वार्षिक प्रतिवेदन

ANNUAL REPORT

2006-2007

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

वार्षिक प्रतिवेदन

ANNUAL REPORT 2006-2007

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.)

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

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

Type setting by : Mr. Deepak Sharma

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

CONTENTS

PREFACE

The achievements of National Research Centre for Mushroom during 2006-2007 are summarized under various heads. During the year, National Mushroom Repository was enriched by addition of 315 mushroom cultures of which some are new records for India. Molecular variation and genetic identities were studied among 22 white pileus cultivars of *Agaricus bisporus* of which 53.7% were polymorphic. Genetic improvement studies on temperate and tropical mushrooms were conducted and some promising single spore isolates in *Agaricus bisporus, Volvariella volvacea,* few hybrids in *Pleurotus florida* and *P. sajor-caju* have been identified.

NRCM continued its efforts to prepare quality compost through indoor composting with the help of thermophilic fungi and mixed results were obtained. NRCM developed the protocol for organic farming. Average mushroom yield of 18-20 kg was harvested in 6 week of cropping from 100 kg compost, with bulk of crop yield obtained in first 3 weeks of cropping. Moving ahead towards diversification, *Macrolepoita procera* was grown successfully at the Centre. Efforts were made to increase the yields of *Flammulina velutipes* by supplementing the cultivation substrates with 10 per cent wheat bran which resulted in early spawn run and significantly higher yields. Saw dust proved better substrate for the cultivation of *Agrocybe aegerita* giving 74.33 per cent biological efficiency when supplemented with 10 per cent wheat bran. Different quantities of substrate were evaluated for the yield of *Ganoderma lucidum*. There was no significant difference in the yield when bags filled with 500 to 1200 g wet substrate were used.

Studies on isolation of the mesophilic mycoflora revealed that Chicken manure harboured the maximum number of mesophilic mycoflora followed by spent compost. Studies on residue analysis of malathion at different concentrations was worked out to recommend safe waiting period. Molecular characterization of eight isolates of *Cladobotryum* exhibited more than 90% similarity, whereas both the isolates of *Acremonium alternatum* and *Chaetomium globosum* showed identical RAPD profiles. Four isolates of *Sepedonium chalcipori* showed the maximum variation. *Fusarium, Chlamydosporum* and *Mortierella alpina* causing Fusarial rot and shaggy stipes, respectively, were recorded to be the new pathogens of white button mushroom in India and species of both the pathogens as new record in the world. Different isolates of *Cladobotryum* resulted in 11-22, 22-50 and 11-22 per cent yield loss in button, oyster and milky mushrooms, respectively.

Studies conducted on the modified atmospheric packaging of button mushroom in PET jars revealed that diffusion channel method was the best to prolong the shelf life of button mushrooms up to 8 days at ambient temperatures. A compost turner of 5 tonnes/hr capacity was designed and fabricated. A compost conveyor is also designed to carry compost to the bunker.

During the year under report, the Centre has organised a total of 14 On and Off-campus training programmes for farmers, entrepreneurs and 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, 2006. It was attended by about 500 mushroom growers, farmers, farm women, researchers, extension workers and businessmen from various States of India. Two progressive mushroom growers Sh. Sunil Kumar and Sh. Joginder Singh both from Haryana were felicitated for adopting innovative practices in mushroom cultivation on larger scale and mobilizing other farmers to adopt mushroom cultivation as source of income. Mushroom production information was collected for India and figures for the year 2006-07 were projected. Punjab led the production with Agro-Dutch alone accounted for 45,000 tonnes of white button mushroom.

Two scientists have been trained in advanced molecular techniques and post harvest technology. Besides this, several students were trained on various aspects of mushroom production technology and molecular identification and characterization techniques.

NRCM is giving greater emphasis on the diversification in mushroom cultivation as it will provide an opportunity to the seasonal mushroom growers for round the year cultivation and for utilization of locally available substrates. The substrate released after taking mushroom crop better known as 'Spent Mushroom Substrate' is of great importance. The recomposted spent mushroom substrate has been found to be a good growing media for majority of the vegetables and the field crops and has shown multifaceted utilities in improving the crop yield, quality and management of the diseases which is encouraging for the mushroom industry. The other utilities of spent mushroom substrate like in vermicomposting, bioremediation and as organic fertilizers are boon to the country's farming system. The farmers should be encouraged to start reusing of spent mushroom substrate for integrated farming and to obtain better revenue out of this agrowastes available at their door step and contribute towards a clean environment.

The Centre has developed infrastructure facilities like 630 KVA Electrical Sub Station and temporary shed for parking of vehicles. The Centre has been also provided with 180 KVA Generator Set. The work of Trainer's Training Facility building is in progress.

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 2006-07 के दौरान राष्ट्रीय खुम्ब अनुसंधान केन्द्र ने अनुसंधान, प्रसार व मानव संसाधन विकास के क्षेत्र में उल्लेखनीय प्रगति की है, जिसका विवरण फसल उन्नयन, फसल उत्पादन, फसल संरक्षण, फसल पोषण एवं उपयोग, प्रसार एवं तकनीकी हस्तांतरण, खुम्ब सूचना प्रौद्योगिकी, शिक्षा एवं अन्य कार्यकलापों के अंतर्गत प्रस्तुत किया गया है।

फसल उन्नयन

क) जैव संपदा संग्रहण : इस वर्ष हिमाचल प्रदेश, हरियाणा एवं चण्डीगढ़ के जंगलों से कुल 315 जंगली खुम्बों के नमूने एकत्र किये गये, जिसमें मुख्यतः *एगेरिकस, एग्रोसाईबी, एमेनिटा, अरमिलेरिया, बोलीटस, केमेरोफिलस, क्लोरोफिलम, क्लाइटोसाईब, कोलीबिया, कोर्टिनेरियस, क्रेपीडोटस, डेसकोलिया, इन्टोलोमा, गेलेरीना, गोमफिडियस, जिम्नोपाईलस, हिबेलोमा, हाइग्रोफोरस, इनोसाईबी, लैक्केरिया, लौक्टारियस, लेक्किनम, लेन्टाइनस, लेपियोटा, लेपिस्टा, ल्यूकोकोप्राईनस, ल्यूकोपैक्सिलस, लिमासेला, लायोफिलम, मिलेनोल्यूका, मैक्रोलेपियोटा, मारास्मियस, माईसिना, नेमेटोलोमा, औडमैन्सियैला, पैनीयोलस, पैनस, पैनेलस, पैक्सिलस, फोलियोटा,प्लूरोफ्लैमुला, प्लूरोटस, प्लूटियस, पोलीपोरस, सैथिरैला, साइलोसाईबी, रूसूला, स्ट्रोबिलोमाईसेस, स्ट्रोफेरिया, सुईलस ट्राईकोलोमा, वॉल्वेरियेला* आदि प्रजातियां पायी गईं।

ख) जंगली खुम्बों का वर्गीकरण : *एगेरिकस* संबद्ध खुम्बों के अलावा, *गैस्ट्रोमाईसीटस, एफाईलोफोरेलस* एवं *एस्केमाईसीट* गूदेदार कवक के नमूने भी एकत्र किये गये। *कोर्डिसेप्स* एवं *कोरेमिया* जातियां प्रथम बार एकत्र की गई हैं। व्यवसायिक रूप से उत्पादित की जा रही खुम्ब जैसे *प्लूरोटस, स्ट्रोफेरिया, वॉल्वेरियेला, लेन्टीनस, हेरीसियम, ऑरिकुलेरिया* आदि से संबंधित जंगली खुम्बें भी एकत्र की गई जिनमें इन महत्वपूर्ण प्रजातियों के प्रजाति सुधार हेतु अधिक क्षमता है।

ग) जैव संपदाओं का विश्लेषण : रूपांतरित सी०टी०ए०बी० विधि द्वारा एगेरिकस जाति की 41 प्रजातियों से जिनोमिक डी०एन०ए० निकाला गया। इन डी०एन०ए० नमूनों को आर०एन०ए०-1 द्वारा शुद्ध किया गया। *एथीडियम ब्रोमाईड फ्लोरिसेन्स* एवं डी०एन०ए० फ्लोरी मीटर द्वारा डी०एन०ए० सांद्रता व विश्वसनीयता को जांचने हेतु डी०एन०ए० का मात्रा निर्धारण किया गया। *ऐगेरिकस बाईसपोरस* की 22 श्वेत छत्रक प्रजातियों में आर०ए०पी०डी० मारकर्स एवं 5.8 एस० राईबोसोमल जीन अनुक्रम आई०टी०एस० सहित विश्लेषण विधि द्वारा *मॉलीकुलर* विभिन्नताएं एवं आनुवंशिक समरूपता (समानता) का अध्ययन किया गया। 24 प्राईमरों ने 175 आर०ए०पी०डी० मारकर्स की वृद्धि की, जिसमें से 53.7 प्रतिशत पॉलीमॉरफिक थे। आनुवंशिक समरूपता सूचकांक 0.64 से 0.99 के मध्य तथा औसतन 0.81 पाया गया। प्रजातियों में 92.7 प्रतिशत आनुवंशिक समरूपता पायी गई, जबकि संकर प्रजातियों में 84.3 प्रतिशत आनुवंशिक समरूपता पायी गई। इस अध्ययन से ज्ञात होता है कि आर०ए०पी०डी० मारकर्स, संकर प्रजातियों की जर्मप्लाज्म के स्तर पर पहचान करने व श्वेत बटन खुम्ब प्रजातियों में मॉलीकुलर परिवर्तन की पहचान के उपयोगी एवं पुष्टिकारक आनुवंशिक यंत्र हैं।

घ) आनुवंशिक सुधार (उन्नयन) : शीतोषण एवं उष्णकटिबंधीय खुम्बों - *एगेरिकस, प्लूरोटस, वॉल्वेरियेला* एवं *लेन्टीनुला* के आनुवंशिक उन्नयन के लिये अध्ययन किये गये। एकल बीजाणु संवर्धन - एस०एस०आई० 8109, संकर-2 एवं व्यवसायिक प्रजाति पी०-5 ने अधिक पैदावार दी तथा फलनकाय की गुणवत्ता भी अच्छी थी। तीन एकल बीजाणु संवर्धनों (सी०एम० 3,

सी०एम० 7, सी०एम० 9) एवं संकर सी०एम०-11 के व्यवसायिक उत्पादन हेतु अनुशंसा की गई। पुआल खुम्ब की 26 प्रजातियों को माल्ट एक्सट्रेक्ट अगर माध यम पर उगाया गया। इन प्रजातियों की रेडियल कवक जाल वृद्धि, ऐरियल तन्तु एवं क्लेमाईडोस्पोर्स में भिन्नता पाई गई। प्रजातियां ओ०ई०-49, ओ०ई०-146 एवं ओ०ई०-91, ओ०ई०-224 को छोड़कर, अधिकतर प्रजातियों ने *वॉल्वेरियेला वॉल्वेसिया* के आदर्श स्वरूपी गुणों को दर्शाया। विभिन्न प्रजातियों में विभिन्न एन्जाईम क्रियाएं पाई गईं। सबसे अधिक एक्जोग्लेकोनेज की सक्रियता प्रजाति ओ०ई०-143 (1.38 यू) पाई गई। उसके बाद प्रजातियों ओ०ई०-214, ओ०ई०-139 व ओ०ई०-215 की बारी आती है। इन्डोग्लूकानेज की सक्रियता सबसे अधिक प्रजाति ओ०ई०-143 (1.57 यू), में पाई गई ओ०ई०-145 में 1.49 यू व ओ०ई०-210 में 1.24 यू० एन्डोग्लूकानेज सक्रियता पाई गई। बीटाग्लूकोसाईडेज एन्जाईम की सबसे अधिक सक्रियता (2.59 यू) प्रजाति ओ०ई० 145 में मिली, उसके बाद अन्य प्रजातियों ओ०ई०-117 व ओ०ई०-210 में इस एन्जाइम की सक्रियता क्रमशः 2.55 यू, व 2.50 यू० पाई गई। जाईलेनेज एन्जाईम की सक्रियता प्रजाति ओ०ई०-215 में सबसे अधिक पाई गई, इसके बाद अन्य प्रजातियों, ओ०ई०-272, ओ०ई०-213, ओ०ई०-209, ओ०ई०-117 व ओ०ई०-214 में इस एन्जाईम की सक्रियता का क्रमबद्ध होना पाया गया। लैक्केज एन्जाईम की सक्रियता सबसे अधिक (3.33 यू०) प्रजाति ओ०ई०-143 में मिली व प्रजातियां - ओ०ई०-29, ओ०ई०-145, ओ०ई०-210 व ओ०ई०-272 अनुसरण करती पाई गईं। पॉलीफिनॉल ऑक्सीजन की सक्रियता सबसे अधिक (6.50 यू०) प्रजाति ओ०ई०-210 में मिली। प्रजातियां ओ०ई०-272, ओ०ई०-139, ओ०ई०-145 व ओ०ई०-214 अनुसरण करती पाई गईं।

लेन्टीनुला के 32 एस०एस०आई० को एम०एन०-1, एम०एन०-2, ओ०ई०-329, एम०पी०टी०-1, एम०पी०टी०-2 एवं एम०पी०टी-3 प्रजातियों के जर्मप्लाज्म से तैयार किया गया। इनको दो वर्गों में बांटकर इनमें संयोग (क्रास) कराया गया। वर्ग-1 में एम०एन०-1 व 2 तथा वर्ग-2 में ओ०ई०-329, एम०पी०टी०-1, 2 व 3 के एकल बीजाणु संवर्धनों को सम्मिलित किया गया।

वर्ग-1 से 15 संकर प्रजातियां व वर्ग-2 से 22 संकर प्रजातियां विकसित की गई। ओ०ई० श्रृंखला के पांच अच्छी प्रजातियों की उपज व तुलनात्मक जैव परिवर्तन क्षमता के अध्ययन हेतु दो ट्रायल लगाये गये। इस श्रृंखला से विकसित किये गये 13 संकरों को भी उनकी उपज व जैव परिवर्तन क्षमता के लिये ट्रायल लगाकर परखा गया।

प्लूरोटस फ्लोरिडा के एकल बीजाणु संवर्धन संकरण से विकसित किये गये छः संकरों का उपज हेतु मूल्यांकन किया गया। सबसे अधिक पैदावार संकर एच-25 से मिली। एच-10, एच-35 व एच-4 संकर प्रजातियाँ अनुसरण करती पाई गई। *प्लूरोटस साजोर-काजू* के विकसित किये गये नौ संकरों का मूल्यांकन तीसरी बार पास्चुरीकृत तूड़ी पर किया गया। पांचों प्रजातियों ने पैतृक किस्म की तुलना में 22-30 प्रतिशत अधिक पैदावार दी। सबसे अधिक पैदावार (63 प्रतिशत बी०ई०) संकर एच-9 में पायी गई।

फसल उत्पादन

क) श्वेत बटन मशरूम (*एगेरिकस बाईस्पोरस*)

i) अंतः कम्पोस्ट निर्माण : अंतः कम्पोस्ट निर्माण विधि से आधारभूत अवयव गेहूं के भूसे से कम्पोस्ट बनाई गई। विधि अनुसार जो चरण अपनाये गये वे इस प्रकार हैं, -2 दिन पर तूड़ी को गीला करना एवं अन्य अवयवों को मिलाना, -1 दिन पर आवश्यकतानुसार कम्पोस्ट मिश्रण की पलटाई करना, अवयवों को ठीक से मिलाना

व आवश्यकतानुसार पानी मिलाना, शून्य दिन पर कम्पोस्ट मिश्रण को अवस्था-I के लिये टनल में भरना, 3 दिन पर टनल से कम्पोस्ट मिश्रण बाहर निकालना, मिलाना, पलटना, पानी मिलाना व पुनः टनल में भरना, 6 दिन पर कम्पोस्ट मिश्रण को अवस्था-II टनल में भरना, 12वें दिन तैयार कम्पोस्ट को बाहर निकालना। इस प्रकार तैयार कम्पोस्ट प्रयोग किये गये गेहूं के भूसे की मात्रा से 2.9 गुना ज्यादा कम्पोस्ट तैयार हुई। इस कम्पोस्ट पर उत्पादन ट्रायल लगाये गये तो औसतन 15.04 किलोग्राम मशरूम/100 किलोग्राम कम्पोस्ट उपज प्राप्त हुई।

हरियाणा, पंजाब, उत्तर प्रदेश व हिमाचल प्रदेश राज्यों से कम्पोस्ट के 50 से अधिक नमूने एकत्र किये गये। ये नमूने कम्पोस्ट बनाने की प्रक्रिया के दौरान भिन्न अवस्थाओं का प्रतिनिधित्व करते है। बहुत अधिक संख्या में थर्मोफीलिक कवक जैसे *म्यूकर, प्यूसीलस, क्यूनिगघमेला* स्पी०, *एस्पर्जीलस फ्यूमीगेटस, एस्पर्जीलस* स्पी०, *साईटेलीडियम थर्मोफिलम, ह्यूमिकोला इंसोलेन्स, ह्यूमिकोला ग्रीसिया, कीटोमियम थर्मोफाइल, थर्मोमाईसिस लेनूजिनोसस, ह्यूमिकोला फ्यूस्कोट्रा, गिल्मेनियेला ह्यूमिकोला* व कुछ *माईसीलिया स्टेरियेला* को पृथक किया गया।

ए० बाईसपोरस के लिये विभिन्न कम्पोस्ट सूत्रों के मूल्यांकन हेतु गेहूं के भूसे पर आधारित सूत्रों को अपनाते हुए छोटी विधि से कम्पोस्ट की छः भिन्न ढेरियां बनाई गई। उपचार-5 जिसमें कॉटनसीड मील मिलाई गई थी से सबसे अधिक मात्रा में कम्पोस्ट प्राप्त हुई।

जब कम्पोस्ट के थर्मोफीलिक कवकों की सहायता से अंतः विधि द्वारा 7 दिनों में फेज-1 अवस्था को अपनाये बिना तैयार किया गया तो ह्यूमिकोला इन्सोलेन्स के एस-2 प्रजाति में सबसे अधिक वजन के फलनकाय (10.07 ग्राम) मिले। जबकि अधिकतम उपज (12.987 कि०ग्राम/100 किलोग्राम कम्पोस्ट) प्रजाति एस-5 से प्राप्त हुई। एस०थर्मोफीलम व एस०ग्रीसिया प्रजातियों में प्रजाति एस-7 व एस-4 से अधिक उपज प्राप्त हुई। नियमित उपचार जिसमें कई कवकों के स्ट्रेन मिलाये गये थे, ने भी अच्छा प्रदर्शन किया व 9.62 किलोग्राम/100 किलोग्राम कम्पोस्ट पैदावार मिली।

ii) जैविक मशरूम उत्पादन : जैविक मशरूम उत्पादन हेतु कम्पोस्ट व केसिंग मिश्रण को भाप के द्वारा पास्चुरीकृत किया गया तथा इनके बनाने की प्रक्रिया के दौरान किसी भी अवस्था पर जिप्सम को छोड़कर अन्य किसी रसायन का प्रयोग नहीं किया गया। औसतन उपज 18-20 किलोग्राम/100 किलोग्राम कम्पोस्ट छः सप्ताह के फसलकाल में प्राप्त हुई, पहले तीन सप्ताह में काफी ज्यादा उपज प्राप्त हुई।

ख) ढिंगरी मशरूम उत्पादन

प्लूरोटस फॉस्यूलेटस के उत्पादन हेतु सूखी हुई पॉपलर की पत्तियों को गेहूं के भूसे में 1:1, 2:1, 3:1 के अनुपात में मिलाया गया तथा केवल पॉपलर की सूखी पत्तियों को भी प्रयोग किया गया। इन सभी पोषाधारों को 5 प्रतिशत की दर से कॉटन सीड केक (बिनौले की खली) से सम्पूरित किया गया तथा 60 मिनट तक आटोक्लेव में निर्जीवीकृत किया गया। सभी उपचारों में फलन क्रिया हुई तथा 280 से 350 ग्राम ताजा मशरूम 45 दिनों के फसल काल में प्राप्त हुई।

ग) विशिष्ट खुम्बों का उत्पादन

मैक्रोलेपियोटा प्रोसेरा को छोटी विधि से तैयार की गई कम्पोस्ट पर सफलतापूर्वक उगाया गया। कम्पोस्ट में कवक जाल फैलाव 27^0 सेल्सियस तापमान पर 30 दिनों में पूर्ण

हुआ। केसिंग परत चढ़ाने के 18-20 दिनों बाद, कलिकायें बनना शुरू हुई। फलनकाय की लंबाई 16-30 से०मी० तथा औसत वजन 30 ग्राम पाया गया।

बुरादे को चोकर से संपूरित करने पर *एग्रोसाईबी एजीरिटा* के उत्पादन की कवक जाल फैलाव अवस्था में लगने वाले समय में कमी आई। असंपूरित बुरादे में कवक जाल फैलाव अधिकतम 42 दिनों में पूर्ण हुआ, 10 प्रतिशत की दर से संपूरित करने पर कवक जाल फैलाव जल्दी (39 दिनों में) पूर्ण हुआ। औसतन फलनकाय की संख्या 129 से 136 के बीच थी। 10 प्रतिशत चोकर से संपूरित बुरादे में औसतन अधिकतम 446 ग्राम उपज प्राप्त हुई।

गेहूं के चोकर का संपूरीकरण करने पर, सेलूलोज, हेमीसेलूलोज व परऑक्सीडेज एन्जाइमों की सक्रियता में बढ़ोत्तरी पायी गई जबकि कॉटन सीड केक, सोयाबीन मील व तेल रहित सोयाबीन के सम्पूरीकरण से इन एन्जाइमों की सक्रियता में कमी पाई गई। बुरादे को गेहूं के चोकर से 10 प्रतिशत की दर से सम्पूरित करने पर *फ्लेमुलिना वेल्यूटिपस* की वृद्धि काफी तेज गति (69 मि०मी०) से बढ़ी। इसी दर से सोयाबीन मील को मिलाने से वृद्धि 62.7 मि०मी० मिली। बुरादे में 10 प्रतिशत की दर से गेहूं का चोकर सम्पूरित करने से कवक जाल बहुत ही तेज गति से फैलता पाया गया व अधिकतम (44 प्रतिशत) जैव परिवर्तन क्षमता प्राप्त हुई।

बुरादे में 40 प्रतिशत की दर से गेहूं का चोकर मिलाने पर *लेन्टीनुला इडोड्स* की अधिकता (80 प्रतिशत) जैव परिवर्तन क्षमता प्राप्त हुई। इसी सम्पलीमेंट की दर घटाने पर उपज में कमी पाई गई।

घ) रिशी मशरूम उत्पादन

रिशी मशरूम उत्पादन में इसकी उपज व गुणवत्ता पर भिन्न-भिन्न वजन के भरे गये बैगों (500, 750, 1000, 1200 व 1500 ग्राम) का प्रभाव जानने के लिये प्रयोग किये गये। एक बैग में 500 से 1200 ग्राम तक भरे गये सूखे माध्यम से प्राप्त उपज में सार्थक अंतर नहीं मिला। सबसे अधिक वजन के बड़े बैगों में बड़ी परंतु कम फलनकाय मिले। रिशी मशरूम की विभिन्न अवस्थाओं में एक्ट्रासेलुलर लिग्नोलाईटिक एन्जाईम (लिग्नीनेज व मैग्नीज पर ऑक्सीडेज) के उत्पन्न होने का अध्ययन, प्रयोग किये जा रहे पोषाधार के सत से ही एन्जाईम को निकाल कर किये गये। यह ज्ञात हुआ कि प्रति यूनिट पोषाधार में इन एन्जाईम की क्रिया कवक जाल की वृद्धि होने पर बढ़ती है, कवक जाल फैलाव पूर्ण हो जाने पर एक दम घटती तथा पिनिंग, वृद्धि व परिपक्वता पर बहुत कम रहती है। फलनकाय विकास की विभिन्न अवस्थाओं के दौरान सार्थक एन्जाइम सक्रियता नहीं पायी गई।

फसल संरक्षण

खुम्ब इकाईयों के सर्वेक्षणों से ज्ञात होता है कि गीला बुलबुला, ब्राउन प्लास्टर मोल्ड, ग्रीन मोल्ड, लिपस्टिक मोल्ड, *कीटोमियम* स्पी० एवं इंक कैप का प्रकोप चम्बाघाट, वाकनाघाट तथा सोलन के समीपवर्ती इलाकों में पाया गया। इन इकाईयों में सियारिड व फोरिड मक्खियां, माईटस एवं स्प्रिंगटेल कीड़े-मकोड़े प्रमुखतः पाये गये। एकत्र किये गये अधिकतर नमूनों में सूत्रकृमियों की उपस्थिति पायी गयी।

मिजोफीलिक माइकोफ्लोरा पृथकीकरण अध्ययनों से ज्ञात होता है कि मुर्गी फार्म खाद में अधिकतम मिजोफीलिक माइकोफ्लोरा मिले, उसके बाद स्पेन्ट कम्पोस्ट में इनकी संख्या अधिक पायी गई। पृथक किये गये माइकोफ्लोरा में *ट्राइकोडर्मा* स्पी०, *एस्पर्जीलस* स्पी० व *पेनीसीलियम* स्पी० प्रमुख थे। *सी० डेन्ड्राइड* पर शरीर क्रिया विज्ञान संबंधी अध्ययन किये गये। विभिन्न स्रोतों से प्राप्त पानी व कवकनाशियों का मूल्यांकन *सी० डेन्ड्राइड* के बीजाणु अंकुरण हेतु करने पर पाया गया कि नलकूप से प्राप्त पानी,

आसवित पानी व चश्में का पानी बीजाणु अंकुरण में अधिकतम (100 प्रतिशत) सहयोग देता है, उसके बाद उबले हुए पानी में अंकुरण अधिक (70 प्रतिशत) मिला। बॉविस्टीन व स्पोरगॉन व डाईथेन जेड-78 के 0.001 प्रतिशत सांद्रता के घोल पर बीजाणु अंकुरण नहीं हो सका। बॉविस्टीन व स्पोरगॉन के 1.0 व 0.1 प्रतिशत सांद्रता पर कवक जाल की वृद्धि शत-प्रतिशत अवरूद्ध हो गई।

पादप सत की श्रेणी में कवकजाल की अधिकतम में अवरूद्धता *केनाविस सटाईवा* (32.02 प्रतिशत) व इससे कम (27.34 प्रतिशत) *टेगेरस एरेक्टा* के सत में पायी गई। सियरिड सूंडी के विरूद्ध बी०टी०आई० की क्षमता का मूल्यांकन करने हेतु केसिंग मिट्टी, स्पेंट कम्पोस्ट, मृत सियरिड सूंडी, मुर्गी फार्म की खाद व खेत की मिट्टी से 18 संवर्धन तैयार किये गये। प्रत्येक संवर्धन (आईसोलेट) को रैपिड टेस्टिंग विधि द्वारा सियरिड सूंडी के प्रति जांच की गई। संवर्धन बी०टी०आई०-132, 24 घण्टों में शत-प्रतिशत सूंडियों को मारने में कामयाब रहा।

खुम्ब में अवशेष (रेजिडयू) मात्रा को जानने के लिये विभिन्न सांद्रता के खुम्ब में मैलाथियॉन की चार साप्ताहिक छिड़काव पास्चुरीकृत कम्पोस्ट पर पैदा की गई *ए० बाईसपोरस* की एस०-11 प्रजाति पर किये गये और पाया कि जब 0.01 प्रतिशत सांद्रता के चार छिड़काव फसल की विभिन्न वृद्धि अवस्थाओं में किये गये तो मैलाथियॉन की अवशोषित (रेजीडयूल) मात्रा 0.003-0.172 पी०पी०एम०, 0.142-0.309 पी०पी०एम० व 0.0149-0.189 पी०पी०एम० क्रमशः प्रथम, द्वितीय व तृतीय फलनचक्रों में पायी गई।

आणुविक चरित्र-चित्रण से ज्ञात हुआ कि *क्लेडोबोट्रियम वेरियल* के सभी 8 संवर्धन (सी०डी०-17 को छोड़कर) ने 90 प्रतिशत से अधिक समानता प्रदर्शित की। जबकि *एक्रेमोनियम अल्टेरनेटम* के दोनो संवर्धन (एम०जी०-4 व एम०जी०-9) व *कीटोमियम ग्लोबोसम* (सी०एम०-1 व सी०एच०-2) की आर०ए०पी०डी० प्रोफाईल में एकरूपता थी। *सैपिडोनियम कैल्सीपोरी* के चार संवर्धनों में अधिकतम विभिन्नता पाई गई।

फ्यूजेरियम क्लेमाईडोस्पोरम व *मॉर्टियरियेला एल्पाईना* जो क्रमशः फ्यूजेरियल रॉट व तना धसन रोग पैदा करते हैं, को भारत में श्वेत बटन खुम्ब के नये रोगकारक के रूप में पहचाने गये। यह दोनों प्रजातियां संसार में नई पहचान है।

क्लेडोबोट्रियम, माईकोगोन, फ्यूजेरियम क्लेमाईडोस्पोरम व *मॉर्टियरियेला एल्पाईना* के विभिन्न संवर्धकों द्वारा उत्पन्न किये गये एन्जाइम के अध्ययन से पता चला कि *प्लूरोटस साजोर-काजू* से प्राप्त *क्लेडोबोट्रियम* के सी०-11 संवर्धन व *एम० पर्निसियोसा* के एम०जी०-1 संवर्धन ने काईटीनेज व पेक्निनेज एन्जाइम की सक्रियता सबसे अधिक पाई गई। *मार्टियरियेला एल्पाईना* व *फ्यूजेरियम क्लेमाईडोस्पोरम* में एक्जो, एन्डो ग्लूकानेज व बीटा-ग्लूकोसाइडेज की सक्रियता अच्छी खासी थी।

क्लेडोबोट्रियम के विभिन्न संवर्धन की वजह से श्वेत बटन, ढिंगरी व मिल्की मशरूम की पैदावार में नुकसान पर किये गये अध्ययन से ज्ञात होता है कि *प्लूरोटस साजोर-काजू* की उपज में *क्लेडोबोट्रियम* के विभिन्न संवर्धनों की वजह से 22-50 प्रतिशत की कमी आई।

सी-11 बहुत ही नुकसान दायक संवर्धन साबित हुआ जिससे उत्पादन में 50 प्रतिशत की कमी पायी गई। दूधिया मशरूम में विभिन्न संवर्धनों द्वारा 11.22 प्रतिशत उत्पादन में कमी हुई, सी-11 द्वारा उत्पादन में 22.22 प्रतिशत की कमी का होना पाया गया। श्वेत बटन मशरूम में विभिन्न संवर्धनों द्वारा उत्पादन में 10.11 से 28.57 प्रतिशत तक कमी पाई गई, सी-15 द्वारा अधिकतम 28.57 प्रतिशत नुकसान हुआ। सी-11 आईसोलेट (संवर्धन), जिसने प्लूरोटस

व दूधिया मशरूम में अधिकतम नुकसान पहुंचाया, में एण्डोग्लूकानेज, एक्जोग्लूकानेज, वीटा ग्लूकोसाइडेज व जाईलेनेज की सक्रियता सी-15 की तुलना में अधिक पाई गई। जबकि सी-15 आईसोलेट में पेक्टिनेज व काईटीनेज की सक्रियता सी-11 की तुलना में अधिक पाई गई।

फसल पोषण एवं उपयोग

श्वेत बटन खुम्ब की पैकेजिंग हेतु रूपांतरित वातावरणीय पैकेजिंग (एम०ए०पी०) तकनीकी को अपनाते हुए पैट जार में प्रयोग किये गये। डिफ्यूजन चैनल तरीका सबसे अच्छा पाया गया, जिसमें श्वेत बटन मशरूम की भण्डारण अवधि वातावरण के सामान्य तापमान (18 ± 1^0 सेल्सियस) पर 8 दिन पायी गई। भण्डारण के लिये प्रयोग किये गये जार में 3 मि०मी० व्यास व 15 से०मी० लम्बा डिफ्यूजन चैनल (प्रसारण नलिका) उपयुक्त है।

देशी मशीनों का विकास

केन्द्र ने स्वयं पांच टन क्षमता का एक कम्पोस्ट टर्नर तैयार किया है जो कम्पोस्ट को पांच टन/घंटा की रफ्तार से एक ही समान रूप से पलटता है। इसी प्रकार कम्पोस्ट कनवेयर मशीन तैयार की गई है जो कम्पोस्ट को पास्चुरीकृत कक्ष में पहुंचाने/भरने में कार्य करती है। इससे समय व मजदूर दोनों की बचत होती है।

प्रसार एवं तकनीकी हस्तांतरण

बटन खुम्ब हेतु वर्मी कम्पोस्ट को कम्पोस्ट के स्थान पर उपयोग करने संबंधी प्रयोग किये गये। पिछले वर्ष के तरीके में थोड़ा बदलाव किया गया, एक फुट ऊंचा बैग भरने की बजाय वर्मी कम्पोस्ट को उथली प्लास्टिक ट्रे में 5 इंच तक भरा गया। दोनों वर्षों के प्रयोगों से यह निष्कर्ष निकाला गया कि वर्मीकम्पोस्ट श्वेत बटन खुम्ब उत्पादन हेतु उपयुक्त माध्यम नहीं है।

देशी तकनीकी - खाद के आवरण के रूप में जली हुई धान की भूसी को गोबर व मिट्टी के साथ विभिन्न अनुपातों में मिलाकर मशरूम उत्पादकों द्वारा प्रयोग में लाई जा रही है। इस देशी तकनीकी को परखने व सुधारने हेतु प्रयोग किये गये। कवक जाल युक्त कम्पोस्ट पर जली हुई धान की भूसी से तैयार केसिंग आवरणों को बिछाया गया तथा उपयुक्त दशाएं बनाई रखी गईं। क्वायर-पिथ+गोबर की खाद+जली हुई धान की भूसी (2:1:2 v/v) से प्राप्त पैदावार नियंत्रित केसिंग आवरण से मिली उपज के नजदीक पाई गई।

वर्ष के दौरान केन्द्र ने मशरूम उत्पादकों, महिलाओं व आदिवासियों के लिये 14 अंतः परिसरीय व बाह्य परिसरीय मशरूम उत्पादन प्रशिक्षण कार्यक्रम आयोजित किये। केन्द्रीय परियोजना 'समेकित बागवानी विकास' के अंर्तगत उत्तर-पूर्वी राज्यों में मशरूम उत्पादन बढ़ाने के लिये बाह्य परिसर प्रशिक्षण कार्यक्रम आयोजित किये गये। सभी प्रशिक्षण कार्यक्रमों में कुल 523 किसानों, कृषक महिलाओं, खुम्ब उत्पादकों व अधिकारियों को प्रशिक्षित किया गया।

प्रत्येक वर्ष की भांति, इस वर्ष भी मशरूम मेला-2006 का आयोजन 10 सितम्बर, 2006 को किया गया जिसमें हिमाचल प्रदेश, हरियाणा, पंजाब, उत्तर प्रदेश, महाराष्ट्र, राजस्थान, दिल्ली, उड़ीसा, जम्मू एवं कश्मीर राज्यों से लगभग 500 किसानों, स्वयं सहायता समूहों, महिलाओं, खुम्ब उत्पादकों, प्रसार कार्यकताओं ने भाग लिया। इस मौके पर एक प्रदर्शनी का भी आयोजन किया गया जिसमें विभिन्न संस्थाओं ने मशरूम व उससे संबंधित विषयों पर अपनी-अपनी तकनीकियों का प्रदर्शन किया। मेले में मशरूम उत्पादकों की समस्याओं के समाधान हेतु, एक किसान गोष्ठी का आयोजन किया गया। मशरूम मेले के समापन समारोह के दौरान केन्द्र ने हरियाणा राज्य से आये दो प्रगतिशील मशरूम उत्पादकों - श्री सुनील कुमार, निवासी अहीर माजरा,

सोनीपत व श्री जोगिन्दर सिंह, निवासी साहरमल पुर, पानीपत को पुरस्कार देकर सम्मानित किया।

मशरूम के बारे में जागरूकता फैलाने के उद्देश्य से केन्द्र ने राष्ट्रीय स्तर की प्रदर्शनी - आई०आई०टी०एफ०, 14-27 नवम्बर, 2006 में अपने केन्द्र की प्रदर्शनी लगाई।

खुम्ब सूचना प्रौद्योगिकी

भारत के विभिन्न राज्यों से मशरूम उत्पादन के बारे में सूचनाएं एकत्र की गईं तथा वर्ष 2006-07 के अनुमानित आंकड़े प्रस्तुत किये गये। श्वेत बटन मशरूम का उत्पादन सबसे अधिक पंजाब राज्य में रहा, इसके बाद तमिलनाडू, महाराष्ट्र, हिमाचल प्रदेश आदि का स्थान है। श्वेत बटन मशरूम पहले की तरह पूर भारतवर्ष में लोकप्रिय साबित हुआ है। ढिंगरी व दूधिया मशरूम को तेजी से उभरते हुए पाया गया। हिमाचल प्रदेश में सबसे अधिक संख्या (450) में मशरूम उत्पादक पाये गये जिसमें अधिकतर सरकारी व प्राईवेट संस्थाओं से कम्पोस्ट खरीदकर मौसमी मशरूम उत्पादन करते हैं।

शिक्षा प्रशिक्षण

इस वर्ष केन्द्र ने मानव संसाधन विकास के क्षेत्र में महत्वपूर्ण प्रगति की है। डा० ओ०पी० अहलावत, वरिष्ठ वैज्ञानिक (बॉयोटेक्नोलॉजी) ने 'नेशनल वर्कशॉप ऑन जेनेटिक इंजीनियरिंग' 24 जून से 7 जुलाई, 2007 में भाग लिया। ई-जी० टी० अरूमुगानाथन, वैज्ञानिक ने सी०आई०ए०ई०, भोपाल द्वारा आयोजित 21 दिवसीय शरदकालीन पाठशाला 'एक्ट्रोजन कुकिंग टेक्नोलॉजी एण्ड इट्स एप्लीकेशन फॉर प्रोसेसिंग सोयाबीन, 1-21 नवम्बर, 2006 में भाग लिया। उन्होंने सेन्टर फॉर एक्सीलेन्स ऑन बायोफ्यूल्स, एग्रीकल्चर इंजीनियरिंग कॉलेज एण्ड रिसर्च इन्सटीच्यूट, तमिलनाडू कृषि विश्वविद्यालय, कोयम्बटूर तथा भारतीय कृषि अनुसंधान परिषद, नई दिल्ली द्वारा दिनांक 5 से 7 मार्च, 2007 तक आयोजित 'बॉयोडीजल - क्राप कल्टीवेशन टेक्नीक्स एण्ड प्रोसेसिंग में भी भाग लिया।

डा० एम०पी० सागर, वरिष्ठ वैज्ञानिक (कृषि विस्तार) को 'सोसाइटी ऑफ एक्सटेंशन एजूकेशन', आगरा द्वारा जवाहर लाल नेहरू कृषि विश्वविद्यालय, जबलपुर (म०प्र०) में दिनांक 9 से 11 मार्च, 2007 तक आयोजित किये गये चतुर्थ विस्तार शिक्षा सम्मेलन के दौरान 'युवा वैज्ञानिक पुरस्कार - 2007 से सम्मानित किया गया।

प्रकाशन

इस वर्ष केन्द्र के वैज्ञानिकों द्वारा राष्ट्रीय व अंतराष्ट्रीय पत्रिकाओं में 19 शोध पत्र, दो पुस्तकें, 2 तकनीकी बुलेटिन, 7 लोकप्रिय/तकनीकी लेख व 45 शोध सारांश का प्रकाशन किया।

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 2006-2007 are summarized under the heads; Crop Improvement, Crop Production, Crop Protection, Crop Nutrition and Utilization, Transfer of Technology, Mushroom Information Technology, Education and Training and Publications

CROP IMPROVEMENT

(a) Germplasm Collection: During the year 315 specimens were collected from the forest areas of Himachal Pradesh, Haryana and Chandigarh. The major genera collected were *Agaricus, Agrocybe, Amanita, Armillaria, Boletus, Camerophyllus, Chlorophyllum, Clitocybe, Collybia, Cortinarius, Crepidotus, Descolea , Entoloma, Galerina, Gomphidius, Gymnopilus, Hebeloma Hygrophorus, Inocybe, Laccaria, Lactarius, Leccinum, Lentinus, Lepiota, Lepista, Leucocoprinus, Leucopaxillus, Limacella, Lyophyllum, Melanoleuca, Macrolepiota, Marasmius, Mycena, Nematoloma, Oudmansiella, Paneolus, Panus, Panellus, Paxillus, Pholiota, Pleuroflammula, Pleurotus, Pluteus, Polyporus, Psathyrella, Psilocybe, Russula, Strobilomyces, Stropharia, Suillus, Tricholoma* and *Volvariella.*

(b) Taxonomy of wild mushrooms: In addition to agaricoid, specimens of several Gasteromycetes, Aphyllophorales and Ascomycete fleshy fungi were collected. Some of the interesting genera collected for the first time were *Cordyceps* and *Coremia*. Wild relatives of commercial cultivated mushrooms genera such as *Pleurotus, Stropharia, Volvariella, Lentinula, Hericium, Auricularia* etc. have been obtained, which has great potential in breeding programmes for strain improvement of these important mushrooms.

(c) Germplasm Characterization:. The genomic DNAs were extracted from 41 strains of *Agaricus* species using modified CTAB method. Molecular variation and genetic identities were studied among 22 white pileus cultivars of *Agaricus bisporus* using random amplified polymorphic DNA markers and by sequence analysis of 5.8S rRNA gene alongwith ITS regions. Twenty-four primers amplified 175 RAPD scorable loci, of which 53.7% were polymorphic. Genetic similarity index varied from 0.64 to 0.99 with the average of 0.81. The varieties exhibited 92.7% genetic similarity, while the hybrids showed 84.3% similarity amongst them. This study demonstrates that the RAPD markers are useful and robust tools for the identification of hybrids in the germ plasm and for detection of intraspecific molecular variation in the white button mushroom cultivars.

(d) Genetic Improvement: Studies for the genetic improvement of temperate and tropical mushrooms were conducted in *Agaricus, Pleurotus, Volvariella* and *Lentinula*. Single spore selection SSI-8109, hybrid-2 and commercial strain P-5 of *A. bisporus* produced significantly higher mushroom yield with better quality fruit bodies. Three single spore selections (CM-3, CM-7 and CM-9) and one hybrid (CM-

11) were recommended for commercial cultivation. In case of paddy straw mushroom 26 strains were grown on malt extract agar medium. The strains varied in their growth characteristics viz., radial mycelial growth, aerial hyphae and chlamydospores. Most of the strains showed characteristics of a typical *V. volvacea* strain, except 4 strains (OE-49, OE-91, OE-146 and OE-224) which showed quite a typical characteristics. The enzymes activities varied in different strains . The highest exoglucanase activity was recorded in strain OE-143 (1.38U), followed by OE-214, OE-139 and OE-215. The highest endoglucanase activity of 1.57U was recorded in strain OE-143, followed by OE-145 (1.49U) and OE-210 (1.24U). The highest β-glucosidase activity of 2.59U was recorded in strain OE-145, followed by 2.55U in OE-117, 2.50U in OE-210. Xylanase activity was the highest in strain OE-215 and was followed by strains, OE-272, OE-213, OE-209, OE-117 and OE-214. The highest activity of laccase (3.33U) was recorded in strain OE-143, followed by strains, OE-29, OE-145, OE-210 and OE-272. The polyphenol oxidase activity was the highest (6.50U) in strain OE-210 and was followed by strains, OE-272, OE-139, OE-145 and OE-214. In case of *Lentinula* thirty-two single spore isolations were made from 6 new shiitake germ plasm strains MN-1, MN-2, OE-329, MPT-1, MPT-2 and MPT-3. Crosses were made in two groups. Group 1 included SSI's of MN-1 and MN-2 and Group-2 included SSI's of OE-329, MPT-1, MPT-2 and MPT-3. Dual cultures of SSI's from different strains were raised in Petri plates on malt extract-glucose-agar culture medium and incubated at 24° C for fifteen days. In Group-1, 15 hybrids and in Group-2, 22 hybrids were developed. Two trials of five elite strains of OE series were conducted for yield performance and comparative biological efficiencies. Thirteen inter-strainal hybrids developed from the five elite strains of OE series were tested for their yield and biological efficiencies. In case of *Pleurotus florida* six strains developed by mating of compatible single spore hybridization and evaluated during winter months (Dec-Feb) on pasteurized wheat straw. The highest yield was recorded in strain H-25 (81% B.E.) followed by H-18, H-35 and H-4 strains. In case of *Pleurotus sajor caju* nine high yielding strains evolved by mating of compatible single spores and evaluated for 3rd time on pasteurized wheat straw. Five strains gave more then 22 to 30 per cent higher yield then the parent strain. The highest yield was recorded in Strain H-9 (63% B.E.)

CROP PRODUCTION

(a) Button mushroom, *A. bisporus*

(i) Indoor composting

Cultivation trials were conducted with wheat straw as the base material. Compost was prepared by wetting and mixing of ingredients on -2 day. -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. The resultant compost gave an average yield of 15 Kg/ 100 Kg compost.

In order to study the thermophilic fungal flora associated with compost more than 50 compost samples fermented at various stages of preparation were collected from Haryana, Punjab, UP and HP. A large numbers of thermophilic fungi including *Mucor pusillus*, *Cunninghamella* sp., *Aspergillus fumigatus*, *Aspergillus* sp., *Scytalidium thermophilum*, *Humicola insolens*, *Humicola grisea*, *Chaetomium thermophile*, *Thermomyces lanuginosus*, *Humicola fuscoatra*, *Gilmaniella humicola*, and few mycelia steriala were isolated.

While evaluating different compost formulations for *A. bisporus* cultivation, six different piles were prepared using wheat straw based formulations. The highest compost was produced in the treatment T-5 where cotton seed meal was used in compost production. When compost was prepared by Indoor method in 7 days through completely by passing Phase-I condition with the help of thermophilic fungi, the highest fruit body weight (10 g) was obtained in S-2 treatment of *H.insolens*. The highest yield of 12.9 Kg/100 Kg compost was obtained with S-5 strain of *H. insolens*. Among the *S. thermophilum* and *H.grisea* strains, strain S-7 and S-4, respectively, gave the higher yields. Control set with mixed inoculum of fungal strains also performed well and gave 9.6 Kg mushroom / 100 Kg compost.

(ii) Organic farming: The compost and casing were steam pasteurized and no chemicals added at any stage of its preparation, except gypsum (calcium sulphate) which is basically used for flocculating / coagulating the colloides in the compost and to provide favourable pH. Average mushroom yield of 18-20 kg was harvested in 6 week of cropping from 100 kg compost, with bulk of crop yield obtained in first 3 weeks of cropping.

(b) *Pleurotus* cultivation: For the cultivation of *Pleurotus fossulatus* dried poplar leaves were mixed with wheat straw in different ratios (1:1, 2:1, 3:1) and poplar leaves alone and supplemented with 5 % cotton seed cake and autoclaved for 60 minutes. From different treatments 280 to 350 g fresh mushrooms were harvested in 45 days.

(c) Cultivation of speciality mushrooms:

Macrolepoita procera was cultivated successfully on compost prepared by short method of composting. The spawn run completed in 30 days at 27°C. The primordia initiated after 18-20 days after the application of casing layer. The fruit bodies were 16-30 cm long with average weight of 30 g.

Supplementation of the saw dust with wheat bran resulted in reduction in spawn run period of *Agrocybe aegerita*. The maximum duration of 42 days was required to complete the spawn run on unsupplemented saw dust and 10 per cent supplementation resulted in quicker (39 days) spawn run . Average number of fruit bodies varied from 129 to 136. Mean highest (446 g) yield was recorded in saw dust supplemented with 10 per cent wheat bran. The average number of fruit bodies harvested in unsupplemented and in 10 per cent supplemented wheat straw was 80 and 84, respectively.

Addition of wheat bran in saw dust enhanced the activity of cellulases, hemicellulases and peroxidases, whereas cotton seed cake, soybean meal and deoiled soybean resulted in reduced activity of these enzymes. Wheat bran at the rate of 10 per cent

supported the fastest linear growth (69 mm) of *F. velutipes* followed by 10 per cent soyabean meal (62.7mm) of the same supplement. Addition of 10 per cent wheat bran in saw dust resulted in quickest spawn run and with the highest biological efficiency (44%).

Addition of 40 per cent wheat bran in saw dust resulted in the highest (80%) biological efficiency of *Lentinula edodes*. Supplementation at the lower rates with the same supplement resulted in decreased yield.

(d) Cultivation of medicinal mushrooms:

An experiment was laid to study the effect of size of bags with 500 g, 750 g, 1000 g, 1200 g, and 1500 g of dry weight moistened to 65% level uniformly and filled in polybag of appropriate sizes, on yield and quality of the Reishi mushroom. There was no significant difference in the yield (B.E.) from 500 to 1200 g dry substrate per bag. Bigger but lesser fruit bodies were obtained in the heavier bags. Production of the extracellular lignolytic enzyme, namely ligninase and Mn^{++} peroxidase by *G. lucidum* during various stages of the crop cycle were studied by extracting the enzyme from the substrate in the growing bag in the citrate buffer. It was found that the activity for unit weight of the substrate increase with the mycelial colonization, declined abruptly after full colonization and remained very low during the pinning, growth and maturation.

CROP PROTECTION

Survey of different farms revealed widespread incidence of wet bubble, brown plaster mould, green moulds, lipstick mould, *Chaetomium* spp, ink caps at Chambaghat, Vaknagghat, and adjoining areas of Solan. Scirids, phorids, mites and springtails were common in most of the farms visited. Compost samples collected/ received showed the presence of nematodes in most of the samples. Studies on isolation of the mesophilic mycoflora revealed that Chicken manure harboured the maximum number of mesophilic mycoflora followed by spent compost. The maximum number of fungal colonies ($10.8X10^3$) were recorded in chicken manure samples. The predominant mycoflora isolated were *Trichoderma* spp., *Aspergillus* spp. and *Penicillium* spp. Evaluation of water from different sources and fungicides for the spore germination of *C. dendroides* revealed that bore well water, distilled water and spring water supported the maximum spore germination(100%) followed by boiled water (70%). Spores failed to germinate up to 0.001% concentration of bavistin, sporgon and diathane Z-78. Bavistin and sporgon at 1.0 and 0.1% concentration caused 100% inhibition of mycelial growth. Among the different plant extracts the maximum inhibition in mycelial growth was recorded in *Cannabis sativa* (32.02%) followed by *Tagetus erecta* (27.34%). In order to assess the efficacy of Bti against sciarid larvae, 18 isolates were isolated from casing soil, spent compost, dead sciarid larvae, chicken manure and field soil. Each isolate was tested against sciarid larvae. Isolate Bti 132 caused 100% mortality of larvae within 24 hours.

Persistence of malathion sprays (1-4) at four different concentrations (0.01, 0.05, 0.07, 0.1%) given at weekly intervals were estimated in *A. bisporus* strain S-11 grown on steam pasteurized compost. It was observed that when four sprays of 0.01% concentration were given during different growth stages of crop, residue of malathion ranged from 0.003 ppm –0.172 ppm, 0.142 ppm – 0.309 ppm and 0.0149 ppm – 0.189 ppm in first, second and third flushes , respectively.

Molecular characterization revealed that all the eight isolates of *Cladobotryum varium*, except CD-17 isolate, exhibited more than 90% similarity, whereas both the isolates of *Acremonium alternatum* viz. MG-4 and MG-9 and *Chaetomium globosum* viz. CH-1 and CH-2 had identical RAPD profiles. The maximum variation within four isolates of *Sepedonium chalcipori* was observed.

Fusarium chlamydosporum and *Mortierella alpina* causing fusarial rot and shaggy stipes, respectively, were recorded to be the new pathogen of white button mushroom in India and species of both the pathogens as new record in the world.

Studies on enzyme production by different isolates of *Cladobotryum*, *Mycogone perniciosa*, *Fusarium chlamydosporum* and *Mortirella alpina* revealed that C-11 isolate of *Cladobotryum* isolated from *Pleurotus sajor-caju* and Mg-1 isolate of *M. perniciosa* showed greater activity of chitinase and pectinase. Both *Mortierella alpina* and *Fusarium chlamydosporum* showed good activity of exo, endo glucanase and β-glucosidases.

Studies on yield loss due to different isolates of *Cladobotryum* in button, oyster and milky mushrooms revealed that various isolates of *Cladobotryum* resulted in 22-50 per cent loss in yield in *Pleurotus sajor-caju*. C-11 isolate proved to be the most harmful resulting in 50 per cent reduction in yield. Similarly in *Calocybe indica* different isolates resulted in 11-22 per cent loss in yield. C-11 resulted in 22 per cent reduction in yield. In case of *Agaricus bisporus* the loss percentage varies from 10 to 28.5, C-15 resulting in the maximum (28.6%) yield loss. It is interesting to note that C-11 isolate which resulted in maximum yield loss in *Pleurotus* and *Calocybe* showed greater activity of Endo-glucanase, Exo-glucanase, β-glucosidase and Xylanases as compared to C-15 isolate which resulted in the maximum yield loss in *A. bisporus*. C-15 isolate was found to having more activity of Pectinase and Chitinase as compared to C-11 isolate.

CROP NUTRITION AND UTILIZATION

Experiments were conducted on the modified atmospheric packaging (MAP) of button mushroom in PET jars. Diffusion channel method was found to be the best method of storage to prolong the shelf life of button mushrooms up to 8 days in ambient storage (18±1^{o}C). Storage containers provided with 3 mm diameter and 15 cm length diffusion channel were found to be highly suitable.

DEVELOPMENT OF INDIGENOUS MACHINERY

A compost turner of 5 tonnes/hr capacity was designed and fabricated. It consisted of MS angle 1 ½" and MS channel 3" frame having dimensions 5' 4" wide, 14' long and 5' 4" high. It comprises of one compost lifting drum of 2' diameter having 2" protrusions of MS angle and a conveyor of 5' length 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.

A compost conveyor is designed to carry compost to the bunker saving the labour and time. The conveyor is of 18' length and 2' width and is carried on four wheels of 8" dia out of which two front wheels are caster wheels to facilitate easy turning.

TRANSFER OF TECHNOLOGY

In order to verify vermicompost as medium for button mushroom cultivation,

vermicompost prepared from FYM was spawned with spawn of button mushroom after treating it with malathion. Shallow plastic trays were used instead of plastic bags and spawned vermicompost was filled upto 5 inches height in the tray and covered with polythene sheet. The results indicated that vermicompost is unsuitable for mushroom growing. To verify and refine ITK about use of burnt rice husk mixed with F.Y.M. and soil in different ratios as casing material in button mushroom by mushroom growers, second experimental trial was laid out at the Centre. The burnt rice husk based different casing formulations namely burnt rice husk + soil (1:1v/v), burnt rice husk + soil + FYM (1:1:1v/v), burnt rice husk + FYM (2:1v/v), burnt rice husk + FYM (1:2 v/v), burnt rice husk + FYM (1:1 v/v), coir pith + FYM + burnt rice husk (2:1:2 v/v) were applied on spawn run compost. The treatment having combination of coir pith + FYM+ burnt rice husk (2:1:2 v/v) was found much closer to control treatment.

During the year under report, the Centre has organised a total number of 14 On & Off-campus training programmes. One day Mushroom Mela was organized on 10th September, 2006. It was attended by about 500 farmers, farm women, mushroom growers, researchers, extension workers and businessmen from various States. An exhibition on improved mushroom cultivation technologies and other related aspect was organised. Kisan Goshthi was held to answer the problems in mushroom cultivation faced by mushroom growers. The problems raised by farmers and mushroom growers were replied by experts. During the Mushroom Mela, the Centre awarded two progressive mushroom growers Sh. Sunil Kumar, R/O village Ahir majra, Sonepat (Haryana) and Sh. Joginder Singh R/O village Saharmal pur, Panipat (Haryana) for adopting innovative practices in mushroom cultivation on larger scale and mobilizing other farmers to adopt mushroom cultivation as source of income.

In order to create awareness about mushroom cultivation, the Centre participated in the National & State level exhibitions in India. NRCM paricipated in international level exhibition-IITF-2006 organized by ITPO at Pragati Maidan, New Delhi From 14-27th Nov., 2006.

One multicoloured folder on recycling of SMS to use as organic manure was printed for distribution at various occasions.The training compendium for farmers (in hindi) has been compiled and edited.

MUSHROOM INFORMATION TECHNOLOGY

Information on mushroom production has been collected for India and figures for the year 2006-07 has been projected. Punjab led the production with Agro-Dutch alone accounted for 45,000 tonnes of white button mushroom. It is followed by Tamil Nadu, Maharashtra, Himachal Pradesh. White button mushroom remains the most popular mushroom in India. *Pleurotus* and *Calocybe* are fast catching up. As regards the number of growers, Himachal Pradesh has the maximum number of mushroom growers (450). A majority of them are seasonal growers who purchase compost from government agencies or private suppliers.

EDUCATION AND TRAINING

The Centre has made significant progress in Human Resource Development. Dr. O.P. Ahlawat attended 14 days training on "National Workshop on Genetic Engineering" from 24th June to 7th July, 2006 at Department

of Biotechnology, Punjab University, Chandigarh. T. Arumuganathan attended 21 days Winter School on "Extrusion Cooking Technology and Its Application for Processing Soybean" organized by the Central Institute of Agricultural Engineering, Bhopal during 1st November to 21st November, 2006 at CIAE, Bhopal. Er. Nathan also attended 3 days Scientists Training on "Bio diesel - Crop cultivation Techniques and Processing" organized by Agricultural Engineering College & Research Institute (Centre of Excellence in Bio fuels), Tamil Nadu Agricultural University and Indian Council of Agricultural Research held at TNAU, Coimbatore on 5th – 7th March, 2007.

PUBLICATIONS

During the year, the scientists of the Centre have published 19 research papers in referreed national and international journals, 2 books, 2 technical bulletins and 7 popular / technical articles and contributed 45 abstracts to different scientific forums.

INTRODUCTION

India is primarily an agriculture based country with about 1100 million human population and about 500 million live stock; 75 per cent human population lives in about 6,00,000 villages and mainly engaged in agricultural and allied activities. Recently a lot of emphasis is given to the development of agro based industries due to advantages of rural employment generation and gainful utilization of natural and farm resources. Large quantities of lignocellulosic residues are generated every year as a result of extensive agricultural practices the disposal of which creates a lot of problems. Mushroom cultivation is one of the largest economically viable commercial operations for bioconversion of lignocellulosic waste into highly acceptable food. Cultivating mushrooms is an ideal income generating activity for landless labourers, unemployed youth and weaker sections of the society in our country. Mushroom is also a perfect health food recommended for use to enrich diet with vegetable protein, vitamins, minerals and fibres.

India is blessed with variety of vegetation and climate which is the most suitable for growing different mushrooms throughout the year. Mushroom industry in India is developing very fast. During the last 10-15 years there has been perceptible change in the scenario, particularly in production system, horizontal spread and vertical growth in productivity, with the present production level more than 1,00,000 tones per annum of all types of mushrooms.

Cultivation of mushrooms for food is undoubtedly an important activity and the way in which mushrooms are cultivated greatly enhance their importance, especially conversion of waste into highly nutritious food vis-a-vis alleviation of environmental pollution and use of vertical space. The substrate released after taking mushroom crop is of great importance. The spent mushroom substrate has been found to be a good growing media for majority of the vegetables and the field crops and has shown multifaceted utilities in improving the crop yield, quality and management of the diseases which is really encouraging for the mushroom industry

National Research Centre for Mushroom is located in mushroom city of India (Solan). Its office and laboratory buildings are situated at Chambaghat, Solan (HP) 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) is operative 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 Repository has been enriched by addition of 315 mushroom cultures of which some are new records for India. Molecular variation and genetic identities were studied among 22 white pileus cultivars of *Agaricus bisporus* of which 53.7% were polymorphic genetic improvement studies on temperate and tropical mushrooms were conducted and some promising single spore isolates in *Agaricus bisporus* and *Volvariella volvacea* have been identified. In *Agaricus bisporus* single spore selection SSI-8109, hybrid-2 and commercial strain P-5 produced significantly higher mushroom yield with better quality fruit

bodies. Three single spore selections (CM-3, CM-7 and CM-9) and one hybrid (CM-11) were recommended for commercial release during 10th Biennial Workshop AICMIP from 26-27 October, 2006 at IGAU, Raipur. In *Pleurotus florida* six strains developed by mating of compatible single spore hybridization. The highest yield was recorded in strain H-25 (81% B.E.) followed by strain H-18. In case of *Lentinula,* thirty-two single spore isolations were made from 6 new shiitake germ plasm strains MN-1, MN-2, OE-329, MPT-1, MPT-2 and MPT-3. Crosses were made in two groups.

NRCM continued its efforts to prepare quality compost through indoor composting with the help of thermophilic fungi. NRCM developed the protocol for organic farming. Average mushroom yield of 18-20 kg was harvested in 6 week of cropping from 100 kg compost, with bulk of crop yield obtained in first 3 weeks of cropping. Moving ahead towards diversification, *Macrolepoita procera* was grown successfully in the Centre. Efforts were made to increase the yields of *Flammulina velutipes* by supplementing the cultivation substrates with 10 per cent wheat bran which resulted in early spawn run and significantly higher yields. Saw dust proved better substrate for the cultivation of *Agrocybe aegerita* giving 74.33 per cent biological efficiency when supplemented with 10 per cent wheat bran. Different quantities of substrate were evaluated for the yield of *Ganoderma lucidum*. There was no significant difference in the yield when bags filled with 500 to 1200g dry substrate were used. Studies conducted on the modified atmospheric packaging of button mushroom in PET jars revealed that diffusion channel method was the best to prolong the shelf life of button mushrooms up to 8 days in ambient temperatures. A compost turner of 5 tonnes/hr capacity was designed and fabricated. A compost conveyor is also designed to carry compost to the bunker. Molecular characterization of some isolates of *Cladobotryum* exhibited more than 90% similarity, whereas both the isolates of *Acremonium alternatum* and *Chaetomium globosum* had identical RAPD profiles. Four isolates of *Sepedonium chalcipori* showed the maximum variation. *Fusarium chlamydosporum* and *Mortierella alpina* causing Fusarial rot and Shaggy stipes, respectively, were recorded to be the new pathogens of white button mushroom in India and species of both the pathogens as new record in the world. Different isolates of *Cladobotryum* resulted in 11-22 , 22-50 and 11-22 per cent yield loss in button, oyster and milky mushrooms, respectively.

During the year the Centre 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 planned to develop mushroom cultivation in all the NE states. One day Mushroom Mela was organised on 10th September, 2006. It was attended by about 500 mushroom growers, farmers, farm women, researchers, extension workers and businessmen from various States of India. Two progressive mushroom growers Sh. Sunil Kumar and Sh. Joginder Singh both from Haryana were felicitated for adopting innovative practices in mushroom cultivation on larger scale and mobilizing other farmers to adopt mushroom cultivation as source of income. Mushroom production information has been collected for India and figures for the year 2006-07 has been projected. Punjab led the production with Agro-Dutch alone accounted for 45,000 tonnes of white button mushroom.

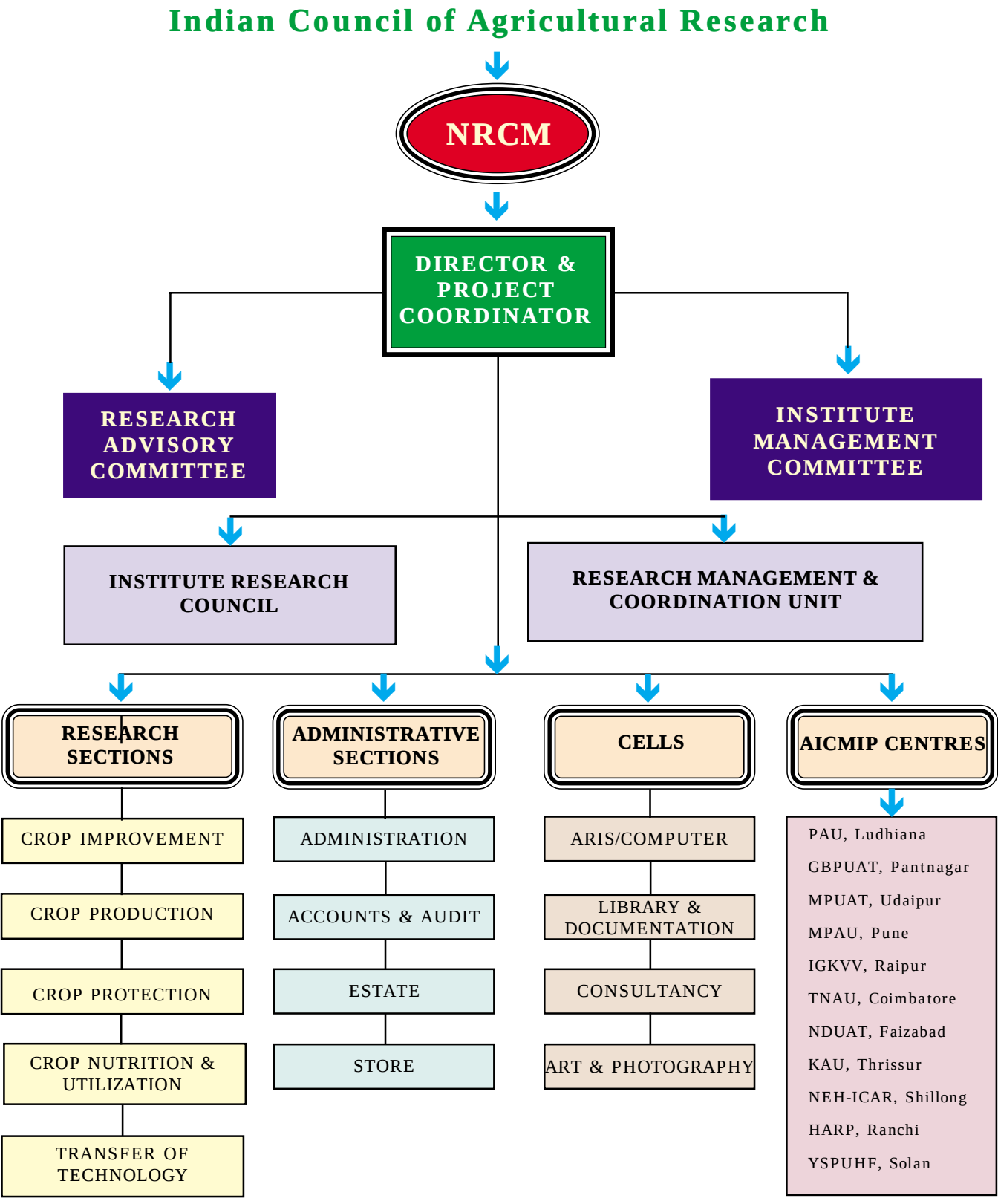
Dr. M.P. Sagar received Young Scientist Award- 2007 presented by the Society of Extension Education, situated at Advance Research & Management Centre of Rural Development, Agra (UP).

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 31.03.2007 was 13 scientists, 14 technical, 16 administrative and 9 supporting staff. The annual budget of the Centre for the year 2006-2007 was Rs.134.07 Lakh (Plan) and Rs. 188 Lakh (Non Plan), the expenditure was Rs 130.09 (Plan) and Rs.187.91 lakh (Non Plan). The Centre earned Rs.14.71 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 associated structures.
- Five well equipped laboratories with sophisticated equipments.
- Sale of pure stock cultures of all the commercial strains of edible mushrooms and quality seed.
- Excellent Library facilities with access to world literature on mushrooms through internet, periodicals on mushroom and related disciplines from all over the world, reference services and CD-ROM search service. It has presently number of accessions including 1289 books, 2500 back volumes of journals. It subscribes eight foreign journals and thirty-two Indian Journals.



Organizational structure of NRCM, ICAR, Solan

1. CROP IMPROVEMENT

1. Mushroom 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 Chail, Chalanda, Chambaghat, Cheog, Chaila, Khadha Pathar, Kufri, Mundaghat, Nankheri, Narkanda , Ratnari , Sadhupul, Sabathu, Tikkar, Shimla Reserve forest , Chamoli, Kumbhalgarh forest. Parts of the Uttaranchal and south Rajasthan were also visited for collection of wild mushrooms. In all 315 wild mushrooms were collected. All the specimens were examined and photographed under natural conditions. The ecology of each taxa was also studied where it was found growing. The list of agaricoid and other genera and their collections family wise are presented in Table-1.

Table 1: List of agaricoid and other specimens collected (familywise)

S. No.	Family	Genera (No. of species collected)
1	Agaricaeae	*Agaricus* (8), *Chlrophyllum* (1), *Lepiota* (5), *Macrolepiota* (3), *Leucocoprinus* (1)
2	Amaniataceae	*Amanita* (14), *Limacella* (1)
3	Bolbitiaceae	*Descolea* (3)
4	Boletaceae	*Boletus* (8), *Leccinum* (2), *Suillus* (1), *Strobilomyces* (3)
5	Coprinaceae	*Psathyrella* (3), *Paneolus* (2)
6	Cortinariaceae	*Cortinarius* (7), *Inocybe* (9), *Gymnopilus* (3), *Hebeloma* (3), *Galerina* (3);
7	Crepidotaceae	*Crepidotus* (1)
8	Entolomataceae	*Entoloma* (5);
9	Gomphidiaceae	*Gomphidius* (1);
10	Hygrophoraceae	*Hygrophorus* (8), *Camarophyllus* (2)
11	Paxillaceae	*Paxillus* (3
12	Pluteaceae	*Pluteus* (5), *Volvariella* (2);
13	Polyporaceae	Polypores (8), *Pleurotus* (4), *Lentinus* (3), *Panus* (1)
14	Russulaceae	*Lactarius* (3), *Russula* (1)
15	Strophariaceae	*Alnicola* (1), *Pleuroflammula* (2), *Naematoloma* (3), *Pholiota* (4), *Stropharia* (1)
16	Tricholomataceae	*Marasmius* (3), *Mycena* (9), *Oudemansiella* (2), *Tricholoma* (4), *Laccaria* (3), *Lyophyllum* (3), *Clitocybe* (4), *Lepista* (3), *Melanoleuca* (3), *Hohenbuehelia* (2), *Collybia* (5), *Armillaria* (2), *Leucopaxillus* (1)
17	Order Aphyllophorales and Gasteromycetales	*Auricularia* (3), *Hydnum* (3), *Ganoderma* (5), *Scleroderma* (6), *Lenzites* (2), *Leotia* (1), *Schizophyllum* (1), *Albatrellus* (1).
18	Ascomycete	*Morchella* sp. (2) *Cordyceps* spp (2)

Some of the genera like *Cordyceps* and *Coremia* were collected for the first time. During the survey wild relatives of commercial cultivated mushrooms genera such as *Pleurotus*, *Stropharia*, *Volvariella*, *Lentinus*, *Hericium*, *Auricularia* etc. have been obtained, which have great potential in breeding programmes for strain improvement of these important mushrooms.

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)

DNA Isolation: The genomic DNA was extracted from three weeks actively grown mycelium on potato-dextrose broth. The genomic DNAs were extracted from 41 strains of *Agaricus* species using modified CTAB method. These DNA samples were purified with RNase I. DNA quantification was done to assay its concentration and integrity by ethidium bromide fluorescence and DNA Florimeter. These samples are being used for studies on DNA fingerprinting, genotyping and diversity analysis.

Molecular analysis: Molecular variation and genetic identities were studied among 22 white pileus cultivars of *Agaricus bisporus* using random amplified polymorphic DNA markers and by sequence analysis of 5.8S rRNA gene alongwith ITS regions. Twenty-four primers amplified 175 RAPD markers, of which 53.7% were polymorphic. Genetic similarity index varied from 0.64 to 0.99 with average of 0.81. The varieties exhibited 92.7% genetic similarity, while the hybrids showed 84.3% similarity amongst them. Both the UPGMA dendrogram and PCO plot grouped all the varieties into a single cluster, while the hybrids formed the separate cluster exhibiting DNA polymorphism (Fig. 1). However, the NRCM hybrid NCH-102 and single spore selection from hybrid NCS-101 showed molecular variation from the varieties as well from the U-3 derivative hybrids. The white pileus Indian collection (WI-1) from Himachal Pradesh region was found to be clustered with commercial varieties, proving that it is not a real wild collection but a variety escaped from the cultivation into the nearby forest area and hence was collected during the survey.

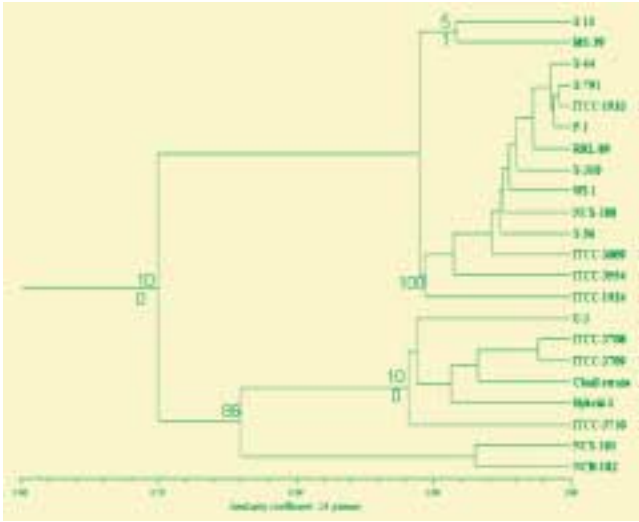


Fig. 1: UPGMA dendogram constructed from the RAPD profiles of 22 cultivars of *Agaricus*

The length of ITS1, 5.8S rRNA gene and ITS2 were 290, 154 and 208 bases, respectively in all the genotypes of *A. bisporus* studied. Two single nucleotide polymorphisms (SNPs) at 522 and 563 nucleotide positions in ITS2 region which distinguished different strains within the species were reported. This study demonstrates that the RAPD markers are useful and robust tools for the identification of hybrids in the germ plasm and for detection of intraspecific molecular variation in the white button mushroom cultivars. Present finding is the first report on the identification of SNPs in the ITS2 region of the 5.8S ribosomal RNA gene which could differentiate cultivars of *A. bisporus*.

2. Genetic Improvement

Project –NCM-37: Genetic manipulations for high yield and better quality in button mushroom (*Agaricus* species)(PI: Dr. Mahesh C. Yadav)

2.1 Breeding in *Agaricus bisporus*

2.1.1 Evaluation of heterokaryotic SSIs and hybrids

Out of 35 *A. bisporus* SSIs, hybrids and commercial strains evaluated during April-May, 2006 trial, single spore selection SSI-8109, hybrid-2 and commercial strain P-5 produced significantly higher mushroom yield with better quality fruit bodies in 6 weeks of cropping (Fig. 2).

Fig. 2: Light brown fruitbodies in strain A-9 (left side) and a good flush in high yielding SSI-8109

2.1.2 Evaluation of strains under AICMIP

Twelve different strains of *A. bisporus* along with S-11 as standard check variety, were evaluated in RBD design with 8 replications each consisting of 10 kg short method compost during April-May, 2006. CM-7 (20.95 kg), CM-11 (21.75 kg) and CM-12 (21.89 kg/ 100kg compost in 6 weeks of cropping) were recorded to be the higher mushroom yielder than the standard check. However, all other strains were at par with the widely adopted strain S-11.

2.2 Breeding in *Agaricus bitorquis*

2.2.1 Testing of parents and hybrids

Three newly developed and high yielding hybrids between strains NCB-6 and NCB-13 were evaluated in a pilot scale trial conducted during Sept.-Oct., 2006 alongwith parents and eight other germplasm strains; the hybrid 2 x 11 yielded better over the parents and standard check varieties and produced more than 16 kg mushrooms/100 kg compost in 6 weeks of cropping.

2.3 Project –NCM-38: Improvement in cultivation of Oyster and developing hybrid strains (PI: Dr. R.C. Upadhyay)

Yield evaluation trials of hybrid strains of *Pleurotus sajor caju, Pleurotus florida* and *P. fossulatus* and yield optimization through cultural practices for growing *Pleurotus fossulatus* were laid out. The results are mentioned below:

2.3.1 Evaluation of *Pleurotus florida* strains

Six strains developed by mating of compatible single spore hybridization were evaluated during winter months (Dec.-Feb.) on pasteurized wheat straw. Eight replications were kept for each strain. Bags were provided with one central aeration tunnel (10 cm). Yield data were recorded for 45 days. Highest yield was recorded in strain H-25 (81% B.E.) followed by strain H-18, strain H-35 and strain H-4.

2.3.2 Evaluation of *Pleurotus sajor-caju* strains

Nine high yielding different strains evolved by mating of compatible single spores were evaluated for 3rd time on pasteurized wheat straw. Five strains have given more than 22 to 30 times higher yield as compared to parent strain. Highest yield was recorded in strain H-9 (63% B.E.) followed by strain H-8 (62.5% B.E.), H-38 (61.5% B.E.), H-27 (60.5% B.E.) and H-31(54.5% B.E.). The parent culture gave 34% B.E.

2.3.3 Evaluation of *Pleurotus fossulatus* strains

Cultivated fruit body of *P. fossulatus* was used for taking spore print and raising single spore culture. All the spores were used for hybridization in petri plates. Fast growing dicaryotic cultures were used for evaluation trials. Out of 26 strains evolved, ten strains failed to produce fruit bodies while 16 strains gave fruiting. No strain gave higher yield than parent, however, quality of fruit bodies of hybrid strains was much better than the parent strain.

2.3.4 Evaluation of different substrates for cultivation of *Pleurotus fossulatus*

Dried poplar leaves were mixed with wheat straw in different ratios (1:1, 2:1,3:1 & poplar leaves alone) and supplemented with 5 % cotton seed cake and autoclaved for 60 minutes. All the treatments gave successful fruiting and 280 to 350 g fresh mushrooms were harvested in 45 days.

2.4 Project –NCM-40: Integrative use of cultivation technologies and molecular techniques for enhancing yield and quality of paddy straw mushroom ,*Volvariella* spp. (PI: Dr. O.P.Ahlawat)

2.4.1 Strainal evaluation in paddy straw mushroom (*Volvariella volvacea*)

The Chinese, paddy straw mushroom, *Volvariella volvacea* is known for its unique aroma and texture and is a fast growing mushroom compared with most other cultivated species. The biological efficiency is mainly attributed to the hydrolytic enzymes system of a mushroom and is very low in this mushroom (about 10% to 15 % on paddy straw) in comparison to other popularly cultivated species, namely *Agaricus bisporus*, *Lentinula edodes* and *Pleurotus* spp. The selection of strains based upon their hydrolytic enzymes activities can be a better strategy for selecting promising strains.

2.4.2 Strains and their morphological characterization

A total of 26 strains were grown on malt extract agar medium in Petridishes and sterilized pounded paddy straw substrate in 250 ml conical flasks at 32 ± 1^{0}C for 8 days. The strains were characterized based upon the mycelial growth rate, aerial hyphae, type of growth and intensity of chlamydospores formed.

The strains varied in their growth characteristics on malt extract agar with respect to radial mycelial growth, aerial hyphae and chlamydospores. Fourteen strains showed radial growth of 90 to 100 mm in 8 days, while 8 strains grew up to 60-70 mm. Rest of the 4 strains grew very slowly and showed growth of 11 to 35 mm. Most of the fast growing strains formed thin or thick fluffy growth with sufficient aerial hyphae and no chlamydospores on 8th day of growth. However, some exceptions were also noticed where in the fast growing strains, OE-272 and OE-274 with radial growth of 90 mm formed quite low level of aerial hyphae. Most of the strains showed characteristics of a typical *V. volvacea* strain, excepting 4 strains (OE-49, OE-91, OE-146 and OE-224) which showed quite atypical characteristics. The remaining 4 strains (OE-143, OE-145, OE-225 and OE-226) showed characteristics of single basidiospore of *V. volvacea*. The typical type strains completely colonized the paddy straw substrate with in 8 days of growth and formed negligible aerial hyphae. Only 7 strains (OE-273, OE-274, OE-12, OE-139, OE-213, OE-214 and OE-215) formed chlamydospores showing no relationship with rate of mycelial growth as some of the slow growing strains (OE-12, OE-212) also formed chlamydospores (Table-2). The variations in morphological characteristics in strains of *V. volvacea* and

Table 2: Morphological characteristics of different strains of *Volvariella volvacea* grown on different cultural media under *in vitro* conditions

Strain	Growth characteristics							
	Malt extract agar				Pounded paddy straw			
	a	b	c	d	a	**	b	c
OE-272	90mm(Tn)	+	-	T	Complete	+	-	-
OE-273	95mm(Tk)	+++	-	T	Complete	++	±	++
OE-274	90mm(Tn)	+	-	T	Complete	+±	±	+
OE-12	65mm(TnF)	++	-	T	Complete	++	±	+
OE-29	65mm(Tk&Tn)	+	-	T	Complete	++	+	-
OE-49	67mm(Tk)	-	-	A(D)	Not used			
OE-55	60mm(Tks)	-	-	T	Complete	+	-	-
OE-91	95mm(Very Tk)	+	-	A(D)	No growth	-	-	-
OE-112	87mm(TnF)	+++	-	T	Complete	+	-	-
OE-117	100mm(TnF)	+++	-	T	Complete	+++	+	-
OE-139	95mm(Tk)	++	-	T	Complete	++	+	+
OE-140	90mm(Tk)	++	-	T	Complete	+++	+	-
OE-143	11mm(Tk)	-	-	T(SSIs)	No growth	-	-	-
OE-144	63mm(Tks)	±	++	T	60%	+	-	-
OE-145	35mm(Tk)	-	-	T(SSIs)	90%	+	-	-
OE-146	63mm(Tk)	-	-	A(D)	Not used			
OE-209	90mm(Tn)	+++	-	T	Complete	+	-	-
OE-210	95mm(Tk)	++	-	T *	90%	++	-	-
OE-211	95mm(Tn)	++	-	T*	Complete	+	-	-
OE-212	100mm(Uniform)	+++	-	T*	Complete	+++	-	-
OE-213	65mm(Tn)	+	-	T	Complete	+++	-	+
OE-214	100mm(Tk)	++++	-	T*	Complete	+++	+	++
OE-215	100mm(HF)	6+	-	T*	Complete	+++	+	+
OE-224	62mm(Tk)	-	-	A(D)	Not used			
OE-225	25mm(Tk)	-	-	T(SSIs)	No growth	-	-	-
OE-226	Very thin growth	-	-	T(SSIs)	No growth	-	-	-

a-mycelial growth; b-aerial hyphae; c-chlamydospore intensity; d-strain type; T-typical; A-atypical; Tn-thin; Tk-thick; Tnf-thin fluffy; Tks-thick strandy; HF-highly fluffy ; *-best with respect to all parameters; ** visual growth; - to 6+ -absent to very high

changes in their growth characteristics at different stages of growth have also been reported earlier.

2.4.3 Enzyme assay

Strains showing growth of a typical *V.volvacea* mycelium, both on malt extract agar and paddy straw substrate, were only used for exoglucanase, endoglucanase, xylanase, β-glucosidase, polyphenol oxidase and laccase enzymes assay. Production of various enzymes was studied on sterilized paddy straw substrate. The enzymes were extracted from the mycelium colonized substrate in 50ml phosphate buffer of pH 7.0 by keeping the buffer mixed substrate at 40°C for 30 min in an incubator shaker maintained at 100 rpm.

The extracted enzymes sources were filtered through Whatman 3 piece filter funnel using glass microfibre filter (GF-C) and stored at 4°C for further use. Laccase and polyphenol oxidase activities were calculated as change in absorbance by 0.001 min^{-1} ml^{-1} of enzyme source, β-glucosidase as mM p-nitrophenol released h^{-1} ml^{-1} of enzyme source and FPase, CMCase and xylanase as the mM glucose released h^{-1} ml^{-1} of enzyme source.

The enzymes activities varied in different strains (Table-3). The highest exoglucanase activity was recorded in strain OE-143 (1.38U), followed by OE-214, OE-139 and OE-215. The highest endoglucanase activity of 1.57U was recorded in strain OE-143, followed by 1.49U in OE-145 and 1.24U in OE-210. The highest β-glucosidase activity of 2.59U was recorded in strain OE-145, followed by 2.55U in OE-117, 2.50U in OE-210. Xylanase activity was highest in strain OE-215 and was followed by strains, OE-272, OE-213, OE-209, OE-117 and OE-214. Highest activity of laccase (3.33U) was recorded in strain OE-143, followed by strains, OE-29, OE-145, OE-210 and OE-272. The polyphenol oxidase activity was highest (6.50U) in strain OE-210. It was followed by strains, OE-272, OE-139, OE-145 and OE-214. Variations in activities of enzymes in different strains of *V. volvacea* along with role of cellulases in mycelial colonization and laccase in sporophore formation have also been reported.

Table 3: Lignocellulolytic enzymes activities profile of different strains of *Volvariella volvacea* on paddy straw substrate

	Enzyme activity					
***V. volvacea* strain**	**Exoglucanase**	**Endoglucanase**	**Xylanase**	**β-Glucosidase**	**Laccase**	**Polyphenol oxidase**
OE-272	0.70	1.19	2.05	0.71	1.75	5.23
OE-273	0.50	0.05	1.41	1.03	1.12	1.38
OE-274	0.46	0.81	1.02	1.18	1.13	1.20
OE-12	0.55	0.28	1.28	1.50	1.32	1.98
OE-29	0.81	1.15	1.54	2.27	3.28	2.42
OE-55	0.28	1.07	ND	1.06	1.13	ND
OE-112	0.63	0.74	1.48	0.52	0.68	0.98
OE-117	0.54	0.64	1.88	2.55	ND	1.80
OE-139	1.23	1.23	0.65	1.38	ND	5.02
OE-140	0.93	0.82	1.71	0.82	1.63	ND
OE-143	1.38	1.57	1.49	1.06	3.33	2.50
OE-144	0.40	0.60	1.80	2.23	1.12	1.38
OE-145	0.13	1.49	0.97	2.59	3.23	4.38
OE-209	ND	1.16	1.92	0.09	ND	0.75
OE-210	0.54	1.24	0.80	2.50	1.88	6.50
OE-211	0.02	0.74	1.43	2.10	0.55	1.23
OE-212	0.37	1.18	1.20	1.10	ND	1.45
OE-213	0.46	0.46	1.95	2.04	1.66	0.93
OE-214	1.27	1.23	1.80	2.22	ND	2.82
OE-215	1.00	0.61	2.24	1.31	0.32	0.68

Exoglucanase, Endoglucanase and Xylanase activities-µM glucose released h^{-1} ml^{-1}, laccase and polyphenol oxidase-0.001 IU min^{-1} ml^{-1} and β-Glucosidase-µM pNP released h^{-1} ml^{-1}, ND-not detected

2.4.4 Mushroom yield

The crops for evaluating the parent strains for yield and quality was raised by improved cage and indoor methods. In cage method 30x10 cm^2 size steam pasteurized paddy straw bundles were used for bed preparation. Eight bundles were used in one layer and the beds were prepared with 5 such layers consisting of total 40 bundles per bed. Five replications were kept for each treatment. In indoor method compost was prepared by using paddy straw, chicken manure, rice bran and lime as the basal ingredients (paddy straw 1000 kg, Lime 10 kg, Chicken manure 100 kg and Rice bran 10 kg). The yield of fresh mushrooms was converted into yield obtained in kg q^{-1} dry substrate used.

Out of 20 strains screened for enzyme assay, a total of 12 strains with varied enzymes activities were used for yield evaluation trials. Mycelial colonization of substrate after 8 days of spawning varied in different strains. On pasteurized paddy straw bundles strains, OE-274, OE-215, OE-272 and OE-55 showed very thick and fluffy growth, while strains, OE-210, OE-213 and OE-139 completely colonized the substrate but with thin mycelial growth (Table-4). The mushrooms were harvested earliest in 20.6 days after spawning in strain OE-274, which was followed, by strains, OE-272, OE-139 and OE-140. Highest mushroom yield of 12.36 kg q^{-1} dry substrate was recorded in strain OE-274, followed by 10.49kg in strain OE-272 and 10.45 kg in OE-210.

In first cultivation trial conducted on composted paddy straw substrate, superior substrate colonization was recorded in strains OE-273 and OE-215, followed by strains, OE-272, OE-210, OE-213 and OE-209. Earliest mushroom pinheads were recorded in strain, OE-272 and were followed by strains, OE-210, OE-213 and OE-209. First harvest of mushroom post-spawning was recorded earliest in 15.0 days in strain, OE-214, followed by strains, OE-272, OE-274 and OE-215. Highest mushroom yield of 8.28 kg q^{-1} of dry substrate was recorded in strain OE-215 followed by strains, OE-272, OE-274 and OE-140 (Table-5). In second trial, the earliest

Table 4: Mycelial colonization, first harvest and yield in different strains of *V. volvacea* grown on pasteurized paddy straw bundles

V. volvacea strain	Mycelial colonization		First harvest (days post-spawning)	Mushroom yield (kg q^{-1}dry substrate)
	Type of growth (visual)	Mycelial density (visual)		
OE-272	fluffy	+++++	21.4±0.68	10.49
OE-274	fluffy	++++++	20.6±1.25	12.36
OE-12	thin	++	23.0±0.94	5.35
OE-29	thin fluffy	+++	No pinning	—
OE-55	fluffy	+++++	25.33±3.66	2.23
OE-139	thin	++++	21.4±0.45	5.36
OE-140	fluffy	+++	21.8±0.42	7.03
OE-209	thin	+++	22.0±0.35	7.05
OE-210	thin	++++	24.2±2.48	10.46
OE-213	thin	++++	22.0±1.00	7.42
OE-214	thin	+++	25.8±1.85	4.66
OE-215	cottony	++++++	22.6±0.57	5.03
CD (0.05%)			**1.69**	**1.16**

Table 5: Mycelial colonization, pinning and yield in different strains of *V. volvacea* grown on composted paddy straw substrate

V. volvacea strain	Mycelial colonization/ pinning (visual)		First harvest (days post-spawning)			Mushroom yield (kg q^{-1}dry substrate)		
	Mycelial colonization	Pinning pattern	Ist Trial	IInd Trial	Average	Ist Trial	IInd Trial	Average
OE-272	+++	+++	15.4±0.87	17.2±0.37	16.30	7.00	4.93	5.96
OE-273	+++++	++	16.6±0.36	17.5±0.29	17.05	5.32	5.71	5.51
OE-274	+++	+++	15.7±0.45	17.6±0.93	16.65	6.89	5.12	6.00
OE-12	+++	+	16.2±0.37	19.2±0.48	17.70	3.28	2.65	2.96
OE-55	++++	-	18.4±0.88	19.7±2.09	19.05	1.62	2.62	2.12
OE-139	+++	+	18.6±0.68	20.0±1.64	19.30	4.26	3.43	3.84
OE-140	+++	+	16.2±0.49	17.6±0.40	16.90	6.42	4.19	5.30
OE-209	++++	++	16.4±0.24	18.6±0.81	17.50	6.10	5.12	5.61
OE-210	+++	++	16.6±1.03	19.0±0.45	17.80	6.00	4.79	5.39
OE-213	+++	++	16.4±0.51	18.2±0.49	17.30	5.80	8.05	6.92
OE-214	+++	±	15.0±0.89	19.2±0.75	17.10	6.10	3.29	4.69
OE-215	++++	+	15.8±0.37	20.0±1.64	17.90	8.28	4.81	6.54
CD (0.05%)			**0.68**	**1.23**	**-**	**1.58**	**0.86**	**-**

harvest in 17.2 days was obtained in strain OE-272 followed by strains OE-273 and OE-274. Highest mushroom yield of 8.05 kg q^{-1} was recorded in strain OE-213 followed by strains OE-273 and OE-274. In average of two trial, strain OE-272 took the lowest time for first harvest and yielded mushrooms almost at par with other high yielding strains OE-213, OE-215 and OE-274 which fruited later than OE-272. Yield evaluation trials for selecting a better performing strain or single spore isolate have also been performed earlier by several workers but none of them have correlated the morphological and biochemical characteristics of a strain with its yield potential.

2.4.5 Mushroom quality

Different quality parameters of fruiting bodies viz., size, shape, whiteness, colour, weight, pileus opening and contents of potassium, sodium, calcium, carbon, phosphorous and nitrogen were recorded. The size, shape, color and pileus opening were recorded based upon the visual observations, while whiteness was recorded as reflectance in per cent using Elico Reflectometer, first by calibrating the instrument with the whiteness standards. The contents of calcium, potassium and sodium were estimated by using Ion Meter (Thermo Orion model 720A+) in ppm g^{-1} of the sample.

The quality of fruiting bodies with respect to size, shape, whiteness, colour, weight, pileus opening and contents of potassium, sodium, calcium, carbon, phosphorous and nitrogen varied in different strains. The fruiting bodies harvested from two types of substrates also varied in their qualities. On pasteurized paddy straw bundles, big size compact fruiting bodies (50-70mm long) with oval or round shape were harvested in strains, OE-274, OE-213 and OE-214 (Table-6). The other high yielding strains OE-272 and OE-210 produced medium size (30-50mm long) oval shaped fruiting bodies. The colour/whiteness

Table 6: Quality characteristics of fruiting bodies of different strains of *V. volvacea* grown on pasteurized paddy straw bundles

V. volvacea strain	Fruiting body quality characteristics											
	Size (visual)	Shape (visual)	Whiteness (Reflect-ance %)	Colour (visual)	Weight (g)	Pileus opening (visual)	K (ppm g^{-1})	Na (ppm g^{-1})	Ca (ppm g^{-1})	Carbon (%)	Phosphorus (%)	Protein/ Nitrogen (%)
OE-272	medium	oval	7.40	dirty white	10.25	high	31.6	1.34	7.13	0.41	0.89	18.75/3.0
OE-274	big	oval	12.20	dark black	16.80	nil	62.0	2.03	11.01	0.21	0.95	16.25/2.6
OE-12	medium	round	17.00	black	8.90	high	45.80	1.54	8.57	0.31	0.57	17.5/2.8
OE-55	small	oval	16.40	white	8.63	nil	1729.0	0.84	10.1	0.37	0.61	13.12/2.1
OE-139	medium	roundish oblong	13.20	light black	10.90	medium	1850.0	0.082	8.92	0.38	0.65	17.5/2.8
OE-140	small	oval	12.60	light black	11.00	high	1667.0	0.00	9.08	0.45	0.99	17.5/2.8
OE-209	medium	oval	17.40	dirty white	10.14	nil	1830.0	0.430	7.13	0.59	1.01	18.75/3.0
OE-210	small	oval	12.00	dirty white	9.95	nil	1431.0	0.747	7.42	0.71	0.89	18.125/2.9
OE-213	big	oval	11.60	dark black	11.12	nil	1339.0	0.780	8.39	0.80	1.05	16.81/2.69
OE-214	big	round	14.80	dirty white	10.95	nil	2370.0	0.910	7.85	0.29	1.09	14.25/2.28
OE-215	medium	oval	14.60	dirty white	9.71	nil	2150.0	1.00	7.31	0.59	0.90	20.00/3.2

Small-2 to 3 cm long, medium-3 to 5cm long, big-5 to 7cm long

varied in fruiting bodies of different strains and whitest fruiting bodies were harvested from strain OE-209 followed by OE-12 and OE-55. The fruiting bodies also varied in weights and heaviest fruiting bodies were harvested from strain OE-274 followed by OE-213 and OE-140. Pileus opening was highest in strains OE-12, OE-140 and OE-272. The contents of calcium, carbon and phosphorus did not vary much in different strains, while the content of sodium was much higher in high yielding strains (OE-274 and OE-272) in comparison to other strains. However, the trend with respect to potassium content was just reverse and it was much lower in strains OE-272, OE-274 and OE-12.

On composted substrate tough and big size fruiting bodies were harvested from strains OE-139, OE-140, OE-274 and OE-209. The fruiting bodies from strains OE-12, OE-273 and OE-274 were whiter than fruiting bodies from other strains (Table-7). Veil opening was highest in strains OE-12, OE-55 and OE-272 forming lightweight soft fruiting bodies. There was no correlation between the length of the fruiting body and the tendency to open, as comparatively bigger fruiting bodies of strains OE-12 and OE-55 opened much more than small fruiting bodies of strain OE-215. The fruiting bodies obtained from strains OE-274, OE-273 was heaviest in weight.

In the present study, the fast growing strains with fluffy mycelial growth and abundant aerial hyphae, namely OE-272, OE-274 and OE-210 gave better mushroom yield on pasteurized paddy straw bundles than other strains. The highest yielder, OE-274 was also recorded to possess fairly good activities of all the cellulases, xylanase and ligninases, while the second best yielding strain, OE-272 was recorded to have superior activities of PPO and xylanase along with good activities of other enzymes. The third strain OE-210 was recorded to possess highest activities of PPO and β-glucosidase enzymes along with good activities of other enzymes. On composted substrate along with strains OE-272 and OE-274, two other strains OE-213 and OE-215 also gave superior yield than other strains. All these strains were fast growing, formed abundant aerial hyphae and chlamydospores, and formed early pinning than other strains.

Table 7: Quality of fruiting bodies obtained from different strains of *V. volvacea* grown on composted paddy straw substrate

***V. volvacea* strain**	**Fruiting body colour (visual)**	**Fruiting body size (cm)**	**Toughness (comparative)**	**Veil opening (visual)**	**Fruiting body weight (g)**
OE-272	+++	3-4	++	+	10.25
OE-273	++++	4 –5	++	-	15.48
OE-274	++++	5	+++	-	16.80
OE-12	+++++	4 –5	++	+++	8.90
OE-55	++	4 –5	++	++	8.63
OE-139	++	5	++++	-	10.90
OE-140	+	5	++++	-	11.00
OE-209	+	4 –5	+++	±	10.14
OE-210	++	3-4	+++	-	9.95
OE-213	++	4-5	+++	-	11.12
OE-214	+++	4-5	++	-	10.95
OE-215	+++	3-4	++++	-	9.71
CD (0.05%)		**0.66**			**2.32**

In enzymatic studies, the two strains OE-213 and OE-215 showed superior activities of xylanase and β-glucosidase and lower activities of endoglucanase and polyphenol oxidase. In addition to these, strain OE-213 was deficient in activity of exoglucanase and strain OE-215 in laccase. The study clearly elucidate that different sets of enzymes activities are responsible for mushroom yield on substrate prepared by different methods; as on pasteurized substrate strains with superior activities of PPO, laccase, xylanase/ β-glucosidase and mediocre activities of exoglucanase and endoglucanase gave superior yield, while on composted substrate strains even deficient in ligninases gave superior yield. The possible role of different sets of enzymes towards mushroom yield on substrate prepared by different methods can be attributed to the need of these enzymes in initial breakdown of the substrate; as in pasteurized substrate the substrate has to be broken down with the help of cellulases and ligninases, while the composted substrate used to be a partially decomposed and harbours other sets of microorganisms with abilities to breakdown the substrate. The different types of substrates need strains with different set of enzymes activities for obtaining optimum yield and yield performance of the strain on a substrate will be regulated not only by the enzymes' activities but also by the chemical composition of the substrate. The study will provide an insight in to the subject and will help in selecting potential strains based upon their lignocellulolytic enzymes' activities profiles and the chemical composition of the substrates to be used.

2.5 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)

In all, 32 shiitake strains were procured from National Gene Bank, North East and Central India were sub-cultured and pure cultures maintained for breeding experiments.

2.5.1 Molecular characterization

Fifteen elite shiitake strains and hybrids were subjected to RAPD analysis and ITS sequencing of 5.8S r RNA gene was done to find out Single Nucleotide Polymorphism (SNP'S). The ITS amplified products of 15 parental strains and hybrids are presented in Fig. 3.

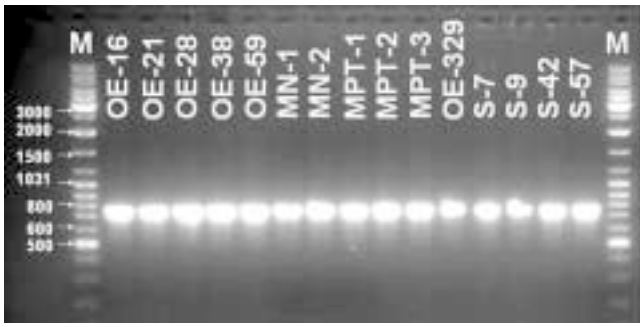


Fig. 3: ITS profiles of 15 shiitake strains and hybrids

2.5.2 Yield and biological efficiency trials

Two trials of five elite strains of OE series were conducted for yield performance and comparative biological efficiencies (Table-8). In trial-1, all the 5 strains resulted in lesser yields and BE as compared to trial-2. This is because in trail-2 physical conditions like light, relative humidity and temperature were adjusted to maximize yields and were precisely maintained without repeated chilling treatments during cropping period. The strain OE-38 gave significantly higher and the maximum biological efficiency of 63 % followed by OE-16 with 60.7 %.

Thirteen inter-strainal hybrids developed from the five elite strains of OE series were tested for there yield and biological efficiencies (Table-9). Out of these two hybrids S-9 (Fig. 4) and S-57 gave significantly higher yields from all the parents tested in the same season.

Table 8: Yield performance of elite shiitake strains of OE series

S. No	Hybrid Strain	Yield (g)	B. E. (%)
1.	S-7	385	51.3
2.	S-9	510	68.0
3.	S-10	315	42.0
4.	S-31	365	48.7
5.	S-32	175	23.3
6.	S-34	315	42.0
7.	S-37	265	35.3
8.	S-38	300	40.0
9.	S-42	405	54.0
10.	S-49	250	33.3
11.	S-56	245	32.7
12.	S-57	485	64.7
13.	S-59	250	33.3
	CD (0.05)	**46.6**	**6.1**

Table 9: Yield performance of shiitake hybrids developed from elite strains of OE Series

S. No	Strain	Yield (g)	B. E. (%)
1.	MT-1	455	60.7
2.	MPT-2	420	56.0
3.	MPT-3	430	57.3
4.	MN-1	475	63.3
5.	MN-2	395	52.7
6.	OE-329	390	52.0
	CD (0.05)	**47.6**	**4.7**

Fig. 4: Profuge fruiting in Hybrid S-9

Six new shiitake parental strains collected from Central India and North-East regions were tested for yield and biological efficiencies. The data are presented in table-10. Strain MN-1 gave the highest biological efficiency of 63.3 %.

Table 10: Yield evaluation of new shiitake germplasm

S. No	Strain	Yield (g)	B. E. (%)
1.	MPT-1	455	60.7
2.	MPT-2	420	56.0
3.	MPT-3	430	57.3
4.	MN-1	475	63.3
5.	MN-2	395	52.7
6.	OE-329	390	52.0
	CD (0.05)	**47.6**	**4.7**

2.5.3 Shiitake breeding

Thirty-two single spore isolations were made from 6 new shiitake germ plasm strains MN-1, MN-2, OE-329, MPT-1, MPT-2 and MPT-3. Crosses were made in two groups. The group-1 included SSI's of MN-1and MN-2 and Group-2 included SSI's of OE-329, MPT-1, MPT-2 and MPT-3. Dual cultures of SSI's from different strains were raised from in petri plates on malt extract-glucose-agar culture medium and incubated at 24° C fifteen days. In Group-1, 15 hybrids and in Group-2, 22 hybrids were developed.

The mycelium from the contact zone was observed under microscope for formation of clamp connections and hybrid formation conformed in all the presumptive hybrids formed. DNA of all these hybrids isolated and molecular profiles of only high yielding hybrids will be compared with that of parents to conform hybridization.

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

Experiment on indoor composting was conducted twice in the season taking wheat straw as the base material. Compost was prepared using following formulation and time schedule for operation.

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 re filling the Phase-I tunnel.
+6 day	Filling the phase-II tunnel.
+12 day	Phase-II operation over.

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 they were 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 1.8-2 meters. Temperature sensors were installed on the top and in the centre of the pile in the bunker. The compost mass was kept as such over night. The temperature between 66-77^{0}C was recorded in the centre of the pile while top to 8" deep showed temperature between 48^{0}C-70^{0}C. Temperature on the sides of the compost mass along the walls was in the range of 52^{0}C-58^{0}C. Blower fan was switched on for 5-7 minutes per hour to aerate the pile. Full penetration of air was noticed in the compost. Further no foul smell was noticed while performing phase -1 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. Standard methodology was employed, thereafter for compost production.

Physical parameters and total yield

Average moisture of the two composts at filling was 68% while it came down to 63.85 % at spawning. pH at filling was 7.9 while it was 7.4 at spawning. Average N per cent at filling was 1.75 while it increased to 1.99 at spawning. Average wheat straw to compost conversion ratio was 3.29 times (Table-1). An average yield of 15.04 kg mushrooms per 100 kg compost was obtained from the trial in fifty days of cropping.

Table 1: Physical parameters and yield obtained with indoor composting technique

Trial	pH		Moisture %		N %		Conversion ratio	Yield Kg/q comnpost
	filling	spawning	filling	spawning	filling	spawning		
1.	7.82	7.3	69.0	63.50	1.82	2.10	3.53	15.24
2	7.90	7.5	68.5	64.20	1.69	1.89	3.03	14.84

1.2 Isolation and identification of thermophilic fungal flora of different composts collected across the country

More than 50 compost samples were collected from Haryana, Punjab, U.P. and H.P. These samples represented the compost, fermented at its various stages of preparation. A large numbers of thermophilic fungi including *Mucor pusillus, Cunninghamella* sp., *Aspergillus fumigatus, Aspergillus* sp., *Scytalidium thermophilum, Humicola insolens, Humicola grisea, Chaetomium thermophile, Thermomyces lanuginosus, Humicola fuscoatra, Gilmaniella humicola,* and few mycelia steriala were isolated. First four fungi were largely isolated from the initial phases of composting while others were dominantly isolated from 6th day of composting onwards. Colony forming units ranged from 0 x 10^4 to 35 x 10^4 in different samples. Highest CFU was obtained in phase two composts. Cultures of *H. insolens, S.thermophilum* and *H. grisea* are showing variability in terms of colony morphology and appear to represent different strains. Further studies on these aspects are underway.

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

Different quantities of various ingredients as listed below were used in different piles.

Six different piles were prepared using above formulations. Compost was prepared by short method. Mesophilic and thermophilic fungal population of these composts was studied in detail.

A total number of seven mesophilic fungi were isolated before filling which included *Mucor pusillus, Fusarium accuminatum, Aspergillus fumigatus, Penicillium* sp., *Spicaria* sp, *Trichoderma viride* and an unidentified species (Table-2). Incidence of *T. viride* was very high in the pile where cotton

ngredients used in composts production

Ingredients	Quantities in kg					
	Pile-1	Pile-2	Pile-3	Pile-4	Pile-5	Pile-6
Wheat straw	200	200	200	200	200	200
Chicken manure	80	80	100	140	0.0	80
Cotton linter	0.0	40	00	00	0.0	0.0
Cotton seed meal	0.0	00	0.0	00	16	0.0
Wheat bran	15	0.0	0.0	0.0	14	12
Urea	3.0	3.0	0.0	0.0	5.0	0.0
Cotton seed cake	0.0	0.0	0.0	14.0	0.0	0.0
Soybean meal	0.0	0.0	0.0	0.0	0.0	12.0
Soybean Nutri	0.0	0.0	0.0	0.0	0.0	12
Gypsum	15	15	15	15	15	15

Table 2: Mesophilic fungal population of composts prepared with different ingredients

Organisms	Piles					
	1	2	3	4	5	6
Mucor pusillus	+	+	-	-	+	++
mycelia steriala	-	-	-	+	-	+
Penicillium sp.	++	+	-	-	+	-
T.viride	-	+++	+	-	-	-
A. fumigatus	+	+	++	+	+	+
Spicaria sp.	-	-	-	+	-	-
Fusarium accuminatum	++	++	-	+	+	+

- nil, + max. 3 colonies, ++ max. 5 colonies, +++ more than 5 colonies

linter was used as one of the ingredients. *A. fumigatus* was isolated from all the piles. Rest of the fungi isolated were of sporadic in nature. Only *A. fumigatus* was isolated from these composts after pasteurization in a very low count.

Data pertaining to thermophilic population is presented in Table –3. Six fungi namely: *S. thermophilum, H. insolens, H. grisea, T. lanuginosus, A. Fumigatus* and *Penicillium* sp. were isolated at various intervals and after kill. Among these *H. insolens* and *T. lanuginosus* were not isolated after phase –2 operations. CFU in different composts showed increasing trend as the composting proceed and was maximum at filling. Highest number of average CFU was obtained with the pile where cotton linter was used as one of the ingredients. Surprisingly after kill population of these fungi drastically decreased with the highest CFU in pile 3 and lowest in pile 5 (nil). This abnormal condition probably achieved due to malfunctioning of the tunnel during the experimentation (an aerobic condition).

Data obtained on physical parameters are presented in Table-4. During phase 1 highest average temperature was recorded in T- 4 treatment (65.8^{0}C) whereas lowest was recorded in T-2 (55^{0}C) where wheat straw was supplemented with cotton linter. The pH at spawning ranged between 8.15- 8.71. The highest compost was produced in treatment T-5 where cotton seed meal was used in compost production. The experiment failed in terms of mushroom production due to malfunctioning of the tunnel during phase two operations.

Table 3: Dominant thermophilic flora and CFU obtained in the different composts at various intervals

Treatments	Phase –1 CFU (fungi)						Phase-2
Pile –1	3.33(1)	0.00	10.3(1)	29.0(1)	13(1,3,6)	11.12	0.30(1)
Pile-2	0.30(1)	4.60(1,4)	21.0(1)	11.6(1)	42.6(4)	16.02	1.0(1,3,5)
Pile-3	8.30(3)	0.60(1)	15.3(1)	18.3(1)	18.6(1)	12.22	14.0(1)
Pile-4	0.00	0.30(4)	0.60(1)	22.3(1)	20.3(1)	8.70	0.0
Pile-5	0.00	0.30(4)	0.60(1)	22.3(1)	20.3(1)	8.70	0.0
Pile-6	0.00	0.60(1)	3.30(1)	4.60(1)	38.0(1,3)	9.30	2.33(1)

Figures in parenthesis represent name of fungi
1.*S. thermophilum* 2. *H.insolens* 3. *H.grisea* 4. *T. lanuginosus* 5. *Penicillium* sp. 6. *A. fumigatus*

Table 4: Physical parameters of different composts

Treatment	Av. temp. phase-1	Final pH	Final moisture	Total compost produced (kg)
P-1	57.00	8.154	66.40 %	610
P-2	55.00	8.214	59.40 %	400
P-3	59.00	8.717	59.40 %	590
P-4	65.83	8.717	59.40 %	680
P-5	60.30	8.531	50.00 %	740
P-6	60.30	8.623	57.20 %	360

1.4 Studies on 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 under mentioned formulation.

Compost ingredients	Quantity
Wheat straw	300 kg
Wheat bran	30 kg
Urea	7.0 kg
Gypsum	15 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). Fifty 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 tunnel in trays. Doors and shutters were closed and blower fan switched on. In the morning temperature of the tunnel stood around 45-48^{0}C. These trays were kept in the tunnel for seven days at a temperature regime of 45-58^{0}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-5. Moisture per cent ranged between 68.1 – 70.0 per cent, pH was in the range of 7.45 to 7.74 and N level between 1.5 to 1.91 per cent. CFU/g of this compounding mixture was 23.1. Dominant thermophilic fungal flora isolated from these mixtures included *Aspergillus fumigatus*, *S. thermophilum* and two unidentified fungi.

Table 5: Physical parameters of initial compounding mixtures

S. No.	Physical parameters					
	Sample	Moisture	pH	N %	CFU/g compost	Dominant flora
1.	Ingredients mixture	70.40	7.74	1.50	23.0	1,2,3,4*
2.	Ingredients sterilized	68.10	7.90	1.85	7.00	3,4
3.	Compost inoculum	70.00	7.45	1.91	16.00	1,2,3,4

* 1, *A. fumigatus* 2. *S.thermophilum* 3. mycelia steriala 4. Unidentified sp.

Physical parameters of the prepared compost after 7 days of conditioning and pasteurization are presented in Table-6. 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 21.11-46.66 per cent. Highest being in *H.insolens* (Strain-4) and lowest in strain S-7 of the same fungus. Compared to different treatments control piles also exhibited almost same wt. loss of the ingredients. Moisture and pH were well within permissible limits for all the

Table 6: Physical parameters of different composts prepared with different thermophilic organisms

Strain	Wt. loss (%)	Moisture at spawning (%)	pH	N (%)	Inoculum load (g^{-1})	CFU (g^{-1}) of compost	Dominant flora*
***Scytalidium thermophilum* (Strains)**							
S-1	34.00	71.60	7.78	3.10	14.66	86.00	1(81), 11(5)
S-2	30.40	61.60	7.63	1.96	12.33	105.30	1(95), 4(2), 6(5), 11(3)
S-3	36.60	69.80	7.33	1.61	3.33	69.30	1(60), 5(2), 11(7)
S-4	38.44	65.10	7.81	2.40	2.33	47.30	1(45), 12(2)
S-5	35.55	73.50	7.90	2.17	9.33	56.81	1(50), 5(1), (1), 11(4)
S-6	34.44	69.20	7.70	1.33	12.66	41.60	1(36), 10(1), 4(1), 11(3)
S-7	37.77	69.30	8.00	2.07	5.33	32.00	1(29), 11(3)
***Humicola insolens* (Strains)**							
S-1	34.66	61.60	7.87	1.77	11.66	58.23	2 (52), 4(2), 12(4)
S-2	36.66	61.10	7.65	2.21	10.66	65.28	2 (60), 9(1), 11(2), 12(2)
S-3	28.88	67.40	7.58	1.90	13.33	62.14	2 (60), 11(2)
S-4	46.66	69.20	7.55	1.87	17.66	70.22	2 (70)
S-5	40.00	67.20	7.56	2.72	10.33	74.53	2 (65), 6 (2), 7(1), 11(4), 12 (2)
S-6	31.11	73.40	8.18	2.72	17.33	110.00	2 (102), 13(2), 12 (6)
S-7	21.11	63.40	7.98	2.74	15.00	78.22	2 (75), 4(1), 6(1), 11(1)
S-8	16.66	66.50	7.64	1.92	29.00	80.22	2 (76), 12(2), 13 (2)
***Humicola grisea* (Strains)**							
S-1	40.00	73.40	8.00	2.24	11.66	43.00	3 (38), 4(2), 6 (2), 13(1)
S-2	30.00	64.60	7.85	2.03	16.00	43.60	3 (39), 11(4)
S-3	24.44	72.20	8.00	2.10	15.33	39.30	3 (33), 4(1), 5(2), 11(4)
S-4	22.50	71.25	7.98	1.68	3.35	38.40	3 (34), 10(1), 4(2), 13(1)
S-5	36.44	71.40	7.71	2.07	12.00	45.00	3 (44), 11(1)
S-6	44.88	74.60	7.69	1.82	14.00	89.00	3 (83), 7(2), 4(1), 11(3)
Control							
C-1	40.00	74.60	8.00	1.80	-	28.30	4(8), 6(5), 13(12), 7(1), 11(2)
C-2	31.11	71.10	7.25	3.50	-	56.30	3 (83)
C-3	37.77	75.10	7.65	1.98	16.0	38.32	4 (11), 5 (1), 6(10), 13(16)
C-4	31.11	71.10	8.00	1.73	7.0	26.6	4 (2), 13(10), 12(5), 13(9)

C1: Control: without any inoculation; C2: Control: inoculated with mix inoculum of above fungi; C3: Control: with compost inoculum (40g/ 10kg of compost); C4: Control: with sterilized compounding mixture

** 1. S.thermophilum:* representative strain, *2. H. insolens* :representative strain, *3. H. grisea :* representative strain, *4. S. thermophilum –1, 5. S. thermophilum –2, 6. H. insolens –1, 7. H. grisa –2, 8. T. lanuginosus, 9. Thermomyces auranticus, 10. C.thermophile,, 11.Aspergillus sp., 12. M. pusillus, 13.* mycelia steriala

treatments including controls. Nitrogen per cent ranged between 1.33-3.50 in different treatments. While it was the highest in the control, as it was inoculated with mixed inoculum of the above fungal strains (C-2).

Colony forming units in the prepared compost ranged between 26.60-110.00 in the 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-7. Condition of spawn run was rated as poor to excellent. Poor spawn run was noted in strain S-4 of *H.griseas*, and in control treatment (SM).

able 7: Yield obtained in different composts prepared with different thermophilic organisms (synthetic formulation).

Strain	Condition of spawn run	Colour of compost produced	Days taken for pinning (After casing)	Av. Fruit body weight (g)	Yield (kg) / q of compost
***Scytalidium thermophilum* (Strains)**					
S-1	++	+	*16*	*8.62*	*10.125*
S-2	+++	++	14	7.24	7.450
S-3	+++	++	13	8.09	6.900
S-4	++	++	14	7.15	7.975
S-5	+++	+++	13	7.09	8.700
S-6	++++	+++	14	9.29	8.637
S-7	++++	+++	12	9.14	**10.531**
***Humicola insolens* (Strains)**					
S-1	++++	++++	12	8.14	8.025
S-2	++++	++++	12	10.07	**10.850**
S-3	+++	++	12	8.54	8.312
S-4	++	++	12	8.37	6.750
S-5	++++	+++	12	8.38	**12.987**
S-6	++	+	13	9.28	7.525
S-7	+++	++	15	7.44	7.150
S-8	++++	+++	*14*	*7.67*	*10.387*
***Humicola grisea* (Strains)**					
S-1	+++	+++	13	9.48	5.250
S-2	+++	+++	14	8.34	8.612
S-3	++++	++++	15	8.67	7.562
S-4	+	+	15	9.92	**8.825**
S-5	++++	+++	15	8.43	7.062
S-6	++++	+++	14	7.81	1.146
Control					
C1	++	++	16	6.12	4.237
C2	+++	++	17	8.12	9.625
C3	+++	+	17	7.99	4.062
C4	++	+	18	5.17	1.200
SM	-	-	-	-	**6.437**

Colour of the compost produced varied from deep yellow to black. Average fruit body weight ranged between 5.17 to 10.07 among the different treatments. Highest fruit body weight (10.07g) was obtained in S-2 treatment of *H.insolens*.and highest yield of 12.987 kg/q compost was obtained with S-5 strain of *H insolens*. Among the *S. thermophilum* and *H.grisea* strains, strain S-7 and S-4, respectively gave the higher 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 and gave 9.62 Kg mushroom /q compost.

As reported last year study conducted suggested that fairly good compost could be produced in 7-10 days time completely bypassing the Phase-I condition of the compost. However, more experiments are required for perfecting this technology.

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

The raw materials used during entire cultivation cycle were organic based. No chemical fertilizer/pesticides were used at any stage of cultivation. The compost formulation was standardized as mentioned below by using carbon and nitrogen sources of organic origin. The C:N ratio was balanced by supplementing the base materials with organic based animal manures, wheat bran, brewers grain, cotton seed cake and other such materials. The nitrogen/dry matter was balance in the formulation using the analytical values determined by Sharma *et al*. The compost and casing were steam treated for pasteurization and no chemicals were added any stage of its preparation, except gypsum which is basically used for flocculating / coagulating the colloides in the compost and to remedy pH.

Formula -1

Compost ingredients	Quantity
Wheat straw	1000 kg
Poultry manure	800 kg
Wheat bran	250 kg
Cotton seed cake	150 kg
Brewers' grain (wet)	400 kg
Gypsum	35 kg

Water : 4000-4500 litre; N content at start : 1.57

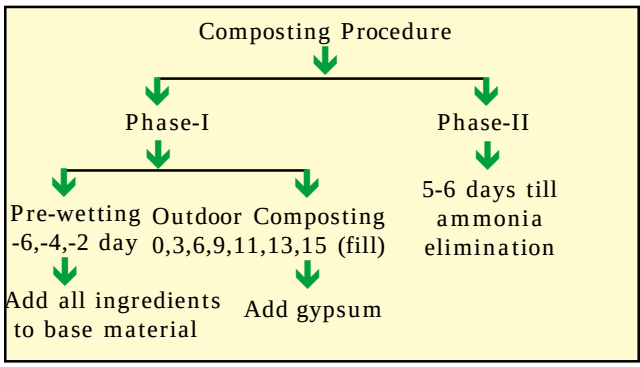
Formula - 2

Compost ingredients	Quantity
Wheat straw	1000 kg
Poultry manure	800 kg
Wheat bran	300 kg
Cotton seed cake	150 kg
Gypsum	35 kg

Water : 4000-4500 litre; N content at start : 1.55

2.1 Composting technology

The flow diagram of composting procedure is as under:



The turnings were more temperature dependent, ensuring temperature of 75°C±2 before each turning. The moisture content on 0-day was at 75%, indicated by slow flow of leaching black fluids from the base of the stack before Ist & 2nd turning. The moisture content is slowly lowered to about 70-72% indicated by leacheates at the bottom present in minute

quantities, but not flowing away. Gypsum was added on 5th turning when ammonia production was at its maximum. The contents are filled into the chamber one or two days after mixing gypsum.

2.2 Spawning and spawn run

Spawning was done @ 0.5% of wet weight of compost, that means adding 500g spawn to 1 q compost by through spawning method. The spawn run compost was filled into polythene bags of 10kg capacity, compacted and mouth loosely closed. The bags were maintained for spawn run at 24°C (air temp.), high CO_2 conc. (vents closed) and 95% RH. The complete spawn run took 2 weeks time, when compost in all bags were fully colonized by mushroom mycelium. Spawn stain A-15 of *Agaricus bisporus* of was used in the trial.

2.3 Casing and case run

Various casing materials were used in the trials includes: i) Spent Mushroom Substrate (2 years old), ii) Farm Yard Manure (2 years old) iii) Coir pith – well decomposed and iv) combinations of (i), (ii) & (iii).

The casing materials were steam pasteurised at 65-70°C for 8 hours, before application. The casing was done in sterile area.Uniform layer of 1" thick casing layer was applied over fully spawn run compost, using 1" thick wooden buttons. The compost surface was levelled before casing application. Water was sprayed over the casing layer in small quantities to keep the casing layer wet. Case run was done at same growing parameters at spawn run, 24°C (air temp.), 95% RH and high CO_2 concentration (vents closed/no fresh air introduced).Case run was completed in 1 week.

2.4 Airing/pinhead formation/cropping

The ventilation was opened after complete case run, bringing in about 30% fresh air and exhausting CO_2. The temperature was simultaneously lowered to 15-17°C (air tempt.), RH of 85% (steam introduction), and CO_2 concentration lowered to almost ambient (around 1000 ppm). The pinheads appeared in 5-7 days after venting. The first harvest was done 17 days after the casing application. The air temperature was maintained in the range of 15-17°C throughout with RH of 85% (steam injection with sensor cut off), and reduced CO_2 concentration (continuous exhaust of CO_2 laden air and introduction of 20-30% fresh air). It was ensured that bed temperature stayed 1-2°C higher than the air tempt. during entire cropping period. The pinheads developed into harvestable mushrooms in 3-4 days. Luxurious mushroom growth all over the cased bed was observed with each flush lasting 5-6 days.

2.5 Harvesting

Average mushroom yield of 18-20 kg was harvested in 6 week of cropping from 100kg compost, with bulk of crop yield obtained in first 3 weeks of cropping. Mushrooms were harvested with care, and casing soil applied at places where mushrooms were picked. Water spraying was done after harvesting of the crop. No pest/disease/competitor mould was observed on the beds during first 3 weeks of cropping, when about 3/4th of the yield was harvested.

2.6 Non chemical pest control

No chemical/pesticide was used at any stage of crop cycle. Flies when detected were trapped on a oil coated polythene sheet hanging at one side of the room with a small yellow bulk at the back side of the sheet. Yellow light attracts the flying insects and brings them to the exposed oiled surface of the sheet, thereby trapping them. This proved very effective in fly control, especially after third week of cropping, when flies start appearing in the room. Diseased mushrooms, as and when spotted on the beds, were covered with

common salt and later removed from the bed. This prevents the spread of the disease organism and also kills the infecting fungus alongwith the mushroom at the site of infection. Strict hygiene was maintained during cropping to prevent the source of inoculum gaining entry into the cropping room. Separate spraying equipment was used for water spraying to the mushroom beds. Provision of double protection on the doors, one insulated door and second inner polythene curtain to prevent entry of inset pests/disease organisms with air steams.

2.7 Pesticide residue analysis

The pesticide residue analysis was done for all the base materials used for composting, casing, spawn, water and finally the fruit body. While pesticides were detected from the base materials before start of composting, but these were successfully eliminated after following the modified composting technique, as no pesticides were detected from the mushrooms harvested (Table-8).

2.8 Conclusion and cost – benefit ratio

Organically produced mushrooms are superior in all quality attributes, besides being free from chemicals/pesticides.Organically produced foods are tastier as compared to areas raised with use of fertilizer. Though cost of production of organically produced button mushrooms was found to be 10-15% higher as compared to non-organically produced mushrooms, but the producer is amply compensated for higher costs fetched by organically produced food crops, including mushrooms.

Table 8: Pesticide residues analytical report of mushroom samples

S.No.	Commdity	Organochlorines (OC)	Organophosphorous (OP)	Synthetic pyrethroids (SY)	Carbendazim	Dithiocarbamate (DTC) on CS_2 basis
1	Organic Mushroom Powder	ND	ND	Deltamethrin 4.050 mg/kg	ND	ND
2	Non-organic Mushroom Powder	ND	ND	Deltamethrin 1.500 mg/kg	ND	ND
3	Phase-I Compost	ND	ND	Deltamethrin 0.350 mg/kg	ND	ND
4	Ready compost Phae-II	ND	ND	ND	ND	ND
5	Chicken Manure (Poultry manure)	ND	ND	ND	ND	ND
6	Cotton Seeed	ND	ND	ND	ND	ND
7	Wheat straw	ND	ND	ND	ND	ND
8	Brewer's grain	ND	ND	ND	ND	ND
9	Ready casing (FYM)	ND	ND	ND	ND	ND
10	Wheat bran	ND	ND	ND	ND	ND
11	Spawn (grain+ mycelium)	Delta-HCH 5.120 mg/kg	ND	ND	ND	ND

ND= Not detected
Organochlorine = Alfa-HCH, Beta-HCH, Gamma-HCH, Delta-HCH, alpha endo, beta endo endosulfan sulfate, dicofol, p,p'-DDE, p,p'-DDD, p,p'-DDT
Organophosphorous = Phorate, dimethoate, phosphamidon, methyl parathion, malathion, chlorpyriphos,
Synthetic pyrethroids= cypermethrin, fenvalerate, fenpropathrin, alfa-methrin, fluvalinate and deltamethrin

3. Speciality mushrooms

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

3.1 Cultivation of *Macrolepoita procera*

Macrolepoita procera was cultivated successfully on compost prepared by short method of composting. The spawn run completed in 30 days at 27°C. The primordia initiated (Fig.1) after 18-20 days after the

Fig. 1: Initiation of primordia

application of casing layer. The fruit bodies were 16-30cm long (Fig.2 &3) with average weight of 30g.

Fig. 2: Growing fruit bodies

Fig. 3: Mature fruit bodies

3.2 Effect of substrate and supplementation on the productivity of *Agrocybe aegerita*

Addition of wheat bran (Table-9) irrespective of rate resulted in quicker spawn run as compared to control thereby reducing the spawn run period. Wheat straw supplemented with wheat bran took 30 days to complete the colonization of the substrate whereas on unsupplemented wheat straw it required 34 days to complete the spawn run. After removal of polypropylene bags the initiation of primordia began in 4-5 days (Fig.4 & 5). The developing primordia attained their full size and the fruit bodies became ready to harvest in 4-5 days. Mean highest (254g) yield was recorded in wheat straw supplemented with 10 per cent wheat bran. Cultivation of *A. aegerita* on wheat straw on addition of wheat bran irrespective of rate resulted in increase in biological efficiency (B.E.). Average number of fruit bodies varied from 80-84. Average weight of the fruit bodies varied between 2.8-3.0g.

The results presented in Table-10 clearly show that supplementation of saw dust with wheat bran resulted in reduction in spawn run period. Maximum duration (42 days) was required to complete the spawn run on

Table 9: Effect of substrate (wheat straw) and supplementation on the yield of *Agrocybe aegerita*

Substrate	Average days required for spawn run	Average total number of fruit bodies	Yield (g/ 400g dry wheat straw)			
			I	II	III	Mean
Wheat straw alone	34	80	233	207	235	225(56.25%)
Wheat straw + 5% wheat bran	30	82	244	227	261	244(61.00%)
Wheat straw + 10% wheat bran	30	84	248	233	281	254(63.50%)
CD 0.05			**7.9**	**14.6**	**9.2**	

Figures in parentheses represent biological efficiency, I: First experiment, II: Second experiment, III: Third experiment

Fig. 4: Spawn run and initiation of primordia after removal of polypropylene bags on wheat straw

Fig. 5: Developing primordia and mature fruit bodies of *A. aegerita* on wheat straw

Table 10: Effect of substrate (saw dust) and supplementation on the yield of *Agrocybe aegerita*

Substrate	Average days required for spawn run	Average total number of fruit bodies	Yield (g/ 400g dry saw dust)			
			I	II	III	Mean
Saw dust alone	42	130	398	428	392	406(67.66%)
Saw dust + 5% wheat bran	40	129	405	433	401	413(68.83%)
Saw dust + 10% wheat bran	39	136	445	460	433	446(74.33%)
CD 0.05			**14.5**	**21.3**	**11.9**	

Figures in parentheses represent biological efficiency, I: First experiment, II: Second experiment, III: Third experiment

Fig. 6: Spawn run and mature fruit bodies of *A. aegerita* on saw dust

unsupplemented saw dust and 10 per cent supplementation resulted in quicker (39 days) spawn run (Fig.6). Average number of fruit bodies varied from 129 to 136. Mean highest (446g) yield was recorded in saw dust supplemented with 10 per cent wheat bran. Irrespective of substrate, supplementation with wheat bran resulted not only in quicker spawn run as compared to unsupplemented substrate but also in increased biological efficiency. The average number of fruit bodies in unsupplemented wheat straw and in 10 per cent supplemented wheat straw were 80 and 84, respectively. There was 5 per cent increase in number of fruit bodies whereas as biological efficiency increased by 8 per cent with supplementation. The increase in yield by supplementation was attributed by both in increase in number of fruit bodies and weight of fruit bodies.

Saw dust proved to be better substrate as it resulted in 67.66 per cent biological efficiency as compared to 56.25 per cent obtained on wheat straw. Supplementation with wheat bran irrespective of substrate resulted in increased biological efficiency. Supplementation of saw dust with 10 per cent wheat bran resulted in 74.33 per cent biological efficiency.

3.3 Enzyme polymorphism and yield of *Flammulina velutipes* in relation to supplementation

Addition of wheat bran in saw dust enhanced the activity of cellulases, hemicellulases and peroxidases whereas cotton seed cake, soybean meal and deoiled soybean resulted in reduced activity of these enzymes. Wheat bran at the rate of 10 per cent supported the fastest linear growth (69mm) of *F. velutipes* followed by 10 per cent soyabean meal (62.7mm) of the same supplement. Addition of 10 per cent wheat bran in saw dust resulted in quickest spawn run and highest (44%) biological efficiency. No fruit body formation took place when the substrate was supplemented with either cotton seed cake or soybean meal or deoiled soybean.

3.3.1 Enzyme assay

The data presented in Table-11 show good activity of Endo-glucanase (41.3 $Uh^{-1}ml^{-1}$), Exo-glucanse (31.0 $Uh^{-1}ml^{-1}$), β-glucanase (28.4 $Uh^{-1}ml^{-1}$) and Xylanase (31.0 $Uh^{-1}ml^{-1}$) by *F. velutipes* in sawdust containing medium while moderate activity of Lignin Peroxidase (19.7 $Umin^{-1}ml^{-1}$) and Mn-peroxidase (38 $Umin^{-1}ml^{-1}$). The activity of cellulases and

Table 11: Extracellular enzymatic activities of *Flammulina velutipes*

Treatment	Dry mycelial wt. (mg/ml) after10 days	Activity of various enzymes								
		Endo-gluca-nase	Exo-gluca-nase	β-gluca-nase	Xylanase	Lamina-rinase	Laccase	PPO	Lig per	Mn per
		$Uh^{-1}ml^{-1}$					$Umin^{-1}ml^{-1}$			
T_1	21	41.3	31.0	28.4	31.0	3.0	0.0	0.0	19.7	38.0
T_2	22	48.7	37.5	29.2	37.5	5.9	3.1	0.0	11.0	26.5
T_3	15	33.0	33.0	29.6	32.6	3.1	0.0	0.0	11.6	21.0
T_4	10	23.3	16.1	12.1	10.0	0.0	0.0	0.0	4.8	14.0
T_5	14	21.4	19.2	17.3	11.4	0.0	0.0	0.0	14.2	15.7
CD(0.05)	**2.2**	**1.04**	**1.32**	**1.04**	**2.61**	**0.73**			**0.54**	**2.11**

Celluloses and hemicellulases: unit= µmole glucose release $ml^{-1}h^{-1}$
Laccase, PPO and Peroxidases: Unit= Change in OD by $0.001ml^{-1}$ min^{-1}

hemicellulases further increased with the supplementation of wheat bran, however, reduction in peroxidase activities was recorded. On the contrary supplementation with cotton seed cake, soybean meal or deoiled soybean resulted in reduced activity of all the enzymes tested. Production of various extracellular degradative enzymes on unsupplemented sawdust indicates the extensive lignocellulose degrading ability of *Flammulina velutipes*.

3.3.2 Growing trials

Addition of wheat bran, irrespective of rate, resulted (Table-12) in increase in biological efficiency (B.E.). Addition of wheat bran resulted in quicker spawn run as compared to control. Addition of 10 per cent wheat bran gave 34.85 to 42.28 per cent B.E. in three different trials as compared to 30.57 to 34.57 per cent B.E. recorded in control. But when the substrate was supplemented with cotton seed cake or soybean meal or deoiled soybean, poor spawn run was recorded and no fruit body formation took place in these treatments.

able 12: Effect of different supplements on the yield of *Flammulina velutipes*

Supplement	Rate (%)	*Days taken for spawn run	Yield (g/350 g dry substrate)		
			I	II	III
Wheat bran	5	26	130 (37.14)	122 (34.85)	148 (42.28)
	10	24	150 (42.85)	138 (39.42)	154 (44.00)
Cotton seed cake	5	Poor spawn run	NFBF	NFBF	NFBF
	10	Very poor pawn run	-do-	-do-	-do-
Soybean meal	5	26	-do-	-do-	-do-
	10	No spawn run	-do-	-do-	-do-
Deoiled soybean	5	Poor spawn run	-do-	-do-	-do-
	10	No spawn run	-do-	-do-	-do-
Control			115	107	121

Average of twenty determinations; NFBF= No Fruit Body Formation; Figures in parentheses represent per cent biological fficiency, I: First experiment, II: Second experiment, III: Third experiment,

3.4 Effect of supplementation on the productivity of *Lentinula edodes*

Addition of 40 per cent wheat bran in saw dust on dry weight basis resulted in highest (80%) biological efficiency of *Lentinula edodes* (Fig.7). Supplementation at the lower rates with the same supplement resulted in decreased yield.

Fig. 7: OE 38 strain of *L. edodes* growing on saw dust supplemented with 40% wheat bran

1. Insect pests and diseases of mushrooms

Project:- NCM-34:Exploitation of indigenous microbes, plant products and pesticides for the management of pests and diseases associated with mushrooms (PI:Dr Satish Kumar)

1.1 Survey and surveillance of major pests and diseases

Survey of different farms revealed widespread incidence of wet bubble, brown plaster mould, green moulds, lipstick mould, *Chaetomium* spp, ink caps at Chambaghat, Vaknagghat, and adjoining areas of Solan. Sciarids, phorids, mites and springtails were common in most of the farms visited. Compost samples collected/ received showed the presence of nematodes in most of the samples.

1.2 Isolation of mesophilic mycoflora

Studies on isolation of the mesophilic mycoflora revealed (Table-1) that chicken manure harboured maximum number of mesophilic mycoflora followed by spent compost. Maximum number of fungal colonies ($10.8X13^3$) were recorded in chicken manure sample. The predominant mycoflora isolated were *Trichoderma* spp, *Aspergillus* spp and *Penicillium* spp. Spent compost contained some of the serious competitor mould like *Verticillium sp, Mycogone* sp and *Sepedonium* sp. *Fusarium* sp. were observed in case of unpasteurized casing. Pasteurized casing mixture was free from the mesophilic mycoflora however, only *Mucor* sp. was observed which is a common air contaminant.

Table 1: Isolation of mesophilic mycoflora

Sample	Mean of number of colonies X 10^3	Predominant mesophilic mycoflora
Chicken manure	10.8	*Trichoderma* sp., *Aspergillus*, sp., *Sepedonium* sp., *Pencillium* sp.
Spent compost	8.4	*Mucor* sp., *Rhizopus* sp., *Sepedonium* sp., *Penicillium* sp., *Verticillium* sp., *Mycogone perniciosa*
Unpasteurised casing	6.8	*Aspergillus* sp., *Fusarium* sp., *Trichoderma* sp.
Pasteurised casing	0	*Mucor* sp.

1.3 Physiological studies on *C. dendroides*

Evaluation of different solid media for the mycelial growth of *C. dendroides* revealed that malt extract agar medium (90 mm) and malt extract peptone dextrose agar (90mm) were the best followed by Joffers medium (81.2mm). Czapekdox medium proved to be the least acceptable medium (38.2mm) for this fungus. Maximum sporulation ($1.92x10^4$) was recorded in MEA medium.

Evaluation of different liquid media for the mycelial growth of *C. dendroides* revealed that Asthana & Hawker broth (0.37 g) was the best followed by Sabourauds broth (0.20g) and Elliot's broth (0.15g) .Least growth (0.04g) was recorded in case of glucose peptone broth and Joffer broth. .

Studies carried out on the effect of different pH levels revealed that the maximum growth was recorded at pH 7 (82.2mm) followed by pH 8 and 9. Least growth was recorded at pH10 (67.7mm). These results indicate that *C. dendroides* is able to grow at wide range of pH.

Studies carried on different nitrogen sources revealed that out of 4 nitrogen sources, the best growth of *C. dendroides* was obtained on aspartic acid (1.05 g) followed by ammonium sulphate (0.12 g) and potassium nitrate (0.11 g). Least growth was recorded in case of sodium nitrate (0.09 g).

Out of 4 carbon sources evaluated maltose (0.32 g) proved to be the best carbon source followed by mannitol (0.09 g) and starch (0.06 g) for the growth of *C. dendroides*. Least growth was recorded in case of folic acid (0.05 g).

Studies conducted on the effect of different growth regulators on the mycelial growth of *C. dendroides* revealed that the best growth was recorded in case of GA (1.02 g) followed by NAA, IAA, IBA, Kinetin (0.99 g) at 5 ppm concentration. When 10 ppm concentrations was tried the best growth was recorded in NAA, IBA and GA followed by IAA and Kinetin (1 g).

1.4 Studies on spore germination

Spore germination studies conducted on 5 different types of water (tap, bore well, distilled, spring and boiled) revealed that bore well, distilled and spring water supported maximum spore germination (100%) followed by boiled water (70%). Least germination was recorded in case of tap water (20%). Longest germ tube was recorded in case of spring water followed by bore well and distilled water. Smallest germ tube was recorded in case of boiled water and in case of tap water germ tube was just emerging.

1.4.1 Effect of different fungicides on spore germination

In order to assess the effect of different fungicides on spore germination, five different concentration of different fungicides were tested. It was observed (Table-2) that in case of bavistin, sporgon and diathane Z-78 spores failed to germinate up to 0.001% concentration. However, at 0.0001% concentration spore germination was 60, 40 and 10%, in case of sporgon, bavistin and diathane Z-78, respectively. In case of kavach spores were able to germinate even at 0.01% concentration. No germination was recorded at 0.1% and higher concentration in any fungicide.

1.4.2 Effect of fungicides on the mycelial growth of *C. dendroides*

When different concentrations of four fungicides were evaluated against *C. dendroides* (Table-3) it was observed that 1.0 and 0.1% concentration of bavistin and sporgon caused 100% inhibition of mycelial growth. However, when bavistin was used at 0.01% and 0.001% concentration 2.02 and 0.11% inhibition in mycelial growth was recorded. Diathane Z-78 proved least effective fungicide against *C.*

Table 2: Effect of different fungicides on spore germination of *C. dendroides*

Fungicide	Germination (%)					
	1.0%	0.1%	0.01%	0.001%	0.0001%	Control
Sporogon	0%	0%	0%	0%	60%	90%
Bavistin	0%	0%	0%	0%	40%	100%
Dithane Z-78	0%	0%	0%	0%	10%	90%
Kavach	0%	0%	2%	20%	20%	100%

Table 3: Effect of different fungicides on the mycelial growth of *C. dendroides*

Fungicide	Diametric growth (mm) and inhibition (%) at different conc. after 7 days							
	1%		0.1%		0.01%		0.001%	
	Dia. growth (mm)	% inhibition	Dia. growth (mm)	% Inhibition	Dia. growth (mm)	% inhibition	Dia. growth (mm)	% Inhibition
Bavistin	0	100	0	100	87.0	2.02	88.7	**0.11**
Sporgon	0	100	0	100	73.4	17.34	87.0	**2.02**
DZ-78	61.2	32	78.8	12.44	87.7	2.6	88.2	**2.0**
Kavach	0	100	46.4	48.44	83.9	6.77	84.3	**6.33**
Control	88.8	-						

dendroides as good mycelial growth was recorded even at 1% concentration. Kavach proved effective when used at 1% concentration .

1.4.3 Evaluation of different plant extracts

Studies carried on different plant extracts revealed (Table-4) that when dry extracts were evaluated against *Cladobotryum dendroides* maximum inhibition in mycelial growth was recorded in *Cannabis sativa* (32.02%) followed by *Tagetus erecta* (27.34%). Least inhibition was recorded in case of *Parthenium* spp (16.52%).

In case of boiled extract maximum inhibition was recorded in *Cannabis sativa* (17.18%) followed by *Thooja campacta* (15.03%). Least inhibition was recorded in case of *Riccinus cummunis* (1.78%).

able 4: Evaluation of plant extracts against *C. dendroides*

Plant	Diametric growth (mm) and inhibition (%)					
	Dry extract		Boiled extract		Alcoholic extract	
	Dia. growth (mm)	% Inhibition	Dia. growth (mm)	% Inhibition	Dia. growth (mm)	% Inhibition
Dhatura strumonium	64.75	24.26	77.2	7.87	60.5	15.26
Tagetus erecta	62.12	27.34	80.6	3.81	60.8	14.84
Nyctanthes aror-tristis	67.75	20.76	78.5	6.32	62.4	12.6
Parthenium spp.	71.37	16.52	75.7	9.66	NT	-
Callistomon lanceolatus	65.62	23.25	79.8	4.77	56.5	20.8
Cannabis sativa	58.12	32.02	69.4	17.18	31.2	56.3
Gardenia spp.	67.5	21.05	73.4	12.41	NT	-
Thooja campacta	65.37	23.54	71.2	15.03	49	31.37
Ricinus cummunis	71.25	16.66	82.3	1.78	58.8	17.64
Eucalyptus spp.	64.62	24.42	81.1	3.22	49.4	30.81
Control	85.5		83.8		71.4	

T = Not Tested

In case of alcoholic extract maximum inhibition was recorded again in *Cannabis sativa* (56.3%) followed by *Thooja campacta* (31.37%). Least inhibition was recorded in case of *Nyctanthus aror- tristis* (12.6%). Among the different extraction methods alcoholic extract of *Cannabis sativa* proved effective anti fungal agent which can be exploited under *in-vivo* conditions.

1.5 Yield loss and management of cinnamon mould during cultivation of *Calocybe indica*

Chromelosporium fulva made its appearance as large circular patches of white aerial mycelium on the compost or casing. The fungus produces numerous cup-like fleshy fruit bodies on beds. Out of the four inoculum levels tried, maximum (62.0 per cent) yield loss was recorded with 2.0g inoculum load. Among fungicides, Dithane Z-78, Bavistin and Sporgon proved to be the most toxic at all the concentrations tried and gave 100 per cent mycelial inhibition. Neemol was the most effective plant product as it gave 84 and 87 per cent reduction in the mycelial growth of *C. fulva* at 2 per cent concentration when it was added before and after sterilization of the substrate, respectively. Two sprays of DithaneZ-78 were most effective against *C. fulva* which gave 825g yield/ 5kg wet substrate.

2 Insect-pests

2.1 Isolation and testing of *Bti*

In order to assess the efficacy of Bti against sciarid larvae, 18 isolates were isolated from casing soil, spent compost, dead larvae, chicken manure and field soil. Each isolate was tested against sciarid larvae following rapid testing method. Isolate Bti 132 caused 100% mortality of larvae within 24 hours. Spore crystal complex of each isolate was prepared and kept in storage for further use. Molecular characterization of each isolate has been completed.

2.2 Studies on the persistence of carbendazim residue in market samples of mushrooms

In order to assess the residue level of carbendazim in 26 samples collected from market , different growers and NRCM were analysed for carbendazim reside. Although residue was detected in every sample but level was below the permissible limit.

2.3 Studies on persistence of malathion in white button mushroom

Persistence of malathion sprays (1-4) at four different concentrations (0.01, 0.05, 0.07, 0.1%) given at weekly intervals was estimated (Table-5) in *A. bisporus* strain S-11 grown on steam pasteurized compost. It was observed

Table 5: Persistence of malathion in first flush

Conc (%)	Residue in ppm / No of sprays			
	One spray	Two spray	Three spray	Four spray
First flush				
0.01	0.003	0.011	0.172	-
0.05	0.316	0.378	0.624	-
0.07	0.064	0.264	0.460	-
0.1	0.091	0.095	0.698	-
Control	ND	ND	ND	ND
Second flush				
0.01	0.142	0.254	0.266	0.309
0.05	-	0.066	0.150	0.244
0.07	-	0.008	0.118	0.152
0.1	0.102	0.183	0.189	0.244
Control	ND	ND	ND	ND
Third flush				
0.01	ND	0.149	0.186	0.189
0.05	ND	0.056	0.201	0.877
0.07	0.132	0.192	0.212	0.243
0.1	0.152	0.167	0.174	0.182
Control	ND	ND	ND	ND

ND= Not Detected

that when four sprays of 0.01% concentration were given during different growth stages of crop, residue of malathion ranged from 0.003ppm –0.172ppm, 0.142 ppm – 0.309 ppm and 0.0149 ppm – 0.189 ppm in first, second and third flushes , respectively. When 0.05% concentration was sprayed, residue in first, second and third flush ranged from 0.316 ppm-0.624 ppm, 0.066ppm-0.244ppm and 0.056ppm-0.877 ppm, respectively. When 0.07% concentration was sprayed, residue in first, second and third flush ranged from 0.064ppm-0.460 ppm, 0.008 ppm-0.152ppm and 0.132ppm-0.243 ppm, respectively. When 0.1% concentration was sprayed, residue in first, second and third flush ranged from 0.091 ppm-0.698 ppm, 0.102ppm-0.244 ppm and 0.152ppm-0.182 ppm, respectively. Malathion at 0.1% can safely be used for the management of mushroom flies.

2.4 Slugs –a new pest of shiitake

The slug, *Laevicantis altii* was recorded as the new pest of shiitake causing 40-60% yield loss. Under laboratory conditions when slugs were released in a jar containing fruit bodies of *Lentinula edodes*, *Agaricus bisporus*, *Pleurotus* spp and *Calocybe indica*, they caused severe damage to the fruit bodies of all the mushrooms within 24 hours.

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

3.1 Molecular characterization

For raising liquid mycelial cultures of 17 fungi for DNA isolation, malt extract broth culture medium containing malt extract 10g, dextrose 5g, distilled water 1 litre was prepared and dispensed 50 ml in 150 ml conical flasks and plugged with non-absorbent cotton. These flasks were then autoclaved at 15 psi (121°C) for 30 minutes. The fungal cultures were inoculated and pure cultures raised at 25^0C for 8 days. Approximately, 100 mg of fungal mycelium from 8 days old broth culture of each strain was taken in Ependoffs tubes of 1.5 ml capacity. For DNA isolation, Qiagen plant mini kit was used and the protocols of the manufacturer were followed. The DNA was quantified using the fluoremeter (Hoefer Tm DyNA quant 200) with calf thymus DNA as standard DNA.

The Polymerase Chain Reaction (PCR) primer ITS-1 (5'-TCC GTA GGT GAA CCT GCG G-3') and ITS-4 (5'- TCC TCC GCT TAT TGA TAT GC-3') were used to amplify the ITS of ribosomal DNA, which encompasses the 5.8S gene and both ITS-1 and ITS-2 regions. Amplification by PCR was performed in a total volume of 50 µl containing: 1U *Taq* DNA polymerase (Promega), 2.5 mM $MgCl_2$, 160 mM dNTP mix (MBI, Fermentas), 50 pmol of each ITS-1 and ITS-4 primers, 50 ng genomic DNA in dH_2O. The reactions were performed in a Master cycler with following conditions. 1 min denaturation at 95 °C, 30 sec annealing at 50 °C, 1 min 20 sec elongation at 72 °C, for 34 cycles with a final elongation step of 72 °C for 10 min. The PCR products alongwith 6x loading dye (MBI Fermentas) were run on 1% agarose gel alongwith DNA ladder mix (MBI Fermentas, SM-0333) in Tris-Acetic acid-EDTA (1x TAE) buffer at 60 V for 100 min. Agarose gels were stained with ethidium bromide (Sigma Chem.) and photographed under UV light for amplified ITS products using Syngene gel documentation system. The ITS amplified region of 5.8S ribosomal DNA of 17 fungi is shown in Fig. 1.

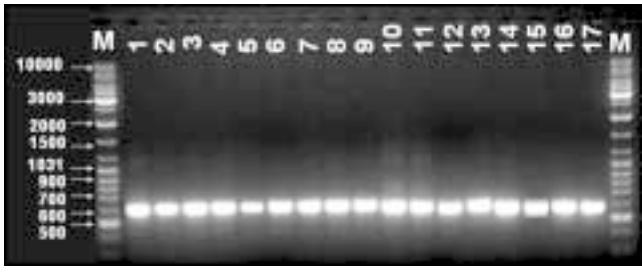


Fig. 1: ITS amplified region of 17 pathogenic fungal strains

The ITS amplified products of 5.8s r RNA gene was send for DNA sequencing at South Campus, New Delhi. The sequences were compared with that of available sequences at NCBI World Databases. Out of 17 pathogenic fungi, the sequences were compared and the nucleotide-nucleotide BLAST results confirmed that the samples 1-9 were of *Caldobotryum varium*, samples 10-13 were identified as *Sepedonium chalcipori*, samples 14 and 15 were identified as *Acremonium alternatum* and samples 16 and 17 were identified as *Chaetomium globosum*

The multilocus genotyping was performed using two decamer primers supplied by Operon Technologies, namely OPA-4 and OPP-16. The PCR analysis was performed for 17 pathogenic fungi. The RAPD profiles of 17 pathogenic fungi by primer OPA-4 are shown in Fig. 2.

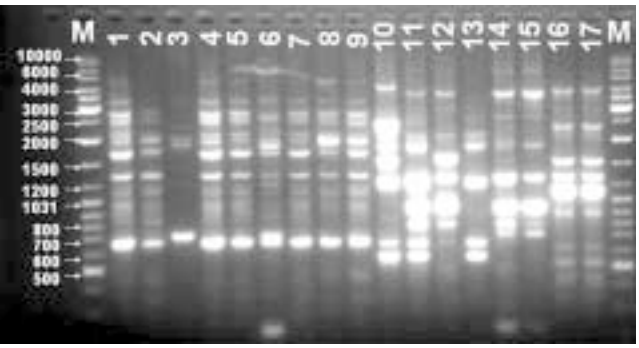


Fig. 2: RAPD profiles of pathogenic fungi

The gel profiles were scored for presence and absence of scorable bands with assumption of positional homology. To estimate genetic distances and similarity coefficients were calculated with the help of dendrogram constructed using UPGMA algorithm (unweighted pair Group Method using Arithmetic Averages) of the NTSYS-pc, version 2.02h software. The phylogenetic tree of these pathogenic fungi is shown in Fig. 3.

Phylogenetic tree clearly reveals that except CD-17 isolate of *Cladobotryum varium*

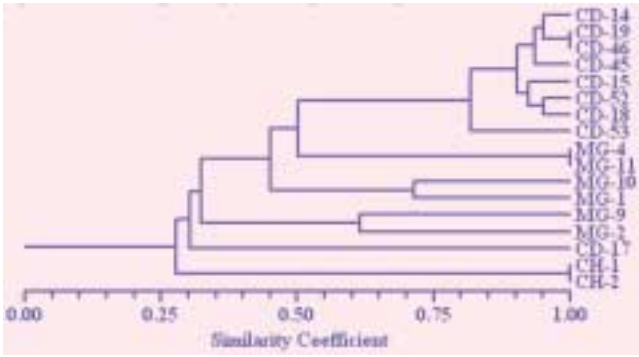


Fig. 3: Phylogenetic tree of pathogenic fungi

all the eight isolates exhibited more than 90% similarity, whereas both the isolates of *Acremonium alternatum* viz. MG-4 & MG-9 and *Chaetomium globosum* viz. CH-1 & CH-2 had identical RAPD profiles. The maximum variation within four isolates of *Sepedonium chalcipori* was observed.

3.2 Studies on *Fusarium chlamydosporum* and *Mortierella alpina*

Fusarium chlamydosporum and *Mortierella alpina* causing Fusarial rot and Shaggy stipes, respectively were recorded to be the new pathogen of white button mushroom in India and species of both the pathogens as new record in the world. Nucleotide sequencing by using Basic Local Alignment Search Tool network services confirmed the identity as *Fusarium chlamydosporum* and *Mortierella alpina*. The sequences obtained were submitted to NCBI Gene Bank and Gene accession numbers were obtained (EF-017709 and EF-015575).

3.3 Studies on enzyme production by different isolates of *Cladobotryum*, *Mycogone*, *Fusarium chlamydosporum* and *Mortirella alpina*

Data presented in Table- 6, revealed that C-11 isolate of *Cladobotryum* isolated from *Pleurotus sajor-caju* showed no activity of Peroxidase, Poly Phenol Oxidase and very low activity of Laccase. This isolate had good

Table 6: Extracellular enzyme production by *Cladobotryum* isolates

Isolate	Endo-gluca-nase	Exo-gluca-nase	β-glucosidase	Xylanase	Peroxidase	Laccase	PPO	Pectinase	Chitinase
C-11	35.7	47.8	35.7	70.4	0	8	0	799.9	89.7
C-14	18.9	29.5	8.1	15.7	0	8	0	770.7	90.7
C-15	9.5	27.4	9.4	28.9	0	0	0	1043.8	63.9
C-17	9.2	52.3	11.9	24.3	0	3	3	737.5	100.9
C-18	7.5	27.1	5.6	23.5	0	4	3	341.6	89.2
C-19	12.5	31.2	9.8	21.2	0	0	2	468.3	90.7
C-45	8.8	24.0	3.2	17.0	0	0	2	343.4	75.1
C-46	9.4	24.0	6.7	21.3	0	0	0	78.0	95.6
C-52	10.9	13.7	3.7	15.5	0	0	0	472.2	88.7
C-53	7.1	18.9	4.8	13.7	0	1	4	468.3	100.9

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}

activity of Exo (29.5 $Uh^{-1}ml^{-1}$), Endo glucanase (35.7 $Uh^{-1}ml^{-1}$), β-Glucosidases (35.7 $Uh^{-1}ml^{-1}$), and Xylanase (70.4 U $min^{-1}ml^{-1}$), and greater activity of Chitinase (89.7 U $h^{-1}ml^{-1}$), and Pectinase (799.9 $Uh^{-1}ml^{-1}$). Isolate C-15, C-46 and C-52 isolated from *Agaricus bisporus* did not show any activity of Peroxidases, Laccase and PPO. Isolate C-15 had the maximum (1043.8 $Uh^{-1}ml^{-1}$) activity of Pectinase. The other isolates too have greater activity of Pectinase. Activity of Chitinase varied from 32.6-100.9 Units in the four isolates isolated from *A. bisporus*. The three (C-15, C-46 and C-52) isolates had good activity of Exo (13.7-24.4 $Uh^{-1}ml^{-1}$), Endo glucanase (9.4-10.9 $Uh^{-1}ml^{-1}$), β-glucosidases (3.7 -9.4 $Uh^{-1}ml^{-1}$), and Xylanase (15.5-28.9 U $min^{-1}ml^{-1}$). Almost a similar trend for various enzymes was observed for C-17 and C-53 isolates isolated from *Calocybe indica*. Mg-1 isolate of *M. perniciosa* showed greater activity of Chitinase (741.4 U ml^{-1} h^{-1}) and Pectinase (124.3 U). No activity of Peroxidase and PPO was observed in any isolate of *M. perniciosa* (Table-7).

Table 7: Extracellular enzyme production by *Mycogone* isolates

Isolate	Endo-gluca-nase	Exo-gluca-nase	β-glucosidase	Xylanase	Peroxidase	Laccase	PPO	Pectinase	Chitinase
Mg-1	15.9	35.1	7.8	13.8	0	0	58	124.3	741.4
Mg-2	12.1	46.0	4.8	16.2	0	0	98	78.5	542.8
Mg-4	11.5	47.1	5.8	11.5	0	0	68	85.6	419.5
Mg-9	20.3	20.2	4.6	9.4	0	0	98	51.7	519.5
Mg-10	33.9	33.8	4.7	8.9	0	0	82	86.7	485.8
Mg-11	45.3	45.3	5.3	5.6	0	0	82	84.9	379.7

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}

It is evident from the data presented in Table- 8 that *Mortierella alpina* showed no activity of Poly Phenol Oxidase and very low activity of Laccase. This isolate had good activity of Exo (36.04 $Uh^{-1}ml^{-1}$), Endo-glucanase (17.39 $Uh^{-1}ml^{-1}$) and β-Glucosidases (56.36 $Uh^{-1}ml^{-1}$). Similarly *Fusarium chlamydosporum* had good activity of Exo (36.63 $Uh^{-1}ml^{-1}$), Endo glucanase (22.27 $Uh^{-1}ml^{-1}$) and β-Glucosidases (73.71 $Uh^{-1}ml^{-1}$).

3.4 Studies on yield loss due to different isolates of *Cladobotryum* in Button, Oyster and Milky mushrooms

The data presented in Table 9 revealed that various isolates of *Cladobotryum* resulted in 22-50 per cent loss in yield in *Pleurotus sajor-caju*. C-11 proved to be the most harmful resulting in 50.00 per cent reduction in yield. C-17 and C-45 resulted in 22 per cent reduction in yield. Similarly in *Calocybe indica* different isolates resulted in 11-22 per cent loss in yield. C-11 resulted in 22.22 per cent reduction in yield and C-46 caused 11.76 per cent yield loss. In case of *Agaricus bisporus* the loss percentage varies from 10.11 to 28.57, C-15 resulting in the maximum (28.57%) loss in yield. It is interesting to note that C-11 isolate which resulted in maximum yield loss in *Pleurotus* and *Calocybe* showed greater activity of Endo-glucanase, Exo-glucanase, β-glucosidase and Xylanases as compared to C-15 isolate which gave maximum yield loss in *A. bisporus*. C-15 isolate was having more activity of Pectinase and Chitinase as compared to C-11 isolate.

Table 8: Enzyme profile *Mortierella alpina* and *Fusarium chlamydosporum*

Fungus	Enzyme activity (Uml^{-1} min^{-1})			Enzyme activity (Uml^{-1} h^{-1})			
	Laccase	PPO	Peroxidase	C_1	C_X	Xylanase	β-Glucosidase
Mortierella alpina	2.08	0.0	52.44	36.04	17.39	4.44	56.36
Fusarium chlamydosporum	4.11	4.17	54.0	36.63	22.27	15.33	73.71

Table 9: Yield loss due to *Cladobotryum* isolates in button, oyster and milky mushrooms

Cladobotryum isolate	Yield (g) of *P. sajor-caju*/ 5 kg wet substrate	Yield (g) of *C. indica*/ 5 kg wet substrate	Yield (Kg) of *A. bisporus*/ 10kg compost
C-11	450 (50.00)	660 (22.23)	1.42 (15.47)
C-14	610 (32.22)	700 (17.64)	1.51 (10.11)
C-15	675 (25.00)	715 (15.88)	1.20 (28.57)
C-17	700 (22.22)	680 (20.00)	1.46 (13.09)
C-18	680 (24.44)	730 (14.11)	1.43 (14.88)
C-19	720 (20.00)	750 (11.76)	1.48 (11.90)
C-45	695 (22.27)	690 (18.82)	1.38 (17.85)
C-46	600 (33.33)	750 (11.76)	1.50 (10.71)
Control	900	850	1.68
CD 0.05	**36.5**	**42.0**	**0.04**

Figures in parentheses represent per cent loss in yield over control

Medicinal Mushrooms

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

1. Germplasm collection

Two indigenous (collected from wild) and one exotic (Malaysian) culture of *Ganoderma* were added to the gene bank.

2. Refinement in cultivation technology

Normally, reishi (*Ganoderma lucidum*) is grown in a polybag filled with 700 gm sawdust supplemented (20%) with wheat bran. An experiment was laid out to study the effect of size of bags with 500 g, 750 g, 1000 g, 1200 g and 1500 g of dry substrate moistened to 65% level uniformly and filled in poly propylene bag of appropriate sizes, on yield and quality of the reishi mushroom. There was no significant difference in the yield (B.E.) from 500 to 1200 g. However, 1500 g bag gave significant lower yield per unit weight of the substrate but average weight of fruit body was highest in 1500 g bag. In general, bigger but lesser fruit body was obtained in the heavier bag.

2.1 Dynamics of the production of extracellular lignolytic enzyme in the substrate during the crop cycle of the reishi

Production of the extracellular lignolytic enzyme, namely ligninase and Mn^{++} peroxidase by *G. lucidum* during various stage of the crop cycle were studied by extracting the enzyme from the substrate in the growing bag in the citrate buffer. It was found that the activity per unit weight of the substrate increase with the mycelial colonization, declined abruptly after full colonization (at the time of yellowing or browning pigmentation of the bag) and remained very low during the pinning, growth and maturation. No significant allegation in the activity was noticed during various stages of fruit body development.

Post harvest technology of mushrooms

Project:- NCM-35: Modified atmosphere packaging and storage of mushrooms (PI: Er. T. Arumuganathan)

The experiments were conducted on the modified atmospheric packaging (MAP) of button mushroom in PET jars. The variation in the gas composition was measured using the CO_2/O_2 meter. The various quality analysis conducted for the stored 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. Diffusion channel method was found to be the best method of storage to prolong the shelf life of button mushroom up to 8 days in ambient storage (18±1^{o}C). Storage containers (Fig.1) provided with 3 mm diameter and 15 cm length diffusion channel were found to be highly suitable for the purpose.

Fig. 1: Button mushroom stored with diffusion channels at ambient condition

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

1. Fabrication of compost turner

A compost turner of 5 tonnes/hr capacity was designed and fabricated (Fig. 1). It consisted of MS angle 1 ½" and MS channel 3" frame having dimensions 5' 4" wide, 14' long and 5' 4" high as 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 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 are 48 rpm, 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 72 and is achieved with the help of pulley and belt mechanism having drive motor 2 HP and 1440 rpm. Mixing rollers are of 360 rpm, which is used for the conveyed compost to be mixed properly. Four wheels carry the compost turner. Two 20" rubber wheels and two 8" wheels were provided in the main frame and the speed of compost turner is 0.8 rpm, which is achieved by main drive mechanism.

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

In order to compare the compost qualities by traditional composting method and by compost turner, the compost has been prepared mechanically using the compost turner by traditional long method using wheat straw and wheat straw + paddy straw and all the quality attributes of both the compost have been 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,

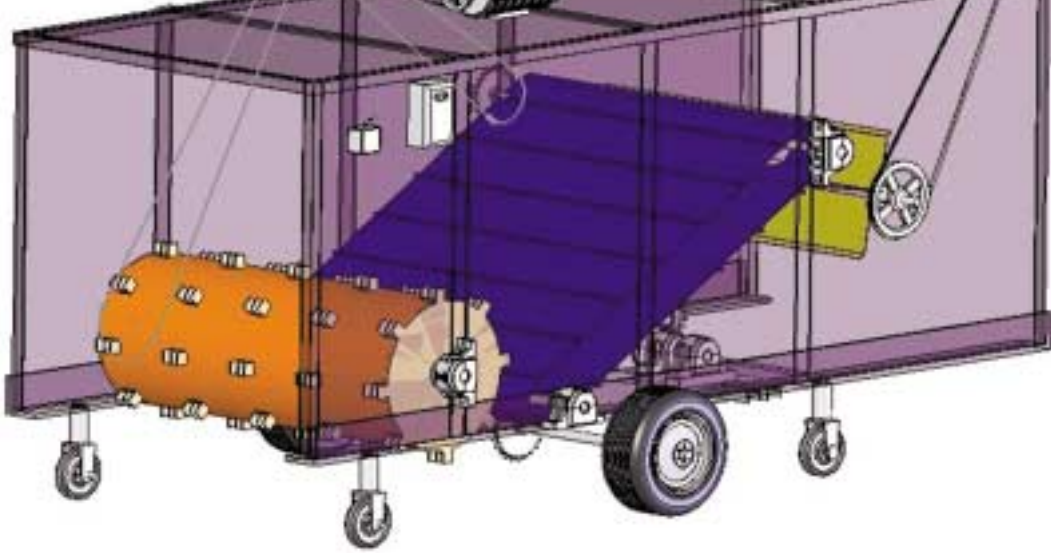


Fig. 1: Diagramatic view of Compost Turner using the software Solid Works

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. All these values were compared with the manually prepared compost pile and it was observed that the quality of the compost turned mechanically was found better. The mushrooms obtained from the mechanically turned compost were superior to the traditional one.

3. Fabrication of compost conveyor

A compost conveyor is designed to carry compost to the bunker or elsewhere saving the labour and time. The conveyor is of 18' length and 2' width and is carried on four wheels of 8" dia, out of 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.

Compost conveyor will carry the compost from the yard to the tunnels and bunkers at the rate of 5 tonnes/hr. The height may be adjusted as per the requirement from 6 feet to 10 feet.

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

In order to verify vermicompost as medium for button mushroom cultivation, vermicompost prepared from FYM was spawned with button mushroom spawn after treating it with malathion. Keeping in mind the experience of last year trial,shallow plastic trays were used instead of plastic bags and spawned vermicompost was filled upto 5 inches height in the tray and covered with polythene sheet. The required temperature for spawn run (22-25^0 C) was maintained. In initial stage, spawn run was noticed in very small patches on the surface but it could not be colonized fully and later on mycillium disappeared from vermicompost. The results of last year as well as current year indicated that vermicompost is unsuitable for mushroom growing. However, few mushroom growers got few mushrooms by chance when they mixed spawn in vermicompost in open field ,but when they tried it systematically as indoor, they could not get success.

To verify and refine ITK about use of burnt rice husk mixed with F.Y.M. and soil in different ratio as casing material in button mushroom by mushroom growers, second experimental trial was laid out at the Centre. The burnt rice husk based different casing formulations namely burnt rice husk+soil(1:1v/v), burnt rice husk+soil+FYM(1:1:1v/v), burnt rice husk+FYM(2:1v/v), burnt rice husk+FYM(1:2 v/v), burnt rice husk+FYM(1:1 v/v), coir pith + FYM+ burnt rice husk (2:1:2 v/v) were applied on spawn run compost and required conditions were maintained in the cropping room. All the combination were found yielding mushrooms but level of production was below the control treatment (spent compost + FYM in 1:1 ratio). The combination - coir pith + FYM+ burnt rice husk (2:1:2 v/v) was found much closer to control treatment.

A new ITK - indigenous bunker system was also collected during the year. This ITK is infact a reinvention done by a mushroom grower. The reinvented bunker system's aerated floor is made of bricks attached with portable ordinary blower instead of iron-slatted floor and powerful fixed blower in scientifically developed bunker for preparing short method compost.

2. Refinement of ITKs on the use of spent mushrooms substrate as manure in field and horticultural crops

The indigenous technical knowledge about recycling of spent mushroom substrate, collected during the first year of the project 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 and horticultural crops viz., wheat, ginger, capsicum, peas, cauliflower and onion. The findings of repeat trials are given below:

Wheat: The vegetative growth with respect to plant height, tillers/m^2, dry wt. of tiller, dry wt. of plants/m^2, ear length, grains/ear and test weight of grains was highest in aerobically recomposted SMS + basal dose of chemical fertilizers. Similarly, the yield parameters with respect to grains/m^2, straw/m^2 and grain: straw ratio was also superior in aerobically recomposted SMS + basal dose of chemical fertilizers treatment.

Onion: In case of onion, plant height, number of leaves/plant, length of bulb and diameter of bulb were superior in anaerobically

and aerobically recomposted SMS + recommended dose of chemical fertilizers, and recommended dose of fertilizers treatment alone. The net yield was highest in anaerobically recomposted SMS + chemical fertilizers and naturally weathered SMS + chemical fertilizers treatments.

Brinjal: In case of brinjal, 24 months old aerobically recomposted SMS gave highest number of fruits/plot followed by control, while highest yield was obtained from recommended dose of fertilizers which was statistically at par with 24 and 12 months old anaerobically/ aerobically recomposted SMS treatments, respectively. Fruit weight was at par in recommended dose of fertilizers and 24 months old anaerobically recomposted SMS.

Ginger: In case of ginger, the vegetative growth of the plants with respect to plant height, number of stems emerged/rhizome and number of leaves/stem was superior in anaerobically recomposted SMS + basal dose of chemical fertilizers treatment. The rhizome yield and quality was again significantly superior in anaerobically recomposted SMS + basal dose of chemical fertilizers treatment and was at par with recommended dose of fertilizers treatment. The best SMS treatment yielded 144.44q/ha of rhizome with an average length(10.20cm), breadth(5.15cm) and thickness (3.1cm).The rhizome rotting was lowest of 5% in FYM and anaerobically recomposted SMS without chemical fertilizer treatments.

Use of SMS for vermicomposting: In order to have premilary information about preparation of vermicompost out of spent compost, trials were laid out at the Centre during the year. A kuchha tank and thatched hut was prepared for this purpose. Tank and heap methods of vermicomposting were adopted and experiments were conducted making variation in second and third layers keeping the base layer almost unchanged. During the experiments, it was learnt that spent substrate obtained from white button and oyster mushrooms cultivation can be converted into vermicompost.

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 2006-07 was collected.

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. Under this project, four off-campus training programmes were also organized in N.E. States during April, 2006-March,2007 at Guwahati (Assam), Aizwal (Mizoram), Jairampur (Arunachal Pradesh) and Agartala (Tripura). The data on training needs assessment were collected before starting all these off-campus training programmes. One on-campus training programme was organised for farmers of Sikkim. The data on training needs assessment and fulfilment were collected for further study.

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, farmwomen, entrepreneurs & Agril/Hort Officers.

5.2 Mushroom Mela- 2006

One day Mushroom Mela was organised on 10th September, 2006 as regular activity of the Centre. It was inaugurated by Dr. Gautam Kalloo, DDG (Hort.), ICAR, New Delhi in the presence of guest of honour Dr. Jagmohan Singh, Vice chancellor Dr. Y.S. Parmar University of Hort. and Forestry, Solan(H.P.) and other dignitaries.

Fig. 1. Dr. G. Kalloo, DDG (Hort.) visiting the exhibition during mushroom mela

It was attended by about 500 farmers, farm women, mushroom growers, researchers, extension workers and businessmen from various States viz; Himachal Pradesh, Haryana, Punjab, Uttar Pradesh, Maharashtra, Rajasthan, Delhi, Orissa and J&K.

An exhibition on improved mushroom cultivation technologies and other related aspect was organised in which fifteen Govt. Organisation, ICAR Institutes/University, Govt. financial organisation, compost and spawn producers, mushroom product manufacturer, seed and 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 cultivation and mushroom products.

In order to make aware to 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 held to answer 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 awarded two progressive mushroom growers Sh.Sunil Kumar, R/O village Ahir majra, Sonepat(HR) and Sh. Joginder Singh R/O village Saharmal pur, Panipat(HR) for adopting innovative practices in mushroom cultivation on larger scale and mobilizing other farmers to adopt mushroom cultivation as source of income.

5.3 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 put up stalls in international level exhibition-IITF-2006 organized by ITPO at Pragati Maidan, New Delhi From 14-27th Nov., 2006.

5.4 Teaching to farmers/entrepreneurs/ SMS

The Centre had conducted two in-house and six sponsored training programmes for farmers at the Centre. All the scientists delivered lectures on various aspects of mushrooms.

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 and training were also replied through telephone and e-mail .

5.6 Preparation of extension literature

One multicoloured folder on recycling of SMS to use as organic manure was prepared.The training compendium for farmers (in hindi) has been compiled and edited. **Chhatrak- Hindi Patrika** has also been compiled and edited.

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

1. Mushroom Production Information of India

Mushroom production information has been collected for India and figures for the year 2006-07 is projected in Table-1. Punjab leads the production with Agro-Dutch alone accounting for 45,000 tonnes of white button mushroom followed by Tamil Nadu, Maharashtra, Himachal Pradesh and so on. White button mushroom remains the most popular mushroom in India. *Pleurotus* and *Calocybe* are fast catching up. As far as the number of growers are concerned, Himachal Pradesh has the maximum number of mushroom growers (450). A majority of them are seasonal growers who purchase compost from government agencies or private suppliers.

able 1: Statewise mushroom production in India

State	Production (tonnes)	Growers/ farmers	*Type of mushroom
Andhra Pradesh	3500	10	A,P
Chattisgarh	100	10	A,P
Goa	500	10	A,P
Gujarat	500		A,P,C
Haryana	7500	100	A,P,C
HP	5000	400	A,P,C,M
J&K	500	50	A,P,M
Jharkhand	50	15	A,P,C
Karnataka	500	25	A,P,C
Kerala	1800	15	A,P,C
MP	3000		A,P,C
Maharashtra	7500	150	A,P,C
Orissa	1000	100	P,C,V
Punjab	7000 +45000 (Agro Dutch)	80	A,P,C,V
Rajasthan	1000	50	A,P,C
Tamil Nadu	14000	25	A,P,C
Uttar Pradesh	2500	15	A,P,
Uttaranchal	4100	100	A,P
West Bengal	500	20	A,P
North East	500	50	A,P
Andamans	*Pleurotus* is being cultivated but data not available		P
Total	**106050**		

A-*Agaricus;* P-*Pleurotus;* C-*Calocybe;* V-*Volvariella*; M-*orchella* (collected)

The information was collected through government officials and mushroom growers through correspondence and personal visits. The figures of the last five years are shown in the Fig. 1. Information has also been collected on the marketing trends of mushrooms in the region, firms which are involved in export of mushrooms and some websites through which online trading of mushrooms can be done.

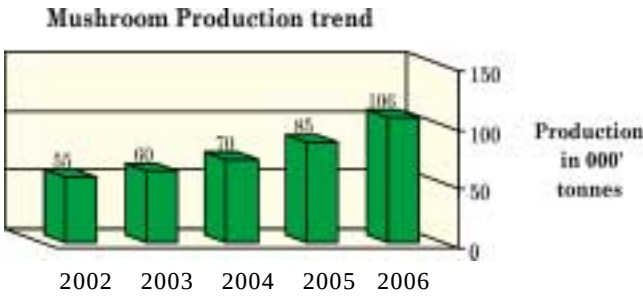


Fig. 1: Mushroom production trend

Project:- NCM-39: Development of expert systems on cultivation of different types of mushrooms (PI: Sh. Yogesh Gautam)

The Knowledge Base of the Expert Systems is being developed. Questions have been formulated related to the white button mushroom production technology for inclusion in the question bank of the knowledge base.

8. TRAINING COURSES ORGANISED

S. No.	Name of training programme	Sponsored by	No. of Trainees	Course Director/ Course Coordinator
1.	Ten days training programme on mushroom production technology for Entrepreneurs w.e.f. 9th to 18th May, 2006.	Paid training programme of the Centre.	23	Dr. R.D.Rai Er. T.A.Nathan
2.	Three days training programme on mushroom production technology for farmers of Rampur Bushar(H.P.) of Forest Dept.under DFID project from 15th -17th April,2006	Dept. of Forest, Rampur Bushar (H.P.) DFID project	9	Dr. M.P.Sagar
3.	Seven days training programme on mushroom production for farmers and unemployed youths w.e.f. 13th to 19th June, 2006.	NRCM, Solan	54	Dr. B.Vijay Dr. M.P.Sagar
4.	Seven days training programme on mushroom production for farmers and unemployed youths w.e.f. 22 to 28th August, 2006.	NRCM, Solan	47	Dr R.P. Tewari Sh.Yugesh Gautam
5.	Seven days training programme on mushroom production technology for HDO's of Haryana State from 19th to 25th Sept, 2006.	Directorate of Horticulture, Panchkula	20	Dr. B.Vijay Dr. M.P.Sagar
6.	Seven days training programme on mushroom production technology for HDO's of Haryana State from 10th to 16th Oct., 2006.	Directorate of Horticulture, Panchkula	16	Dr. B.L. Dhar Dr. S.K. Singh
7.	Seven days training programme on mushroom production for supervisors, ADOs & Hort. Inspectors of Dept. of Hort. Ranikhet (UA) w.e.f. 7th to 13th Nov., 2006.	Dept. of Horti. (UA)	21	Dr.R.C. Upadhyay Dr. M.P. Sagar
8.	Ten days training programme on mushroom production technology for Entrepreneurs sponsored by HP-STEP, Shimla w.e.f. 29th Nov – 7th Dec.,06 & 28th Dec, 2006.	HP-STEP, Shimla	20	Dr. B. Vijay Dr. M.P. Sagar
9.	Three days off campus training programme on mushroom production technology for farmers of Mau (U.P.) w.e.f. 22nd - 24th July, 2006.	NBAIM,Mau (U.P.)	100	Dr.R.P.Tewari Dr. D. Arora Dr. B. Vijay Dr. R.D. Rai Dr. A.K. Singh
10.	Three days off campus training programme on mushroom production technology for mushroom growers/ farmers at Itanagar (Arunachal Pradesh), w.e.f. 5th – 7th Dec, 2006	MM-I Scheme	40	Dr. B. Vijay Dr. M.P. Sagar

S. No.	Name of training programme	Sponsored by	No. of Trainees	Course Director/ Course Coordinator
11.	Eight days training programme on mushroom production technology for farmers of Sikkim state w.e.f. 26th Feb. to 5th March, 2007.	MM-I Scheme	28	Dr. B. Vijay Dr. M.P. Sagar
12.	Three days off campus training programme on mushroom production technology for progressive farmers & officers of Aizwal(Mizoram), w.e.f 5th – 7th March,2007	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 & officers of Guwhati (Assam), at Guwhati, w.e.f. 20th – 22nd Feb, 2007	MM-I Scheme	40	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. 23rd–25th Feb, 2007	MM-I Scheme	65	Dr. B. Vijay Dr. M.P. Sagar

Fig. 1. Chief Guest awarding certificates to the trainees

Fig. 2. Chief Guest awarding certificates to the entrepreneurs

Fig.3: Off Campus training in Arunachal Pradesh under MM-1 Scheme

9. EDUCATION AND TRAINING

Training of scientists

1. Dr. O.P.Ahlawat attended 14 days training on "National Workshop on Genetic Engineering" from 24th June to 7th July, 2006 at Department of Biotechnology, Punjab University, Chandigarh.

2. T.Arumuganathan attended 21 days Winter School on "Extrusion Cooking Technology & Its Application for Processing Soybean" sponsored by Indian Council of Agricultural Research and organized by the Central Institute of Agricultural Engineering, Bhopal from 1st November to 21st November, 2006 at CIAE, Bhopal (M.P.).

3. T.Arumuganathan attended 3 days scientists training on "Bio diesel - Crop Cultivation Techniques and Processing" organized by Agricultural Engineering College & Research Institute (Centre of Excellence in Bio fuels), Tamil Nadu Agricultural University and Indian Council of Agricultural Research held at TNAU, Coimbatore on 5th – 7th March, 2007.

Summer training of students

1. Mr. Bhushan R. Joshi, M.Sc. (Botany) student of University of Pune completed his project work on "DNA Fingerprinting of *Agaricus bisporus* Strains using RAPD markers" w.e.f. 22-05-2006 to 22-07-2007 under the guidance of Dr. M.C.Yadav.

2. Mr. Satinder Rana, M. Sc. (Biotechnology) student of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni completed his RAPD analysis work of thesis entitled "Identification of Gender in Dioecious *Hippophae salicifolia* Using RAPD Markers" from June, 2006 – December, 2006, under the guidance of Dr. M.C.Yadav

3. Miss. Navjyoti Narang, M.Sc. (Biotechnology) student of Shoolini Institute of Life Sciences and Business Management, Solan, completed her training project on "DNA Fingerprinting of *Agaricus bisporus* Strains using RAPD Markers" w.e.f. 9-1-2007 to 9-3-2007 under the guidance of Dr. M.C.Yadav

4. Mr Ashok Kumar, M.Sc students in the Department of Biotechnology,KAP's Institute of Medical Science, Panchkula completed his training Project "Molecular and biochemical studies on yellow mould " w.e.f. 02-11-2006 to 02-02-2007 under the guidance of Dr. V.P. Sharma.

5. Mr Ajay Kumar, M.Sc students in the Department of Biotechnology, Sadhu Vaswani College, Bairagarh, Bhopal (MP) completed his summer training project on "Molecular and biochemical studies on *Spepedonium* spp." w.e.f. 07-06-2006 to 07-09-2007 under the guidance of Dr. V.P. Sharma

6. Mr Atul Mishra, M.Sc student in the Department of Microbiology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni completed his training Project "Molecular characterization of *Bacillus* strains" w.e.f. 20-02-2007 to 20-03-2007 under the guidance of Dr. V.P. Sharma.

7. Mr Sanjeev Kumar, M.Sc student in the Department of Microbiology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni completed his training Project "Molecular characterization of *Pseudomonas* strains" w.e.f. 20-02-2007 to 20-03-2007 under the guidance of Dr. V.P. Sharma.

8. Mr Varun Sharma, M.Sc (Bio-technology) student of AICTE (Affiliated to M.D.S. University, Ajmer, Raj.) completed his project work on "Mushroom cultivation technology of white button mushroom" w.e.f. 24-08-2006 to 23-09-2006 under the guidance of Dr. M.P. Sagar.

10. AWARDS, RECOGNITION AND FOREIGN VISITS

1. Dr. M.P. Sagar received Young Scientist Award- 2007 presented by the Society of Extension Education, situated at Advance Research & Management Centre of Rural Development, Agra (UP).

2. OP Ahlawat Received Best Poster Award for paper entitled "Studies on bioremediation of pesticides using spent mushroom substrate" authored by Pardeep Gupta, OP Ahlawat, Satish Kumar, DK Sharma and Dev Raj during XIX Annual Conference of National Environment Science Academy (NESA), New Delhi and National Seminar on Solid Waste Management: Solutions and Concerns held on September 16-18, 2006 at Punjab University, Chandigarh.

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 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. 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 Headquarter at NRCM, Solan which are listed below:

- 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, Thiruvananthapuram (Kerala).
- ICAR Research Complex for NEH Region, Barapani (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, Pradeep, Raj, Dev and Vijay, B. 2006. Dye decolorization potential of spent substrates from *Agaricus bisporus* and *Pleurotus* sp. - a laboratory study. *Mushroom Research* **15:** 75-82.

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

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

4. Kumar, Satish and Sharma, V.P. 2006. Persistence of carbendazim and mancozeb on *Agaricus bisporus*. *Annals of Plant Protection Sciences* **14:** 266-267.

5. Sagar, M.P. and Vijay, B. 2006. Impact of mushroom cultivation training on horticulture officers. *Indian Res. J. Extension Education* **6:** 45-47

6. Semwal, K.C., Bhatt, R.P. and Upadhyay, R.C. 2006. *Amanita avellaneosquamosa* (Imai) Imai, a new record of the genus *Amanita* for India. *Mushroom Research* **15:** 7-9.

7. Sharma, S.R., Kumar, Satish and Sharma, V.P. 2006. Physiological requirement for cultivation of Malaysian strain of shiitake, *Lentinula edodes*. *J. Mycol. Pl. Pathol*. **36:** 149-152.

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

9. Sharma, V.P. and Kumar, Satish. 2006. Effect of crop residue supplements to substrate on the productivity of black poplar mushroom, *Agrocybe aegerita*. *J. Mycol. Pl. Pathol*. **36:** 189-192.

10. Sharma, V.P., Kumar, Satish and Kumari, Ranjna. 2006. Symptomatology and management of cobweb disease of oyster mushroom. *Mushroom Research*. **15:** 55-58.

11. Sharma, V.P., Kumar, Satish and Mahajan, Sonali. 2006. Yield loss and management of *Oedocephalum* during cultivation of *Calocybe indica*. *Annals of plant protection sciences* **14:** 306-309.

12. Singh, S.K., Tiwari, M., Kamal, S. Yadav, M.C. and Singh, S. 2006. Cytology of hyphal interactions in ascospore cultures of *Morchella esculenta*. *Mushroom Research* **15:** 11-17.

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

14. Mugdha, Tiwari, Singh, S.K., Kamal, S., Singh, S. and Yadav, M.C. 2006. Extra-cellular enzyme polymorphism in *Morchella* and related species. *Journal of Mycology and Plant Pathology* **36:** 64-68.

15. Raj, Dev, Lal, B.B., Rai, R.D. and Ahlawat, O.P.2007. Yield, quality and storability of

the fried potato chips of different Indian cultivars. *Processed food Industry*, March 2007: 40-47.

16. Vijay, B. 2006. Indoor composting for button mushroom cultivation. *Mushroom Research* **15:** 23-27.

17. Tandon, Gayatri and Sharma, V.P. 2006. Yield performance of *Calocybe indica* on various substrates and supplements. *Mushroom Research* **15:** 33-35.

18. Tandon, Gayatri, Sharma, V.P. and Jandaik, C.L. 2006. Evaluation of different casing materials for *Calocybe indica* cultivation. *Mushroom Research* **15:** 37-39.

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

A. Book/ Book Chapter

1. Dhar, B.L. and Kaul, T.N. 2007. Biology and Cultivation of Edible Mushroom. Westille Publisher House, New Delhi. p. 240.

2. Sharma ,V.P. and Suman B.C. 2006**.** *Khumb Ki Kheti***.** Agribios , Jodhpur (India) p. 103.

B. Technical Bulletins

1. Ahlawat, O.P. and Sagar, M.P. 2006. Management of Spent Mushroom Substrate (SMS). National Research Centre for Mushroom, Chambaghat, Solan (HP) - 173 213, India. p. 37.

2. Ahlawat, O.P. and Tewari, R.P. 2006. Cultivation Technology of Paddy Straw Mushroom (*Volvariella volvacea*). National Research Centre for Mushroom, Chambaghat, Solan (HP) - 173 213, India. p. 30.

C. Reports

1. Ahlawat, O.P. and Kumar, Satish. 2006. Compiled and edited AICMIP Annual Report 2005-06, NRCM, Solan (HP) p. 52.

2. Ahlawat O.P., Kumar, Satish and Gautam, Yogesh. 2006. Compiled and edited NRCM Mushroom Newsletter 11(2), p. 8.

3. Ahlawat O.P. 2006. Compiled and edited proceedings of the Xth Biennial Workshop of AICMIP held on 26-27 October, 2006 at IGAU, Raipur, p. 72.

4. Bhatia, Reeta and Ahlawat, O.P. 2006. Khumb Prakasn / Publications on mushroom (folder in Hindi and English). NRCM, Solan (HP) p. 20.

5. Rai, R.D., Singh, S.K., Tewari, R.P. and Yadav, M.C. 2007. Complied and edited Souvenir-cum-Abstracts on "International Conference on Mushroom Biology and Biotechnology" organized by Mushroom Society of India and National Research Centre for Mushroom, Solan, NRCM, Solan on 10-11th February, 2007, p. 209.

6. Sharma, V.P., Kumar, Satish and Sagar, M.P. 2006. Compiled and edited NRCM's Annual Report 2005-2006, p. 91 + xii.

7. Yadav, M.C., Singh, S.K. and Verma, Shailja. 2006. Compiled and edited *Mushroom Newsletter* January-June, 2006 volume 12 (1) p. 8.

D. Popular/ Technical Articles

1. Ahlawat, O.P. and Sagar, M.P. 2006. Paira (prali) mushroom ki kheti (folder in Hindi). NRCM, Solan (HP).

2. Ahlawat, O.P. and Sagar, M.P. 2006. Recycling of Spent Mushroom Substrate to use as organic manure (folder in English). NRCM, Solan (HP).

3. Dhar, B.L. and Arumuganathan, T. 2006. *Kam mulya ka khumb utpadan kaksh*. (Folder in Hindi) NRCM, Solan. p. 8.

4. Gautam, Y. 2006. The Million Dollar email. On http://www.home.rica.net/alphae/fighter1.html

5. Gautam, Y. 2006. Marketing Strategies of Mushrooms. Project Report submitted to IGNOU in partial fulfillments of the degree of MBA. p. 45.

6. Sharma, V.P. and Kumar, Satish. 2006. *Kumb ki Kheti ke dauran aavashyak savdhaniyan*. *Indian J. Mush.* XXIII: 37-39.

7. Sharma, V.P., Kumar, Satish and Singh, S.K. 2006. *Trichoderma* causing green mould in mushrooms and its management - A Review. *Mushroom Research* **15(2):** 93-102.

E. Abstracts

1. Ahlawat, O.P., Raj, Dev, Sagar, M.P., Gupta, Pardeep, and Vijay, B. 2007. Recycling of spent mushroom substrate as manure for wheat (*Triticum aestivum*) cultivation. In: International conference on "*Mushroom Biology and Biotechnology*" held on 10-11 Feb, 2007 at NRCM, Solan(HP)

2. Ahlawat, O.P., Raj, Dev, Sagar, M.P., Gupta, Pardeep, and Vijay, B. 2007. Recycling of spent mushroom substrate as manure for ginger (*Zingiber officinale*) cultivation. *Ibid.*

3. Ahlawat, O.P., Gupta Pardeep, Sharma, D.K. Raj, Dev and Vijay, B. 2007. Bioremediation through SMS: An eco-friendly technique to improve the soil environment. In: Souvenir – cum – Abstracts of International Conference on Mushroom Biology and Biotechnology (ICMBB) held on 10-11 February, 2007 at National Research Centre for Mushroom, Solan (HP), India, p. 89-90.

4. Ahlawat, O.P., Raj, Dev, Sagar, M.P., Gupta, Pardeep and Vijay, B. 2007. Evaluation of recomposted spent mushroom substrate as manure for ginger (*Zingiber officinale*) cultivation. In: Souvenir – cum – Abstracts of International Conference on Mushroom Biology and Biotechnology (ICMBB) held on 10-11 February, 2007 at National Research Centre for Mushroom, Solan (HP), India, p. 94.

5. Ahlawat, O.P., Raj, Dev, Sagar, M.P., Gupta, Pardeep and Vijay, B. 2007. Use of recomposted spent mushroom substrate as manure for wheat (*Triticum aestivum*) cultivation. p. 95 *Ibid.*

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. *Ibid.*

8. Arumuganathan, T., Chandrasekar, V. and Rai, R.D. 2007. Preparation of mushroom preserve (*murabba*) from the white button mushroom (*Agaricus bisporus*). Souvenir cum Abstracts on "International Conference on Mushroom Biology and Biotechnology" organized by Mushroom Society of India and National Research Centre for Mushroom, Solan held at NRCM, Solan on 10-11th February, 2007, pp. 166.

9. Arumuganathan, T., Ahlawat, O.P. and Rai, R.D. 2007. Standardisation of the process for preparation of the nuggets from the button mushroom powder. p 165. *Ibid.*

10 Atri, N.S, Upadhyay, R.C. and Bajwa, Rajinder Singh 2007. Evaluation of different solid and liquid media for mycelial growth of *Lentinus squqrrosulus*.Mont. *Ibid.*

11. Dhar, B.L., Ahlawat, O.P., Dubey, J.K. Patyal, S.K. and Thakur, Meera. 2006 Organic Mushroom Production, Pesticide Residue Analysis and Quality Procedure. "Symposium on Biodiversity and Biotechnology: Research and Development Needs in Edible Mushroom and Crop Disease Management". Nov 9-11, 2006, ISMPP and Deptt. Of Path., GB Univ. of Agriculture and Tech., Pantnagar, Uttranchal.

12. Dhar, B.L. Ahlawat, O.P. Dubey, J.K. Patyal, S.K. and Thakur, Meera. 2007. Organic Farming of Mushrooms-Importance, Status and Technology. "International Conference on Mushroom Biology and Biotechnology" MSI and NRCM, Solan, 10-11 Feb., 2007.

13. Gautam, Y. 2007. Prospects of E-Commerce for Markeing of Mushrooms. pp191-192. *Ibid.*

14. Gautam, Y. 2007. Internet Resources on Mushroom Science and Production. pp187-188 *Ibid.*

15. Gupta, Pardeep, Ahlawat, O.P., Sharma, D.K., Raj, Dev and Vijay, B. 2007. Bioremediation capacity of spent mushroom substrate (SMS) against fungicides and insecticides. p. 96 *Ibid.*

16. Gupta, Pardeep, Ahlawat, O.P. and Kumar, Satish. 2006. Bioremediation of heavy metals through spent mushroom substrate. In: Abstracts of XIX Annual Conference of National Environment Science Academy (NESA), New Delhi and National Seminar on Solid Waste Management: Solutions and Concerns held on September 16-18, 2006 at Punjab University, Chandigarh. p. 88.

17. Gupta, Pardeep, Ahlawat, O.P., Kumar, Satish, Sharma, D.K. and Raj, Dev. 2006. Studies on bioremediation of pesticides using spent mushroom substrate. p. 89. *Ibid.*

18. Kumar, S., Sharma S.R. and Sharma V.P. 2007. Biological control of insects-pests of mushrooms. Souvenir cum Abstracts on "International Conference on Mushroom Biology and Biotechnology" organized by Mushroom Society of India and National Research Centre for Mushroom, Solan held at NRCM, Solan on 10-11th February, 2007 pp. 109-110.

19. Kumar, S., Sharma S.R. and Sharma, V.P. 2007. Studies on persistence of malathion on white button mushroom. p. 112. *Ibid.*

20. Kumar, S., Sharma , S.R. and Sharma, V.P. 2007. Effect of various insecticides against edible fungi and sciarid fly (*Bradysia* spp) larvae. p. 113. *Ibid.*

21. Kumar, S. ,Sharma, S.R. and Sharma, V.P. 2007. Screening of different oyster species against sciarid (*Bradysia* spp). pp. 114-115. *Ibid.*

22. Prasad, K., Singh, Harsimran, Sogi, D.S. and Rai, R.D. 2007. Optimization of drying parameters of button mushroom (*Agaricus bisporus*) in fluidized bed drying using response surface methodology. p. 163. *Ibid.*

23. Raj, Dev, Sagar, M.P., Ahlawat, O.P., Gupta, Pardeep, and Vijay, B. 2007. Recycling of spent mushroom substrate as manure for Brinjal (*Solanum melongena)* cultivation. *Ibid.*

24. Raj, Dev, Sagar, M.P., Ahlawat, O.P., Gupta, Pardeep and Vijay, B. 2007. Use of recomposted spent mushroom substrate as manure for brinjal (*Solanum melongena*) cultivation. p. 97 *Ibid.*

25. Raj, Dev, Vaidya, Devina, Gaur, Shreshtha, Rai, R.D., Sharma, P.C. and Vaidya, M.K. 2007. Standardization and evaluation of value added product (Mushroom noodles) from white button mushroom (*Agaricus bisporus*). p. 172. *Ibid.*

26. Rai, R.D. 2006. Biological diversity, pharmacological properties, bioactive constituents and clinical studies on medicinal mushroom Reishi (*Ganoderma lucidum*). Proc. 33rd National Conference of Association of Clinical Biochemists of India, AFMC, Pune on 23-26th November 2006.

27. Rai, R.D. 2007. Importance and scope for the value-addition in mushrooms. pp. 155-156. *Ibid.*

28. Rai, R.D. 2007. Current status of biodiversity in the genus *Ganoderma*. Souvenir cum Abstracts on "International Conference on Mushroom Biology and Biotechnology" organized by Mushroom Society of India and National Research Centre for Mushroom, Solan held at NRCM, Solan on 10-11th February, 2007, pp. 21-22.

29. Rai, R.D. and Arumuganathan, T. 2006. Potential of *Ganoderma* as medicinal mushroom – an appraisal. 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.

30. R.D.Rai and Arumuganathan., T. 2007. Effect of pretreatments on quality and drying characteristics of sun-dried oyster mushroom (*Pleurotus florida*) in the temperate region. pp: 160-161. *Ibid.*

31. Sagar, M.P., Ahlawat, O.P., Raj, Dev, Gupta, Pardeep and Vijay, B. 2007. Recycling of spent mushroom substrate as manure for pea (*Pisum sativum*) cultivation. p. 98 *Ibid.*

32. Sagar, M.P., Ahlawat, O.P., Raj, Dev, Gupta, Pardeep and Vijay, B. 2007. Reuse of spent mushroom substrate for onion (*Allium cepa* L.) cultivation. p. 99. *Ibid.*

33. Sagar, M.P. and Vijay, B. 2007. Livelihood security through mushroom cultivation. Presented in 4th National Extension Education Congress on Livelihood Security and Extension System Perspectives from 9th to 11th, March, 2007 at JNKVV, Jabalpur(MP).

34. Sharma, S.R., Kumar, S. and Sharma, V.P. 2007. Present Status of wet bubble in India. Souvenir cum Abstracts on "International conference on mushroom biology and biotechnology" held at NRCM, Chambaghat w.e.f. 10-11 February, 2007, pp. 107-109.

35. Sharma, V.P., Sharma, S.R. and , Kumar, S. 2007. Cultivation of least exploited commercial mushrooms. pp. 129-130. *Ibid*.

36. Sharma, V.P. and Kumar, S. 2007.Studies on Yield loss by different species and isolates of *Trichoderma* in Oyster, Milky and Button mushrooms. pp. 110-111. *Ibid*.

37. Sharma, V.P. and Kumar, S. 2007. Extracellular enzyme profile of *Mycogone* and *Cladobotryum* species associated with mushrooms. pp. 100-101. *Ibid*.

38. Singh, S.K. 2006. Molecular diagnostic tools for genetic characterization of edible mushrooms in Conference on “Biodiversity and Biotechnology: Research and Development Needs in Edible Mushrooms and Crop Disease Management” held at GBPUAT, Pantnagar, Uttrakhand from 9-11, November, 2006.

39. Singh, S.K. 2007. Molecular characterization and cryopreservation of edible mushroom germplasm. In International Conference on Mushroom Biology & Biotechnology from 10-11,Feb.,2007 at National Research Centre for Mushroom, Chambaghat, Solan. pp. 36-38.

40. Singh, A.J. and Gautam, Y. 2007. HCI in Mushroom Industry. pp188-189. *Ibid*.

41. Tewari, R.P. and Ahlawat, O.P. 2007. Recycling of Agro-wastes for microbial protein production through mushroom production. p. 96 . *Ibid*.

42. Upadhyay, R.C., Kaur Aman jeet and Semwal, K.C. 2007. New records of fleshy fungi from North western Himalaya. *Ibid*.

43. Vijay, B. and Mediratta, Vishal. 2007. Studies on thermophilic fungi of *Agaricus bisporus* compost – a review. *Ibid*.

44. Yadav, M.C. 2006. Recent Advances in Molecular Breeding of Button Mushroom *Agaricus*species. In: Souvenir of National symposium on “Biodiversity and Biotechnology:Research and Development Needs in Edible Mushrooms and Crop Disease Management” organised by G.B. Pant University of Agriculture and Technology, Pantnagar, from 9-11 November, 2006. pp. 46-48.

45. Yadav, M.C. 2007. Mushroom genome: current status and implications for genetic improvement. In: Souvenir-Cum-Abstracts of International Conference on “Mushroom Biology and Biotechnology” jointly organised by Mushroom Society of India and National Research centre for Mushroom, Solan from 10-11 February, 2007, pp. 39-41.

13. APPROVED ONGOING RESEARCH PROJECTS

On-going Research Projects of NRCM

Institute Code	Title	Researchers		Period/Remarks
NCM-15	Survey, collection and identification of fleshy fungi	Dr. R.C. Upadhyay	Principal Investigator	Jan., 98 – continued
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.,2002 to July, 2007
NCM-37	Genetic manipulations for high yield and better quality in button mushroom (*Agaricus* species)	Dr. M.C. Yadav Dr. S.K. Singh	Principal Investigator Co-Investigator	Aug., 2006 to July, 2011
NCM-36	Genetic enhancement for higher yield and better quality in milky mushroom (*C.indica*)	Dr. M.C. Yadav Dr. S.K. Singh Dr. R.P. Tewari	Principal Investigator Co-Investigator Co-investigator	Aug., 2006 to July, 2010
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 to June, 2009
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.,1998 – continued
NCM-38	Improvement in cultivation of oyster and developing hybrid strains	Dr. R.C. Upadhyay Dr. R.P. Tewari	Principal Investigator Co-Investigator	Jan., 2007 to Dec., 2012
NCM-40	Integrative use of cultivation technologies and molecular techniques for enhancing yield and quality of paddy straw mushroom, *V. volvacea*	Dr. O.P. Ahlawat Dr. R.D. Rai Dr. V.P. Sharma Dr. Satish Kumar	Principal Investigator Co-Investigator Co-Investigator Co-investigator	Jan., 2007 to Dec., 2012
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 – continued
NCM-31	Organic mushroom production and quality produce	Dr. B.L. Dhar Dr. O.P. Ahlawat Dr. J.K. Dubey, Dr. Amit Nath	Principal Investigator Co-Investigator Co-Investigator Co-investigator	March, 2002 to March, 2007
NCM-34	Exploitation of indigenous microbes, plant products and pesticides for the management of pests and diseases associated with mushrooms	Dr. Satish Kumar Dr. S.R. Sharma Dr. V.P. Sharma	Principal Investigator Co-investigator Co-Investigator	July, 2006 to June, 2011

Institute Code	Title	Researchers		Period/Remarks
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, 2004 to June, 2009
NCM-35	Modified atmosphere packaging and storage of mushrooms	Er. T. Arumuga-nathan Dr. R.D. Rai	Principal Investigator Co-Investigator	Aug., 2006 to July, 2010
NCM-25.	Studies on development of evaporatively cooled mushroom growing rooms and low cost mechanization for mushroom industry	Er.T. Arumuga-nathan Dr. R.P. Tewari	Principal Investigator Co-Investigator	July, 1999 to July, 2007
NCM-26	Database on mushroom growers of India	Sh. Yogesh Gautam Dr. M.P. Sagar	Principal Investigator Co-Investigator	Jan., 2001 – continued
NCM-39	Development of expert system for cultivation of different types of mushrooms.	Dr. Y. Gautam	Principal Investigator	Jan., 2007- Dec., 2009
NCM-30	Collection, documentation and validation of indigenous technical knowledge about mushroom cultivation.	Dr. M.P. Sagar Dr. B. Vijay	Principal Investigator Co-Investigator	Feb., 04 to July, 2007

Externally Funded Projects:

Title of the Project	PI/Co-PI of the Project	Duration	Funding Agency
Collection, identification and culturing of Agricoid and Polyphorid fungi from North Western Himalayas for new drug discovery.	Dr. R.C. Upadhyay	July, 2004 to June, 2007	CSIR
Development of indigenous machinery for spawn and mushroom production	Dr. R.P. Tewari Er. T. Arumuganathan	Nov.,2004 to Nov., 2007	Network Project
Agrowaste management, bioremediation and microbes in post harvest processing	Dr. B. Vijay Dr. R.P. Tewari Dr. M.P. Sagar	Aug., 2006 to July, 2009	ICAR
Microbial diversity and identification	Dr. R.C. Upadhyay	Aug., 2006 to July, 2009	ICAR
Standardization of conditions for exploitation of spent mushroom substrate for decolourization of colouring dyes.	Dr. O.P. Ahlawat	Nov., 2006 to Oct., 2009	DST
Integrated development of horticulture in North-Eastern States.	Dr. R.C. Upadhyay (NRCO) Dr. B. Vijay Dr. M.P. Sagar	April, 2004 to March, 2007	Central sector scheme HTM (MM-I) ICAR

Consultancy Provided by the Scientists of NRCM

1. HAIC Agro R&D Centre, Integrated Mushroom R&D Project, G.T. Link Road, Murthal (Hry.) installation of machinery consultancy charges 75% of 1% consultancy charges for the P/O Skid Steer Loader of amount of Rs.7,30,000.00

2. Sh. Uma Dutt Sharma, V&PO Shargaon, Via, Ochghat, Distt. Sirmour (H.P.) Techno Economic Feasibility Report was prepared.

3. Sh. J.P.S. Brar, 4832, Jai Dayal Street, Mukstar – 152026 (Pb.) Techno Economic Feasibility Report was prepared.

14. COMMITTEE MEETINGS

(a) Institute Management Committee: Institute Management Committee, NRCM, Solan (H.P.) approved by the Council vide office order F.No. 14-13/90-1 A.V. dated 8th July, 2004 and F.No. 14-13/90-1A.V. dated 26th July, 2005 for a period of three years w.e.f. 24.06.2004 and 18.07.2005. Two meetings of IMC were held on 30.08.2006 and 22.11.2006.

1.	Dr. R.P. Tewari, Director, National Research Centre for Mushroom, Chambaghat, Solan (H.P.) – 173213.	-	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, Shimla – 2, Himachal Pradesh.	-	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. Bhadsavle, At: Malegon, Post Neral, Taluka Karjat, Distt. Raigarh, Maharashtra – 410 101.	-	Member
8.	Sh. Karma Gyasto Bhutia, Lachng House, Chandmari, T.V. Tower Road, Gangtok, East Sikkim – 737202.	-	Member

9. Dr. S.R. Sharma, Principal Scientist, National Research Centre for Mushroom, Chambaghat, Solan (H.P.) – 173213.	-	Member
10. Dr. R.C. Upadhyay, Principal Scientist, National Research Centre for Mushroom, Chambaghat, Solan (H.P.) – 173213.	-	Member
11. Dr. S.K. Chakraborty, Principal Scientist, Central Potato Research Institute, Shimla (H.P.).	-	Member
12. Finance & Accounts Officer, National Dairy Research Institute, Karnal (Haryana)	-	Member
13. Sh. Hari Singh, Administrative Officer, National Research Centre for Mushroom, Chambaghat, Solan (H.P.) – 173213.	-	Member Secretary
14. Dr. R.D. Rai, Principal Scientist, National Research Centre for Mushroom, Chambaghat, Solan (H.P.) – 173213.	-	Special Invitee
15. Sh. Jiwan Lal, National Research Centre for Mushroom, Chambaghat, Solan (H.P.) – 173213.	-	Special Invitee

(b) Research Advisory committee: One meeting was held on 1-2 August, 2006

1. Dr. H.S. Garcha, Ex-Dean PAU, 36, Sant Park, Behind Agar Nagar, Phase-I, Ludhiana (Pb.).	-	Chairman
2. Dr. T.N. Lakhanpal, Ex-Head, Deptt. of Biosciences, H.P. University, Summer Hills, Shimla - 171 005 (HP).	-	Member

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

Fig. 1. Dr H.S.Garcha, Chairman RAC conducting meeting at NRCM

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

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

6. Sh. Chandra Shekhar H. Badsawale, - Member
Saguna Baug, At: Malegaon,
PO Neral, Taluka Karjat,
Distt. Raigad – 410 101 (MS).

7. Sh. Karma Gyasto Bhutia, Lachng House, Chandmari, T.V. Tower Road, Gangtok,	-	Member
8. Asstt. Director General (VC), Indian Council of Agricultural Research, Krishi Anusandhan Bhavan-II, Pusa, New Delhi – 110 012.	-	Member
9. Dr. R.P. Tewari, Director, NRCM, Solan	-	Member
10. Dr. S.R. Sharma, Principal Scientist NRCM, Solan	-	Member Secretary

(c) Staff Research Council (SRC)

The meeting of Staff Research Council (SRC) was held on 29th and 31st August, 2006 and 30th November, 2006. It was attended by all the scientists under the Chairmanship of the Director, NRCM, Solan.

(d) 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. Three meetings were held on 24.05.2006, 19.06.2006 and 02.12.2006 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/E.O.	-	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

(e) Sectional Heads Meeting

One meeting of sectional heads was held on 25.05.2006 under the chairmanship of Dr. R.P. Tewari, Director.

Dr. R.P. Tewari, Director	-	Chairman
Dr. S.R. Sharma, Head, Crop Protection Section	-	Member
Dr. R.D. Rai, Head, Crop Nutrition & Utilization Section	-	Member
Dr. B.L. Dhar, Head, Crop Production Section	-	Member
Dr. R.C. Upadhyay, Head, Crop Improvement Section	-	Member
Dr. B. Vijay, Head, Crop Production Section	-	Member
Sh. Rishi Ram, AAO	-	Member
Sh. Jiwan Lal, AFACO	-	Member
Sh. Hari Singh, Administrative Officer	-	Member Secy.

(f) Senior Officer's Meetings

Two meetings of Senior Officer's of this Centre were held on 30.06.2006 and 28.02.2007 under the chairmanship of Dr. R.P. Tewari, Director, NRCM. All the scientists, AAO, AFACO are the members & AO was the Member Secretary.

(g) Institute Joint Staff Council (IJSC)

Two meetings of IJSC were held on 19.07.2006 and 03.01.2007 under the chairmanship of Dr. R.P. Tewari, Director. The members of IJSC are:

I. 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, Assistant Administrative Officer

II. 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

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

(v) Sh. Nika Ram, SS Grade-III

(vi) Sh. Ajeet Kumar, SS Grade-II

(h) Grievance Cell

Since no grievance of any employee came hence no meeting was held.

I 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

II Staff side Member

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

(i) Consultancy Processing Cell (CPC)

Two meetings of Consultancy Processing Cell (CPC) were held 01.12.2006 and 02.03.2007 under the chairmanship of Dr. B. Vijay, Principal Scientist.

Members

1. Dr. B. Vijay, Principal Scientist	-	Chairman
2. Dr. S.K. Singh, Senior Scientist	-	Member
4. Sh. Hari Singh, Admn. Officer	-	Member
5. Sh. Jiwan Lal, AFACO	-	Member
6. Dr. O.P. Ahlawat, Senior Scientist	-	Member Secretary

(j) Rajbhasa Implementation Committee(Hindi Committee)

Committee of Parliament on Official Langauge visited, NRCM, Solan on 10.06.2007 in connection with inspection of hindi work.

Four meetings of Rajbhasa Implementation Committee were held on 21.06.2006, 01.09.2006, 26.12.2006 and 28.03.2007 under the chairmanship of Dr. R.P. Tewari, Director.

Members

Dr. R.P. Tewari, Director	-	Chairman
Dr. Satish Kumar, Senior Scientist	-	Member
Dr. M.P. Sagar, Senior Scientist	-	Member
Sh. Hari Singh, A.O.	-	Member
Er. T. Arugumunathan, Scientist	-	Member
Ms. Reeta, T.O.	-	Member
Mr. Deep Kumar Thakur, Stenographer	-	Member
Mrs. Sunila Thakur, Stenographer	-	Member Secy.

Hindi Week

Hindi Week was celebrated at NRCM, Solan w.e.f. 14-21 September, 2006 in which all the staff members took part. Various competitions viz. debate competition for scientists, dictation, writing, essay, noting, computer typing and technical note for all the Officers/Officials were held.

Hindi workshops

Three workshops were held on 05.07.2006, 28.11.2006 and 15.03.2006 for all the staff members (except class IV) in which it was emphasized to do maximum work in Rajbhasa.

15. SEMINARS/SYMPOSIA/CONFERENCES ATTENDED

Dr. B.L.Dhar

- Attended "Symposium on Biodiversity and Biotechnology: Research and Development Needs in Edible Mushroom and Crop Disease Management". Nov 9-11, 2006, ISMPP and Deptt. Of Path., GB Univ. of Agriculture and Tech., Pantnagar, Uttranchal.

Dr. R.C. Upadhaya

- Attended Xth Biennial Workshop of Mushroom Workers of All India Coordinated Mushroom Improvement Workshop at IGKVV, Raipur on October, 26-27, 2006.

Dr. S.K. Singh

- Attended symposium on "Molecular diagnostic tools for genetic characterization of edible mushrooms" in Conference on "Biodiversity and Biotechnology: Research and Development Needs in Edible Mushrooms and Crop Disease Management" held at GBPUAT, Pantnagar, Uttrakhand from 9-11, November, 2006.

Dr. O.P. Ahlawat

- Attended Xth Biennial Workshop of Mushroom Workers of All India Coordinated Mushroom Improvement Programme (AICMIP) at IGKVV, Raipur on October, 26-27, 2006 at Indira Gandhi Krishi Vishvavidhalaya, Raipur (Chhattisgarh).

Dr. M.C. Yadav

- Attended National symposium on "Biodiversity and Biotechnology: Research and Development Needs in

Fig. 1. International conference on mushroom Biology and Biotechnology at NRCM

Edible Mushrooms and Crop Disease Management" organised by G.B. Pant University of Agriculture and Technology, Pantnagar, from November, 9-11, 2006.

Dr. M.P. Sagar

- Attended National Extension Education Congress on " Livelihood Security and Extension System Perspectives " organized by Society of Extension Education, Advance Research & Management Centre of Rural Development, Agra and JNKVV, Jabal pur from March, 9-11, 2007 at Jabal pur.

- Attended Workshop on Right to Information Act-2005 organised by NAARM, Hyderabad from April, 25-26, 2006.

All NRCM Scientists

- Participated in conference on Mushroom Biology and Biotechnology held at NRCM Solan w.e.f. 10-11 Feb.07

16. DISTINGUISHED VISITORS

1. Smt Hitesh Kumari, Ex Minister, U.P. visited NRCM on 15th June, 2006.

2. Dr Kirti Singh, Ex Chairman, ASRB, visited NRCM on 26th July, 2006

Fig. 1. Dr Kirti Singh, Chairman ASRB visiting Crop Improvement lab at NRCM

3. Dr. G.S.Sekhon, Ex Director Potash Research institute visited NRCM on 26th July, 2006.

4. Dr M.N. Khare, Ex Dean and Professor Scientist, JNKVV, Jabalpur (M.P) visited NRCM on 26th July, 2006.

5. Dr R.J.Rabindra, Project Director, Directorate of Biological Control, Bangalore, visited NRCM on 1st Sept., 2006.

6. Dr G. Kalloo, DDG (Hort.) laying foundation stone of TTC building at NRCM, Solan, on 10th Sept., 2006.

Fig. 2. Dr G. Kalloo, DDG (Hort.) laying foundation stone of TTC building at NRCM

7. Mr. K. Dhanavel, PS to Union Health Minister, New Delhi visited NRCM on 18th November, 2006.

8. Mr Anupam Anand, Diroctor, Printing, Govt of India, and New Delhi visited NRCM on 30th November, 2006.

9. Mr A.K.Sinha, General Manager, Diroctorate of Printing, Govt of India, New Delhi visited NRCM on 30th November, 2006.

10. Prof. Lindsay MacDonald, London College of Communication, visited NRCM on 30th November, 2006.

17. PERSONNEL AND FACILITIES

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	Principal 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-4)
Sh.Lekh Raj Rana	Technical Assistant (T-2)
Sh.Ram Swaroop	Technical Assistant (T-2)
Sh.Parma Nand	Mushroom Assistant (T-2)
Sh.Jeet Ram	Mushroom Assistant (T-2)
Sh.Guler Singh Rana	Electrician (T-2)
Sh.Deepak Sharma	Electronic-cum-Computer Operator (T-2)
Sh.Dala Ram	Driver (T-3)
Sh.Ram Lal	Driver (T-3)
Sh.Ram Ditta	Driver (T-3)

Administrative

Name	Designation
Sh.Raj Kumar	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.Naresh Kumar	SSG-III (Safaiwala)
Smt.Dayawanti	SSG-IV (Safaiwala)
Sh.Nika Ram	SSG-III (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-II (Lab. Attdt.)
Sh.Arjun Dass	SSG-I (Messenger)
Sh.Vinay Sharma	SSG-I (Messenger)

PROMOTIONS

- Dr. S.K. Singh, Sr. Scientist promoted as Principal Scientist w.e.f. 31.03.2006.
- Sh.Gian Chand, Boiler Attdt. (T-3) promoted as Boiler Attdt. (T-4) w.e.f. 24.04.2006.
- Sh.Dala Ram, Driver (T-2) promoted as T-3 w.e.f. 29.06.2006.
- Sh.Ram Ditta, Driver (T-2) promoted as T-3 w.e.f. 29.06.2006.
- Sh.Ram Lal, Driver (T-2) promoted as T-3 w.e.f. 19.09.2006.
- Smt.Dayawanti, SSG-III promoted as SSG-IV w.e.f. 01.11.2006.
- Sh.Nika Ram, SSG-II promoted as SSG-III w.e.f. 01.11.2006
- Sh.Ajit Kumar, SSG-I promoted as SSG-II w.e.f. 01.11.2006.

ACP

- Sh.Deep Kumar Thakur, Stenographer G.III granted next higher scale of Rs.5500-9000 under ACP w.e.f. 03.10.2006.
- Sh.Dharam Dass, LDC granted next higher scale of Rs.4000-6000 under ACP w.e.f. 02.02.2007.
- Smt.Shashi Punam, LDC granted next higher scale of Rs.4000-6000 under ACP w.e.f. 09.02.2007.

RETIREMENT

- Sh. Dhani Ram, SSG-IV retired from his services w.e.f. 31.10.2006.

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 Plan worth Rs.57.70 Lakhs and under non Plan Rs.36.00 Lakhs were utilized. The details of the completed works are as under:

Under Plan

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

(2) C/O Trainers Training Centre building.

(3) C/O Road to composting yard

(4) Providing and fixing of 180 KVA Generator Set for Electrical Sub Station of 630 KVA.

(5) Providing of 630 KVA Electrical Sub Station at NRCM

Under Non Plan

(1) Providing of temporary shed for electrical sub station

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

(3) Repair and renovation of electrical fittings in mushroom house.

1930-2007

Dr. Harnek Singh Sohi breathed his last on February 11, 2007. Born on February 25, 1930 in Ropar, Punjab, Dr. Sohi obtained his Ph.D in 1966 from IARI, New Delhi. Dr. Sohi served IARI, New Delhi (1954-62) and Himachal Pradesh as State Plant Pathologist and Deputy Director (Crop Research) (1962-1969). In ICAR, he occupied the position of Plant Pathologist (1969-72), Senior Plant Pathologist and Head, Division of Plant Pathology (1972-79), IIHR, Bangalore; Project Coordinator, AICMIP and Director, National Research Centre for Mushroom, Solan, H.P. (1984-90). He also served as Chairman, Botany Department, Panjab University, Chandigarh (1979-83).

Dr. Sohi was instrumental in developing cost-effective methods for disease management of vegetable, fruit and ornamental crops. He developed and perfected techniques for cultivating edible mushrooms, besides popularizing the same. He described scores of new taxa of fungi including edible mushrooms. He guided several M.Sc. and Ph.D. research scholars and published one book and around 300 research articles in reputed journals, besides bulletins, review articles and chapters in various books.

Dr. Sohi was a member of many scientific committees of ICAR and occupied key positions in professional societies like, President, Indian Phytopathological Society, 1992; Indian Society of Mycology and Plant Pathology 1983; Indian Society of Mycology, Madras, 1994 and Indian Mushroom Growers' Association 2005-07. He remained Member, Plant Protection Commission of ISHS and also Vice President, Indian Society of Mycology, Calcutta 1982-84.

Dr. Sohi was Fellow of Indian National Science Academy, Indian Academy of Horticulture, Society of Plant Pathologist besides NAAS. He was honoured with Jeersa Nidhi Award and Dr. M. Prasad Memorial Lecture.

He was a very dedicated teacher and committed researcher. On Dr. Harnek Singh Sohi's death, the country has lost an eminent scientist. His contributions will remain the source of inpiration to the young scientists and colleagues. Indian Mushroom Growers' Association and Mushroom Society of India, Solan pay their deep homage and pray for peace of the departed soul.