibility Report was prepared.

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COMMITTEE MEETINGS

(a) Institute management committee:

Institute Management Committee, NRCM, Solan (H.P.) approved by the Council vide Office Order F.No.14-13/90-IA.V. dated 8th July, 2004 and F.No.14-13/90-IA.V dated 26th July, 2005 for a period of three years w.e.f. 24.06.2004 &18.07.2005.

One meeting was held on 21.09.2005

1.	Dr. R.P. Tewari, Director, NRCM, Solan.	-	Chairman
2.	Assistant Director General (VC), Indian Council of Agricultural Research, Krishi Anusandhan Bhavan-II, PUSA, New Delhi – 110 012.	-	Member
3.	Director of Horticulture, Directorate of Horticulture, Government of H.P., Shimla – 2 (H.P.).	-	Member
4.	Director, Horticulture & Food Processing, Uttaranchal, Udyan Bhavan, Chaubatia, Ranikhet, Distt. Almora (Uttaranchal).	-	Member
5.	Dr. D.K. Arora, Director National Bureau of Agriculturally Important Microorganisms (NBAIM), Kusmaur, MAU Nath Banjan (U.P.).	-	Member
6.	Prof. & Head, Deptt. of Mycology & Plant Pathology, Dr. Y.S. Parmar Univ. of Hort. & Forestry, Nauni, Solan (H.P.).	-	Member
7.	Sh. Chandrashekhar H. Badsawale, At: Malegon, Post Neral, Taluka Karjat, Distt. Raigarh, Maharashtra – 410101.	-	Member

8.	Sh. Karma Gyasto Bhutia, Lachng House Chandmari, T.V. Tower Road, Gangtok, East Sikkim, Sikkim.	-	Member
9.	Dr. S.R. Sharma, Principal Scientist, N.R.C.M., Solan (H.P.).	-	Member
10.	Dr. R.C. Upadhyay, Principal Scientist, N.R.C.M., Solan (H.P.).	-	Member
11.	Dr. S.K. Chakraborty, Principal Scientist, C.P.R.I., Shimla (H.P.).	-	Member
12.	Finance & Accounts Officer, National Dairy Research Institute, Karnal (Haryana)	-	Member
13.	Sh. Hari Singh, Administrative Officer, N.R.C.M., Solan (H.P.).	-	Member Secretary

(b) Research Advisory Committee: One meeting was held on 13-14 June,2005

1. Dr. H.S. Garcha, Ex-Dean PAU,
   36, Sant Park,
   Behind Agar Nagar,
   Phase-I, Ludhiana (Pb.).

Fig. 1: Dr. HS Garcha, Chairman RAC discussing medicinal mushroom at NRCM, Solan

2. Dr. T.N. Lakhanpal, Head, Deptt. of Biosciences,
H.P. University, Summer Hills,
Shimla - 171 005 (H.P.).

3. Dr. R.D. Singh,Retd. Professor,
Rajasthan Agricultural University,
276, Gayatri Nagar-A,
Durgapura - 300 019, Jaipur (Rajasthan).

4. Dr. R.N. Verma, Ex-Director, NRCM,
"Ashirvad", Rabindra Nagar Phase-II,
Tagore Hill Road, Morabad University PO,
Ranchi - 834 008, Jharkhand.

5. Dr. B.D. Patil, Retd. Professor (Mushroom),
1066, Sneh Kamal, Model Colony near Om Super Market,
Pune - 16.

6. Sh. Chandra Shekhar H. Badsawale,
Shaguna Baug, At: Malegaon, PO Neral,
Taluka Karjat, Distt. Raigad – 410 101 (M.S).

7. Sh. Karma Gyasto Bhutia,
Lachng House, Chandmari,
T.V. Tower Road, Gangtok,
East Sikkim, Sikkim.

(c) Quenquennial Review Team: One meeting was held on 25-26 June,2005

Fig. 2: QRT team visiting labs at NRCM, Solan

1. Dr. S. Kannaiyan, Former VC,
   TNAU & Chairman, QRT, NRCM,
   AL-85, 4th Street, 11th Main Road,
   Anna Nagar, Chennai – 600 040, T.N.

2. Dr. T.N. Lakhanpal, Head, Deptt. of Biosciences,
   H.P. University, Summer Hill,
   Shimla – 171 005 (H.P.).

3. Dr. T. Marimuthu, Director,
   Centre for Plant Protection Studies,
   Tamil Nadu Agricultural University,
   Coimbatore – 641 003 (Tamil Nadu).

4. Dr. T.N. Kaul, Retd. Dy. Director,
   RRL Srinagar, 249, Nilgiri Apartments,
   Alaknanda, New Delhi – 110 019.

5. Dr. R.P. Gupta, Coordinator of Research,
   COBS&H, Punjab Agricultural University,
   Ludhiana (Punjab).

6. Dr. R.P. Tewari, Director,
   NRCM, Solan (H.P.)

7. Dr. R.D. Rai, Principal Scientist
   Member Secy. QRT,
   NRCM, Solan (H.P.).

(d) Staff Research Council (SRC)

One meeting of Staff Research Council was held on 05-06 September, 2005 and was attended by all the scientists under the chairmanship of Director, NRCM, Solan.

(e) Core Committee

Core Committee was constituted at this Centre to settle the outstanding advances like Contingent, TA/LTC & Medical Advances, Works with other Govt. Departments. Four Meetings were held on 23.04.2005, 27.06.2005, 24.08.2005 and 23.11.2005 and followings are the Members of the Core Committee.

Members

(i)	Dr. R.P. Tewari, Director	-	Chairman
(ii)	Dr. R.D. Rai, Principal Scientist/ S.O.(P-I)	-	Member
(iii)	Dr. V.P. Sharma, Senior Scientist/Estate Officer	-	Member
(iv)	Sh. Hari Singh, A.O.	-	Member Secretary
(v)	Sh. Rishi Ram, AAO/DDO/S.O.(P-II)	-	Member

(vi)	Sh. Jiwan Lal, AFACO	-	Member
(vii)	Sh. Sh. R.K. Bhatnagar, Asstt.(Audit)	-	Member
(viii)	Sh. Rajinder Sharma, Asstt.(Store Purchase)	-	Member
(ix)	Sh. Bhim Singh, Asstt.(Cash)	-	Member
(x)	Sh. Tulsi Dass Sharma, Dealing Asstt.(Estate)	-	Member
(xi)	Sh. Deep Kumar Thakur, Dealing Asstt.(Hostel)	-	Member

(f) Sectional Heads' Meeting:

Two meetings of Sectional Heads including AO, AAO & AFACO were held on 23.06.2005 and 26.10.2005.

(g) Senior Officers' Meetings:

One meeting of Senior Officer's of this Centre was held on 23.04.2005 under the Chairmanship of Dr. R.P. Tewari, Director. It was attended by by all the scientists, AO, AAO & AFACO of NRCM, Solan.

(h) Institute Joint Staff Council (IJSC):

IJSC of this Centre was constituted vide Office Order No.F.IJSC/2004/7208-7222 dated 18.11.2004 for a period of three years w.e.f. 18.11.2004.

Two meetings were held on 15.07.2005 and 09.11.2005.

Office side members

(i) Dr. B. Vijay, Principal Scientist

(ii) Dr. O.P. Ahlawat, Senior Scientist

(iii) Dr. Satish Kumar, Senior Scientist

(iv) Sh. Hari Singh, Administrative Officer – Secretary (Office Side)

(v) Sh. Jiwan Lal, Asstt. Finance & Accounts Officer

(vi) Sh. Rishi Ram, Asstt. Administrative Officer

Staff side members

(i) Sh. Dala Ram Verma, Driver (T-2), Member CJSC

(ii) Sh. Deep Kumar Thakur, Steno (Gr.III), Secretary (Staff Side)

(iii) Sh. Sanjeev Sharma, LDC, Member

(iv) Smt. Reeta, T.O. (Library)

(v) Sh. Tej Ram, SS Grade-II/Sh. Nika Ram, SS Grade-II

(vi) Sh. Ajeet Kumar, Lab. Attendant

(i) Grievance Cell: Grievance Cell was constituted vide Office Order No.F.GC/15/2004-05/2131 dated 28th June, 2004 for a period of two years w.e.f. 28.06.2004. Since no grievance of any employee came hence no meeting was held.

Office Side Members

1.	Dr. R.D. Rai, Principal Scientist	-	Chairman
2.	Dr. B. Vijay, Principal Scientist	-	Member
3.	Dr. Sh. Hari Singh, A.O.	-	Member
4.	Sh. Jiwan Lal, AFACO	-	Member
5.	Sh. Rishi Ram, AAO	-	Member Secretary

Staff Side Member

1.	Dr. M.C. Yadav, Senior Scientist	-	Member
2.	Sh. Sanjeev Sharma, LDC	-	Member
3.	Sh. Lekh Raj Rana, T-1-3	-	Member
4.	Sh. Arjun Dass, SS Grade-I	-	Memebr

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SEMINARS/SYMPOSIA/ CONFERENCES ATTENDED

Dr. B.L. Dhar

- Attended 3 days National Convention on "Knowledge – Driven Agricultural Development: Management of change" organized by ARS Scientists Forum & ICAR at IARI, New Delhi from 24-26th March, 06.

Dr. S.K. Singh

- Attended "International Seminar on Forensic Science" from 22-24 February, 2006 at Amity University, Noida, Uttar Pradesh.
- Attended National Symposium on "Molecular Breeding in Crop Plants" from 20-21 March, 2006 at the Indian Institute of Vegetable Research (IIVR), Varanasi.

Dr. O.P.Ahlawat

- Attended International Conference on Microbial Diversity: Current Perspectives and Potential Applications from 16th -18th April, 2005, UDSC, New Delhi.
- Attended ICAR-IPA National Conference on IPR and Management of Agricultural Research from 27th - 29th August, 2005, NASC Auditorium, New Delhi.
- Attended 5th Meeting of Programme Advisory Committee on Plant Sciences of Dept of Science and Technology, on 10th and 11th February, 2006 at CDFD, Hyderabad.

Dr. M.C.Yadav

- Attented National symposium on Molecular Breeding in Crop Plants, organised by IIVR, Varanasi, from 20-21st March, 2006.

Dr. M.P. Sagar

- Attended National Extension Education Congress on " Revitalization of Extension Education Systems in New Economic Order" organized by Society of Extension Education, Advance Research & Management Centre of Rural Development, Agra and NDRI, Karnal from 27th to 29th ,April., 2005 at Karnal.
- Attended International Conference on " Social Science Perspectives in Agricultural Research and Development " jointly organised by VARDAN, New Delhi, ISEE, New Delhi and IFPRI, Washington,DC,USA from 15th - 18th Feb, 2006 at New Delhi.

All NRCM Scientists

Participated in Brain-Storming Session on Status and Future Strategies on R&D on Mushroom from 18-19th March, 06 at NRCM, Solan .

Fig. 1: Brain storming session at NRCM Solan

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DISTINGUIHED VISITORS

1. Sh I.D. Bali, Member of H.P. Human Right Commission visited NRCM on 21th June, 2005.
2. Hon'ble DG ICAR and secretary DARE releasing technical bulletins during his visit at NRCM on 12th July, 2005.
3. Minister of Agriculture, Govt. of Arunachal Pradesh visited NRCM, on 14th July, 2005.
4. Sh A.K.Singh, Joint Secretary, Lok Sabha visited NRCM on 6th December, 2005.

Fig. 1: Hon'ble DG, ICAR and secretary DARE releasing technical bulletins during his visit at NRCM on 12th July, 2005

Fig. 2: Minister of Agriculture, Govt. of Arunachal Pradesh visited NRCM, on 14th July, 2005

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PERSONNEL AND FACILITIES

Personnel

Scientific

Name	Designation
Dr.R.P. Tewari	Director
Dr.S.R. Sharma	Principal Scientist (Pl.Path.)
Dr.R.D. Rai	Principal Scientist (Biochemistry)
Dr.B.L. Dhar	Principal Scientist (Pl.Path.)
Dr.R.C. Upadhyay	Principal Scientist (Pl.Path.)
Dr.B. Vijay	Principal Scientist (Pl.Path.)
Dr.S.K. Singh	Senior Scientist (Pl.Path.)
Dr.O.P. Ahlawat	Senior Scientist (Biotechnology)
Dr.V.P. Sharma	Senior Scientist (Pl.Path.)
Dr.M.C. Yadav	Senior Scientist (Genetics)
Dr.Satish Kumar	Senior Scientist (Entomology)
Dr.M.P. Sagar	Senior Scientist (Agril.Extension)
Sh.Yogesh Gautam	Scientist (SS) (Computer Application)
Er.T. Arumugnathan	Scientist (Agril.Engineering)

Technical

Name	Designation
Sh.Sunil Verma	Technical Officer (T-6)
Smt.Reeta	Technical Officer (T-5)
Sh.Jia Lal Verma	Technical Officer (T-5)
Smt.Shailja Verma	Technical Officer (T-5)
Sh.Gian Chand	Boiler Attdt. (T-3)
Sh.Lekh Raj Rana	Technical Assistant (T1-3)
Sh.Ram Swaroop	Technical Assistant (T-2)
Sh.Parma Nand	Mushroom Assistant (T1-3)
Sh.Jeet Ram	Mushroom Assistant (T-2)
Sh.Guler Singh Rana	Electrician (T-2)

Name	Designation
Sh.Deepak Sharma	Computer Operator (T-2)
Sh.Dala Ram	Driver (T-2)
Sh.Ram Lal	Driver (T-2)
Sh.Ram Ditta	Driver (T-2)

Administrative

Name	Designation
Sh.Hari Singh	Administrative Officer
Sh.Jiwan Lal	Asstt.Finance & Accounts Officer
Sh.Rishi Ram	Asstt.Admn.Officer
Sh.R.K. Bhatnagar	Assistant
Sh.Rajinder Sharma	Assistant
Sh.Bhim Singh	Assistant
Sh.Surjit Singh	Personal Assistant
Sh.T.D. Sharma	UDC
Sh.N.P. Negi	UDC
Sh.Satinder Thakur	UDC
Smt.Sunila Thakur	Stenographer Gr.III
Sh.Deep Kumar	Stenographer Gr.III
Sh.Dharam Dass	LDC
Smt.Shashi Punam	LDC
Sh.Roshan Lal Negi	LDC
Sh.Sanjeev Sharma	LDC

Supporting

Name	Designation
Sh.Dhani Ram	SSG-IV (Chowkidar)
Sh.Naresh Kumar	SSG-III (Safaiwala)
Smt.Dayawanti	SSG-III (Safaiwali)
Sh.Nika Ram	SSG-II (Chowkidar)
Sh.Tej Ram	SSG-II (Chowkidar)
Smt.Meera Devi	SSG-II (Lab.Attdt.)
Sh.Raj Kumar	SSG-I (Lab. Attdt.)
Sh.Ajeet Kumar	SSG-I (Lab. Attdt.)
Sh.Arjun Dass	SSG-I (Messenger)
Sh.Vinay Sharma	SSG-I (Messenger)

Promotions

I. Scientists

- Dr.Satish Kumar, Scientist (SS) promoted as Sr.Scientist w.e.f. 01.07.2005 under CAS.
- Dr.M.P. Sagar, Scientist (SS) promoted as Sr.Scientist w.e.f. 15.07.2005 under CAS.

II Technical staff

- Smt.Sunila Thakur granted next higher pay scale under ACP Scheme w.e.f. 06.12.2005.

Sports

NRCM, Solan participated in ICAR Zonal Sports Meet held at National Dairy Research Institute, Karnal w.e.f. 7-10th March, 2006. The Centre participated in Volley Ball (Smashing & Shooting), Badminton, Kabaddi, Chess, Table Tennis, Carrom Board and Athletic events (men). The women team participated in Carrom Board, Chess, Badminton, and Athletics events.

Mrs. Sunila Thakur won Ist prize in Badminton Singles.

Mrs. Shailja Verma and Mrs. Sunila Thakur won the badminton double Ist prize.

Fig. 1: NRCM contingent participating in ICAR sports meet at Karnal

Mrs. Shailja Verma won the IInd prize in singles.

Mrs. Sunila Thakur won Ist Prize in High Jump, IInd Prize in Long Jump, IInd Prize in Shotput .

Infrastructural facilities developed

To improve the research and other infrastructure of the Centre, the renovation and special repair/ incomplete work were initiated and completed.The allocated funds under Non Plan worth Rs.114.90 Lakhs and under non Plan Rs.40.00Lakhs were utilized. The details of the complete works are as under:-

Under Plan

(1) C/O One Lakh Ltrs. capacity water harvesting tank

(2) Face lifting of main building (Exterior and Interior)

(3) C/O Type-I & II Qtrs one no. each

(4) C/O Road to composting yard

Under Non Plan

(1) Special repair of hostel building

(2) C/O Temporary shed for parking of vehicles

(3) Repair of rolling shutters and partition walls in car garrages of resi. complex

(4) Providing of cup board in Type-III-4 Nos

(5) Replacement of existing damaged flooring of toilets, lobby of Type-IV Qtrs. 2 Nos

(6) Providing of parapet and M.S. railing in type -IV new including Stair Case for transit roof

(7) Renovation of Guest House in ground floor of hostel bldg. toilets, corridor and dining hall

(8) Repair and replacement of damaged false ceiling in auditorium including internal electrification

(9) Levelling and dressing in back side of Library

(10) Renovation of library block including false ceiling and flooring

(11) Renovation of museum

(12) Providing of parking shed in front of main building

(13) Development of existing road and front portion of main building

(14) Providing of temporary shed for 630 KVA

(15) Dev. of site for construction Sub Station

(16) Providing of kitchen cup boards and tiles in type-V

(17) Renovation of open and front area composting yard area

(18) Renovation of VIP suit of Guest House plus replacement of wooden doors and window in aluminium in library block.

(19) Providing of boring tubewell alongwith sub mersible water pump

(20) Development and renovation of existing path in front of library building

(21) Dev. of site near Type-I Qtr.

(22) S/R of Director's Resi.

(23) Prov. of Park Lighting in front of main bldg.