ANNUAL REPORT
2009

DIRECTORATE OF MUSHROOM RESEARCH

(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 2009

Compiled and Edited by : Dr. V.P. Sharma, Principal Scientist
Dr. Satish Kumar, Senior Scientist
Mrs. Shailja Verma, Technical Officer

Published by : **Dr. Manjit Singh**
Director
Directorate of Mushroom Research
(Indian Council of Agricultural Research)
Chambaghat, Solan - 173 213 (H.P.)

Hindi Translation : Mrs. Reeta Bhatia, Technical Officer (Lib.)
Mr. Deep Kumar Thakur, Stenographer (Typing)

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

Type Setting by : Mr. Deepak Sharma

Printed at : Yugantar Prakashan (P) Ltd., New Delhi-110064
Ph: 011-28115949, 28116018
(M): 09811349619, 09953134595
E-mail: yugpress01@gmail.com, yugpress@rediffmail.com

CONTENTS

PREFACE

Commercial production of edible mushrooms represents unique exploitation of the microbial technology for the bioconversion of various wastes into highly nutritious food (mushrooms). Mushrooms, in addition to being a source of quality food, have various health benefits and are most potential mode of utilising agro-wastes. Keeping in view the potential of this commodity in overcoming malnutrition and generating employment, the Directorate is purseuing R&D activities on different mushrooms suiting to varied agro-climate conditions in the country so that mushroom cultivation could be taken up as cottage industry.

Collection of germplasm is one of the important activities of the Directorate and during the year National Mushroom Repository has been enriched by addition of more than hundred mushroom cultures. In crop improvement, large number of single spore isolates and hybrids of *Pleurotus sajor-caju* were evaluated for laccase and fruit body formation. In *Volvariella* some parent strains and few single spore isolates were evaluated for productivity after studing their various characteristics like mycelial growth, extracellular lignocellulolytic enzyme activity profiles and genetic distinctness.

Preparation of quality compost in shortest time is one of the important goals in button mushroom cultivation. Compost prepared by combination of INRA and Anglo Dutch method resulted in 3.6 times compost from wheat straw and gave 11.14 kg mushrooms per quintal compost in forty days of cropping. Pasteurized compost was used as consortium of thermophilic organisms for shortening the composting phase with partial success. Among substrates evaluated for yield potential of paddy straw mushroom, the compost prepared with cotton ginning mill waste + paddy straw proved a better substrate as it gave same level of yield in 2 weeks time as was obtained in 4 weeks from spinning mill waste + paddy straw compost.

Work on another important mushroom shiitake is going on and number of strains are being explored to find out their commercial potentiality. Work on one of the most sought after medicinal mushroom *Cordyceps sinensis* has been initiated at this Directorate.

Optimum conditions have been worked out for the decolorization of different dyes through SMS of different mushrooms. Information generated on residual toxicity and neem based biopesticides will help in refining in IPM modules.

During the year under report, the Directorate organised 15 training programmes, a Mushroom Mela in addition to conducting regular visits for farmers from various States.

The Directorate 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 the Directorate.

(Manjit Singh)
Director

कार्य सारांश

खुम्ब अनुसंधान निदेशालय ने अनुसंधान, तकनीकी हस्तांतरण व मानव संसाधन विकसीत करने में महत्वपूर्ण उपलब्धियाँ हासिल की हैं। निदेशालय ने वर्ष 2009 के दौरान फसल उन्नयन, फसल उत्पादन, फसल संरक्षण, तकनीकी हस्तांतरण, शिक्षा एवं प्रशिक्षण में जो उपलब्धियाँ हासिल की है, उनका सारांश यहाँ दिया जा रहा है।

1. फसल उन्नयन

(क) जैव सम्पदा का संग्रहण एवं चरित्र-चित्रण

अरुणाचल प्रदेश, हिमाचल प्रदेश, उतराखंड, बिहार तथा अण्डेमान निकोबार, द्वीप समूह के जंगली क्षेत्रों के सर्वेक्षण किये गए। कुल 154 नमूने एकत्रित किये गए जिनमें से 123 प्रजातियों की पहचान जीनस स्तर तक की गई। जंगली प्रजातियों जिसमें मुख्यतः प्लूरोटस, लेपिस्टा, माईसिना, क्लोरोफिलम, स्पेरेसिस, स्ट्रोफेरिया व हर्सियम प्रजातियाँ है, का जिनोमिक डी.एन.ए. निकाला गया।

(ख) जैव संपदाओं का चरित्र-चित्रण

प्लूरोटस साजोर काजू की 20 एकल बीजाणु तथा 57 संकर प्रजातियों को विकसित किया गया। इन प्रजातियों को 2 प्रतिशत मालट एक्सट्रेक्ट अगर माध्यम पर उगाया गया। ए.बी.टी.एस. विधि द्वारा लैक्केज की सक्रियता का पता लगाया और फलनकायों को कल्चर प्लेट में उगाया गया।

(ग) आनुवांशिक सुधार

वाल्वेरियेला वॉल्वेसिया की तीन प्रजातियों ओ.ई. 272, ओ.ई. 274 व ओ.ई. 210 तथा चार एकल बीजाणु संवर्धनों (ओ.ई. 12-06, ओ.ई. 12-22, ओ.ई. 55-08 व ओ.ई. 55-30) को धान के पुआल पर उगाया गया। यह प्रयोग उनकी कवक जाल फैलाव को देखने, लिग्नोसेलूलाईटिक एन्जाइमस की सक्रियता, अनुवांशिक भिन्नता तथा उपज क्षमता जानने हेतु किए गए। तीन प्रयोगों में धान पुआल तथा कपास के अवशेष को 1:1 के अनुपात में मिलाकर उगाने के माध्यम के रूप में उपयोग किया गया। जबकि चौथे प्रयोग में धान के पुआल के साथ कपास के बिनौले के अवशेष को 1:1 के अनुपात में मिलाकर उगाने के माध्यम के रूप में उपयोग किया गया।। सभी प्रयोगों में मुर्गी की खाद तथा 5.0% की दर से कैल्शियम कार्बोनेट भी मिलाया गया। सभी चार प्रयोगों में से सबसे अधिक फलनकाय प्रजाति ओ.ई. 272 में दर्ज की गई।

2. फसल उत्पादन

(क) बटन मशरूम

विभिन्न अवयवों (धान का पुआल, मुर्गी की खाद, गेहूँ का चोकर, यूरिया, कपास के बीज का अवशेष व जिप्सम) को अच्छी तरह मिलाया गया तथा आई.एन.आर.ऐ. तथा एंग्लो डच विधियों के मिलान द्वारा खाद तैयार की गई। अवयवों को अच्छी तरह से मिलाया गया व ठीक ढंग से भिगोया गया ताकि खाद में लगभग 75% नमी प्राप्त की जा सके। सभी अवयवों को ठीक से 2 दिनों तक मिलाने व भिगोने के पश्चात् फेज-1 बंकर में फेज-1 क्रिया के लिए स्थानांतरित किया गया। फेज-1 टनल में छः दिनों के आंशिक खमीरीकरण के पश्चात् पूरी खाद को बाहर निकाला गया तथा फेज-II के कार्य के लिए सूरंग में स्थानांतरित किया गया। इसके पश्चात खाद बनाने के लिए मानक पद्वति व उपयोग किया गया। फेज-II का कार्य 7 दिनों में पूर्ण हुआ।

खाद में नमी की मात्रा 68% थी जबकि बीजाई के समय यह 64% थी, इसी तरह पी.एच. 7.7 था जो कि बीजाई के समय 7.4 हो गया। गेहूँ के सूखे भूसा से 3.6 गुणा खाद प्राप्त हुई। प्रति क्विंटल खाद में से 11.14 कि. ग्रा. खुम्ब की पैदावार चालीस दिनों के परीक्षण के दौरान प्राप्त की।

पास्चरीकृत कम्पोस्ट में साधारण थर्मोफिलिक कवकों के बजाय थर्मोफीलिक जीवों का उपयोग किया गया ताकि खाद बनाने की अवधि को कम किया जा सके तथा पैदावार में भी बढ़ौतरी हो। खाद की चार ढेरियाँ तैयार की गई जिसमें गेहूँ का पुआल (3.0 कि.), गेहूँ का चोकर (30 कि०ग्रा०) यूरिया (7 कि०ग्रा०) तथा जिप्सम (20 कि०ग्रा०) मिलाया गया। पहली, दूसरी तथा तीसरी ढेरी में पास्चुरीकृत कम्पोस्ट 30 कि०ग्रा० की दर से मिलाई गई। यह क्रमशः 0 दिन, 4 दिन तथा 8वें दिन दोहराया गया, जबकि चौथी ढेरी को नियंत्रित रखा गया। लम्बी विधि से खाद तैयार करने में सामान्यतः 28 दिन का समय लगता है, जबकि इसमें 20 दिन का समय लगा। पलटाई 0 दिन, 4 दिन, 6 वें दिन, 8 वें दिन, 12 वें दिन, 14 वें दिन, 16 वें दिन, 18 वें दिन तथा 20 वें दिन दी गई। 20 वें दिन ढेरी को खेला गया तथा इसमें ए.बाइस्पोरस के.एस. 11 प्रजाति की बीजाई की गई। इस खाद में बहुत से थर्मोफिलिक कवक पाये गए इसमें एस. थर्मोफीलियम भी था। विभिन्न कम्पोस्ट की ढेरियों से विभिन्न अन्तराल पर थर्मोफीलिक कवक - ए.फयूमीगेटस, एम.पुसीलियस, एच. ग्रेसिया, एच. इन्सोलेंस तथा कोप्राइमस को पृथक किया। लघु विधि द्वारा तैयार खाद की विधि को अपनाते हुए लम्बी विधि से खाद तैयार करने में 20 दिन का समय लगा। विभिन्न उपचारों में कोप्राईनस एस.पी. तथा ब्राउन प्लास्टर फंफूँद का हल्का तथा तीव्र प्रकोप देखा गया। प्रयोग के दौरान पहली ढेरी में सबसे अधिकतम उपज प्राप्त की गई, जिसमें की पास्चुरीकृत खाद का निवेशन 0 दिन के लिए किया गया था। इससे 100 कि.ग्रा. खाद में 7.4 कि. ग्रा. फसल प्राप्त की गई। प्रयोग के दौरान पाया गया कि इस प्रकार की खाद का उपयोग लम्बी विधि द्वारा खाद तैयार करने के लिए किया जा सकता है।

(ख) पुआल खुम्ब

विभिन्न खाद के पोषाधार का पुआल खुम्ब की पैदावार तथा पोषक गुणों पर क्या प्रभाव पड़ता है इसके लिए तीन मुख्य अवयवों, धान का पुआल, कपास मिल से निकला हुआ अवशेष तथा मुर्गी की खाद का उपयोग किया गया। इसमें वी. वोल्वेशिया के स्ट्रेन ओ.ई. 274 का उपयोग किया गया। खाद बनाने के लिए निम्न तीन विभिन्न सूत्र उपयोग किए गए। धान का पुआल+मुर्गी की खाद (5.0% की दर से) + कैल्शियम कार्बोनेट (1.5% की दर से), कपास मिल का व्यर्थ +कैल्शियम कार्बोनेट (1.5% की दर से) तथा धान का पुआल+कपास मिल का व्यर्थ (1:1)+मुर्गी की खाद (5% की दर से)+कैलशियम कार्बोनेट (1.5% की दर से) खाद तैयार करने के लिए दो फेस खाद विधि अपनाई गई।

विभिन्न सूत्रों से तैयार की खाद में क्रमशः नमी, नाईट्रोजन, पोटाशियम, सोडियम, कैल्शियम तथा पी.एच. में विभिन्ता पाई गई। अधिमतम नाईट्रोजन की मात्रा कपास 'मिल' के अवशेष द्वारा तैयार की खाद में मिली। इसका अनुसरण उस खाद ने किया जिसमें कि 1:1 के संयोजन में धान का पुआल+कपास मिल का व्यर्थ मिलाया गया। सामान्यतः सबसे अधिक नमी प्रयोग 2 की खाद में थी।

कपास मिल के अवशेष से तैयार की खाद में सोडियम तथा पोटाशियम तत्व सबसे कम थे जबकि कैल्शियम तत्व सबसे अधिक थे।

सबसे अधिक पैदावार तथा बढ़िया गुणवत्ता के फलस्वरूप स्ट्रेन ओ.ई. 274 ए.एस. 1 तथा ओ.ई. 55-08 से प्राप्त हुए। इन प्रजातियों में बीमारियों से लड़ने तथा कीड़े मकौड़ों से लड़ने की अधिक क्षमता भी दर्ज की गई। विभिन्न पोषाधारों में से कपास मिल का अवशेष तथा धान का पुआल सबसे अच्छा पोषाधार साबित हुआ, क्योंकि इस अवस्तर में से फसल दो सप्ताह के समय में प्राप्त की गई जो कि स्पीनिंग मिल व्यर्थ तथा धान के पुआल द्वारा तैयार खाद में से चार सप्ताह में प्राप्त की जाती है।

(ग) विशिष्ट खुम्बें

लेंटिना इडोडस की विभिन्न प्रजातियों (ओ.ई. 142, ओ.ई. 388, ओ.ई. 329, ओ.ई. 17 तथा ओ.ई. 38) पर अध्ययन से यह ज्ञात हुआ कि सभी प्रजातियों की वानस्पतिक वृद्वि के लिए 20 से 25 से. अनुकूल होता है। प्रजाति ओ. ई. 38 में पी.एच. के लिए व्यापक अनुकूलनशीलता देखी गई और यह प्रजाति पी.एच. 4.0 पर भी उग सकती है। जबकि सभी प्रजातियों की वृद्वि के लिए 6.5 से 7.0 पी.एच. अनुकूल था। लेंटिना इडोडस की विभिन्न प्रजातियाँ उगाने के लिए भुट्टे की खुकड़ी सबसे अच्छा माध्यम था। इस माध्यम में प्रजाति ओ.इ. 2, ओ.ई. 13 तथा ओ.ई. 27 को छोड़कर अन्य सभी प्रजातियों में रेखीय वृद्वि देखी गई है। सभी प्रजातियाँ जिनका परीक्षण किया गया में से ओ.ई. 388 प्रजाति सबसे तेजी से वृद्वि करने वाली प्रजाति पाई गई। उगाने वाले पोषाधार को विभिन्न अवधियों के लिए ठण्डे पानी (4-5 से.) में भिगोया गया, जिसमें छः घंटे तक भिगोने पर अधिकतम पैदावार प्राप्त की गई।

कोरडीसीपस साइनेंनसिस में जैव वृद्वि का पता लगाने हेतु 12 ठोस तथा 5 तरल माध्यमों का मूल्यांकन किया गया। सबसे अधिक त्रिज्य वृद्वि रिचर्ड के सिंथेटिक अगर माध्यम में देखी गई, जबकि पोटेटो डेक्सट्रोस माध्यम में सबसे कम वृद्वि देखी गई। सभी तरल माध्यमों में से जेपडोक्स में अधिकमतम कवक वृद्वि हुई। इसके अतिरिक्ति लकड़ी के बुरादे का भी इस्तेमाल किया गया जिससे कि सफलतापूर्वक सी. साइनेंनसिस से उपनिवेशित किया गया।

3. फसल संरक्षण

बटन खुम्ब के विकास की विभिन्न अवस्थाओं पर कीटों तथा रोगों के प्रकोप जानने के लिए अध्ययन किए गए। केसिंग करने के एक सप्ताह के बाद पेजिजा दिखाई दिए। भूरा दाग तथा जाली रोग का प्रकोप भी देखा गया। केसिंग करने के दो सप्ताह के पश्चात् कीड़ों मकोड़ों में सिएरिड तथा फोरिड मक्खियों का संक्रमण देखा गया।

पास्चरीकृत खाद पर ऐगेरिकस बाईस्पोरस के स्ट्रेन एस-11 को उगाया गया। इसमें डाईक्लोरोवास का अस्तित्व देखा गया। केसिंग से पहले तथा 7 दिनों के बाद डाईक्लोरोवास का सात विभिन्न सांद्रणों के साथ छिड़काव किया गया। केसिंग के बाद 0.001% की दर से डाईक्लोरोवास के छिड़काव करने के बाद 11.5 कि.ग्रा. उपज प्राप्त की गई, जबकि केसिंग करने के 7 दिनों के पश्चात् 0.03% की दर से सांद्रण का छिड़काव किया गया तो खुम्ब की उपज 12.78 कि.ग्रा. प्राप्त की गई।

मिट्टी के जीवाणु की संख्या पर फोर्मेलीन के प्रभाव को आँकने हेतु अध्ययन किये गए। जिसमें कि फार्मेलिन के पाँच विभिन्न सांद्रणों का उपयोग भिन्न-भिन्न अंतरालों पर किया गया। यह पाया गया कि केवल 2 मिनट तक छिड़काव करने से भी जीवाणुओं की संख्या घटती है।

माईकोपेरासाईट के विरूद्व जब विभिन्न नीम कीटनाशकों का मूल्यांकन किया गया। एम. पर्निसियोसा के कवक जाल में वृद्वि का 100% निरोध नीमोल से हुआ। अचूक से क्रमशः 75% तथा 38-47% निरोध हुआ। अचूक ही एक ऐसा उत्पाद था जिसमें कि टी. हरजेनियम के लिए 22.22% निरोध देखा गया। सभी नीम कीटनाशकों ने एम. पर्निसियोसा, सी. डेन्ड्रायडस तथा टी. हरजेनियम को विभिन्न अवस्थाओं में वृद्वि पर नुकसान पहुँचाया है।

बटन मशरूम की फसल पर जब विभिन्न माइकोपेरासाइट, सी. डेन्ड्रायडस तथा डी. हरजेनियम का उपनिवेशन किया तो क्रमशः 43.2, 87.6 तथा 29.9% की क्षति हुई। विभिन्न कीटनाशकों के छिड़काव करने के बाद क्रमशः 37.0-41.2%, 81.5-88.8%, 40.7-50.6% तथा 12.2-24.7% के माध्य हानि देखी गई। इससे यह साफ प्रतीत होता है कि इन नीम के कीटनाशक पूरी तरह असरदायक नहीं है।

4. स्पेंट खुम्ब पोषाधार की उपयोगिता

ऐ. बाइस्पोरस तथा ले. इडोडस के स्पेंट पोषाधारों का विभिन्न पी.एच. तथा तापमान परिस्थितियों में रंगों की रंगहीनता क्षमता जानने हेतु अध्ययन किए गए। विभिन्न खुम्बों के स्पेंट खुम्ब पोषाधारों में पी.एच. की श्रेणी 4-7 तथा 7-10 के मध्य होती है, परन्तु सभी मामलों में पी.एच. 7.0 केन्द्र बिन्दु रहता है और इससे काफी अधिक रंगहीनता देखी गई तथा इसे दोनों मशरूमों को उगाने के लिए सबसे अच्छा पी.एच. माना जाता है, कुछ मामलों में स्पेंट खुम्ब पोषाधारों में 25 तथा 35° से. तापमान में विभिन्न रंगों की अधिक रंगहीनता देखी गई है। अतः ऐ. बाईस्पोरस तथा ले. इडोडस के स्पेंट खुम्ब पोषाधारों के रंगों की अधिक रंगहीनता के लिए माध्यम का पी.एच. 7.0 तथा तापमान 25° से. होना चाहिए। मेथिल वायलेट-2बी. की 100% रंगहीनता प्राप्त करने हेतु ऊपरलिखित पैमानों को बनाए रखना होगा तथा सूक्ष्मजीवी निवेशन के लिए पी. साजोर-काजू के स्पेंट पोषाधार का इस्तेमाल करना चाहिए। पी. साजोर-काजू से प्राप्त स्पेंट पोषाधार साधारण नलके के पानी में भी रंगों की रंगहीनता को कम करता है।

5. तकनीकी हस्तांतरण

वर्ष 2009 के दौरान निदेशालय ने किसानों, महिलाओं, उद्यमियों, अधिकारियों तथा अनुसंधानकत्ताओं के लिए कुल 15 अंतः परिसरीय एवं बाह्य परिसरीय प्रशिक्षण कार्यक्रम आयोजित किए।

हर वर्ष की भांति इस वर्ष भी 10 सितम्बर, 2009 को निदेशालय द्वारा मशरूम मेले का आयोजन किया गया। मेले का उद्घाटन डा. के.आर. धीमान, माननीय कुलपति डा. यशवंत सिहं परमार औधोगिकी एवं वानिकी विश्वविधालय, नौणी, सोलन के द्वारा हुआ। इस अवसर पर केन्द्रीय आलू अनुसंधान संस्थान, शिमला के निदेशक डा. एस.के. पांडेय माननीय अतिथि थे। मेले में विभन्न राज्यो जैसे कि हिमाचल पद्रेश, हरियाणा, पंजाब, उत्तर प्रदेश, महाराष्ट्र, मध्यप्रदेश, छत्तीसगढ़, बिहार, झारखंड, दिल्ली, उत्तराखंड, सिक्किम, गुजरात, तमिलनाडू तथा उड़ीसा के लगभग 650 किसानों, महिलाओं, खुम्ब उत्पादकों, अनुसंधानकर्त्ताओं, विस्तार कार्यकत्ताओं आदि ने भाग लिया।

खुम्ब उत्पादन की उन्नत तकनीकियों तथा अन्य संबंधित पहलुओं पर एक प्रर्दशनी का आयोजन किया गया, जिसमें विभिन्न सरकारी संस्थाओं, भारतीय कृषि अनुसंधान परिषद् के संस्थानों तथा विश्वविधालयों, सरकारी वित्तीय संस्थाओं, खाद तथा स्पॉन उत्पादकों, खुम्ब उत्पाद निर्माताओं, बीज तथा कीटनाशक व रसायनिक पदार्थों के निर्माता तथा गैर-सरकारी संस्थाओं ने अपनी बहुमूल्य सूचनाओं, तकनीकियों व उत्पादों का प्रर्दशन किया तथा अपनी सेवाएं मशरूम मेले के प्रतिभागियों को प्रदान की। खुम्ब उत्पादकों द्वारा उठाई गई समस्याओं के उत्तर विशेषज्ञओं द्वारा क्रमबद्व तरीके से दिए गए। मशरूम मेले के दौरान निदेशालय ने 8 प्रगतिशील खुम्ब उत्पादकों को पुरस्कृत किया। इन किसानों ने बड़े पैमाने पर खुम्ब उत्पादन की नवीनतम तकनीकियां अपनाई तथा अन्य किसानों को खुम्ब उत्पादन को आय के स्रोत के रूप में अपनाने के लिए एकजुट किया।

निदेशालय ने बहुत से राज्य तथा राष्ट्रीय स्तर की प्रर्दशनियों तथा मेले में भी भाग लिया। निदेशालय ने औधोगिकी एवं वानिकी विश्वविधालय में दिनांक 28-29 जनवरी, 2009 को आयोजित किसान मेले में भाग लिया। इसके अतिरिक्त निदेशालय से 24.05.2009 तक आयोजित प्रथम अर्न्तर्राष्ट्रीय बागवानी प्रर्दशनी 'संगम' में भी भाग लिया। मशरूम उत्पादन के विभिन्न पहलुओं, प्रशिक्षणों व विपणन से संबंधित सलाहाकार सेवाएं विस्तार विभाग द्वारा डाक द्वारा पत्रों के माध्यम से प्रदान की गई। मशरूम उत्पादन तथा प्रशिक्षण संबंधित प्रश्नों के उत्तर दूरसंचार तथा इ-मेल माध्यम द्वारा दिए गए। औसत के आधार पर एक दिन में पाँच प्रश्न प्राप्त हुए जिनके उत्तर दिए गए। दूरदर्शन शिमला द्वारा कृषि दर्शन कार्यक्रम में 12 फोन तथा क्षेत्र आधारित कार्यक्रम प्रसारित किए गए।

6. प्रकाशन

वर्ष के दौरान निदेशालय के वैज्ञानिकों द्वारा 12 शोध पत्र राष्ट्रीय व अंतर्राष्ट्रीय जर्नल्स में प्रकाशित किए गए। एक किताब, 2 अध्याय व 2 तकनीकी बुलेटिनों का भी प्रकाशन हुआ।

The Directorate of Mushroom Research has made significant progress in research, transfer of technology and human resource development. The achievements of Directorate during 2009 in area of Crop Improvement, Crop Production, Crop Protection, Utilization of Spent Mushroom Substrate, Transfer of Technology, Education and Training are summarized here.

1. CROP IMPROVEMENT

(a) Germplasm Collection and characterization

Fungal forays were undertaken in the forest areas of Arunachal Pradesh, Himachal Pradesh, Uttarakhand, Bihar and Andeman and Nicobar islands and 154 specimens were collected of which 123 have been identified upto genus level.

Genomic DNA of interesting wild mushroom species namely *Pleurotus* sp., *Lepista* sp., *Mycena* sp., *Chlorophyllum* sp., *Sparaciss* sp., *Stropharia* sp and *Hericium* spp. was isolated and their ITS sequencing was undertaken.

(b) Germplasm Characterization

Twenty single spore isolates and 57 hybrids of *Pleurotus sajor-caju* evolved by compatible mating were grown on 2% malt extract agar medium for qualitative estimation of laccase using ABTS and fruit body formation in culture plates.

(c) Genetic Improvement

Three parent strains of *Volvariella volvacea* namely, OE-272, OE-274 and OE-210 and 4 single spore isolates (OE-12-06, OE-12-22, OE-55-08 and OE-55-30; 2 each from parent strains, OE-12 and OE-55, respectively), were pre-screened for mycelial growth characteristics, extracellular lignocellulolytic enzymes activity profiles, genetic distinctness and superior yield potential on paddy straw substrate. Paddy straw + blow-room-waste from cotton spinning mill (1:1 w/w) was used as cultivation substrate in three experiments while in the 4th experiment paddy straw + cotton ginning mill waste (1:1 w/w) was tried. Chicken manure and $CaCO_3$ were added @ 5.0% and 1.5% (dry wt basis), respectively in all the experiments. In all the 4 trials, highest numbers of fruiting bodies were recorded in strain, OE-272.

2. CROP PRODUCTION

Button mushroom

Compost was prepared by mixing different ingredients (wheat straw, chicken manure, wheat bran, urea, cotton seed waste and gypsum) by using combination of INRA and Anglo Dutch methods. Ingredients were thoroughly mixed and wetted properly to achieve around 75% moisture percentage. After two days of thorough mixing and wetting it was transferred to phase-I bunker, for phase-I operation. After 6 days of partial fermentation in phase-I tunnel, entire compost mass was taken out and transferred to phase-II tunnel for usual phase-II operations. Standard methodology was employed, thereafter for compost production. Phase II operation was completed in 7 days time.

Moisture of the compost at filling was 68 % and it came down to 64 % at spawning, however,

pH at filling was 7.7 and 7.4 at spawning. Wheat straw to compost conversion ratio was 3.6 times. An average yield of 11.14 kg mushrooms per quintal compost was obtained from the trial in forty days of cropping.

Pasteurized compost was used as consortium of thermophilic organisms for shortening the composting phase and to increase the yield. Four compost piles of wheat straw (300 kg), wheat bran (30 kg), urea (7 kg) and gypsum (20 kg) were prepared. First, second and third pile was inoculated with pasteurized compost @ 30 kg on 0 day, 4th day and 8th day, respectively, while 4th pile served as control. Duration of the composting period was kept 20 days against 28 days normally taken for long method compost. Turning was given on, 0 d, 4 d, 6 d, 8 d, 10 d, 12 d, 14 d, 16 d, 18 d and 20 d. On 20th day pile was opened and spawned with S-11 strain of *A. bisporus*. This compost harboured the usual thermophilic population including *S. thremophilum*. Among the thermophilic fungi *A. fumigatus*, *M. pussilus, S. thermophilum*, *H. grisea*, *H. insolens* and *Coprinus* sp were isolated from different piles at various intervals. Compost production by long method in 20 days using short method compost, as inoculum, was a partial success. Mild to severe incidence of *Coprinus* sp. and brown plaster mould was noticed in different treatments. The highest yield in the experiment was obtained in pile–1, which was inoculated by pasteurized compost on 0 day (7.4 kg/q compost). Thereby, indicating that such compost can be successfully utilized for long method compost production.

Paddy straw mushroom

The role of composted substrates in yield and nutritional attributes of paddy straw mushroom was studied using 3 basal ingredients viz., paddy straw (PS), cotton ginning mill waste (CGMW) and poultry manure (PM) along with Paddy straw based spawn of OE-274 strain was used. Three different formulations used for compost preparation were; PS + CM (5.0%, w/w) + $CaCO_3$ (1.5%, w/w); CGMW + $CaCO_3$ (1.5%, w/w) and PS + CGMW (1:1, w/w) + CM (5.0%, w/w) + $CaCO_3$ (1.5%, w/w). The compost was prepared using two-phase composting method.

Compost from different formulations varied with respect to moisture, nitrogen, potassium, sodium, calcium and pH . The highest nitrogen was in compost prepared with CGMW in both the trials followed by compost of 1:1 combination of PS + CGMW. In general, moisture was much higher in trial 2 compost than the respective compost in trial 1. Sodium and potassium contents were the lowest and calcium content was the highest in compost prepared from CGMW.

Srain OE-274 and SSI OE-55-08 gave higher mushroom yield and better quality fruiting bodies. Both were more resistant against competitor moulds and insect-pests infestation. Among substrates, compost prepared with cotton ginning mill waste + paddy straw proved better substrate as it gave same level of yield in 2 weeks time as obtained in 4 weeks from spinning mill waste + paddy straw compost.

Specialty mushrooms

Physiological studies conducted on various strains (OE-142, OE-388, OE-329, OE-17 and OE-38) of *L. edodes* revealed that 20-25^{0}C temperature is optimum for the vegetative growth of all the strains. Strain OE-38 showed wide adaptability to pH and could grow even at pH 4.0, whereas, pH 6.5-7.0 was optimum for the growth of all the strains. Corn cob was the best medium for the growth of most of the *L. edodes* strains which supported the maximum linear growth of all the strains except strain OE-2, OE-13 and OE-27. OE-388 strain was the fastest growing strain among all the strains tested. Cultivation substrate was exposed to cold water (4-5^{o}C) for different duration's revealed that shock treatment for 6 h is the best which resulted in the maximum production.

Twelve solid and 5 broths were evaluated for bio-mass production in *Cordyceps sinensis*. The maximum radial growth was recorded in Richards's synthetic agar medium while potato dextrose agar medium supported the minimum growth. Among all the different broths Czapdox broth yielded the maximum mycelial mass. In addition saw dust was also evaluated for the growth of *C. sinensis*.

3. CROP PROTECTION

The succession of pests and diseases during different growth stages of button mushroom was studies. *Peziza* appeared within a week after casing. Bacterial blotch and cobweb diseases were also recorded. Among the insect-pests, sciarids and phorids were recorded after two weeks of casing.

Persistence of Dichlorvos was investigated by raising the crop of *Agaricus bisporus* (S-11) on pasteurized compost. Dichlorvos at seven different concentrations was sprayed at the time of casing and seven days after casing. It was observed that 0.001% dichlorvos sprayed immediately after casing resulted in 11.5 kg mushroom yield whereas, application of 0.03% concentration seven days after casing resulted in 12.78 kg mushroom yield.

Effect of formalin on soil bacterial population studied under *in vitro* conditions at 5 different concentration and varying time intervals revealed that even two minutes exposure significantly reduce the bacterial population.

Different neem pesticides evaluated against various mycoparasite revealed that Neemol resulted in 100% inhibition of *M perniciosa*. Achook resulted in 75% and 38.47% inhibition of *C. dendroides*, and *V. fungicola,* respectively. Achook was the only product showing inhibition (22.22%) against *T. harzianum*. All the neem pesticides inhibited the growth of *M perniciosa, C. dendroides* and *T. harzianum* to varying degrees.

Button mushroom crop inoculated with different mycoparasites, *C. dendroides*, *M. perniciosa, V. fungicola* and *T. harzianum* resulted in 43.2, 87.6, 48.1 and 25.9 per cent yield loss, respectively. Spraying with various neem pestides, the loss varied between 37.0-41.2 %, 81.5- 88.8%, 40.7-50.6% and 12.2-24.7% in *C. dendroides*, *M. perniciosa, V. fungicola* and *T. harzianum* inoculations, respectively thereby clearly indicating little or no effectiveness of

these neem pesticides under mushroom house conditions.

4. UTILIZATION OF SPENT MUSHROOM SUBSTRATE

Spent substrate from *A. bisporus* and *L. edodes* was studied for dye decolorization capacity at different pH and temperature conditions. Requirement of pH of the medium varied in the range of 4-7 and 7-10 in case of SMS of both mushrooms but in all cases pH of 7.0 has remained central point and has shown quite high decolorization, as it is also considered ideal pH of substrates used for cultivation of different mushrooms. With some exceptions, temperatures of 25 and 35^{0}C have shown quite high decolorization of different dyes through SMS of different mushrooms. Hence pH 7.0 of medium and 25^{0}C as incubation temperature is recommended for decolorization of different dyes through SMS of *A. bisporus* and *L. edodes*. Decolorization using *P. sajor-caju* spent substrate @ 1.0%, w/v in PDB medium occurs at higher rate with lower initial concentration of dye, on addition of carbon and nitrogen sources except cellulose, maintaining agitated growth condition, inoculation with pellets of *P. sajor-caju* mycelia, and in presence of enzyme mediator like veratryl alcohol, enzymes co-factor $MnSO_4$ and some heavy metals like Lead and Cadmium. Nearly 100% decolorization of Methyl Violet 2B was achieved by maintaining the above mentioned parameters and using *P. sajor-caju* spent substrate as source of microbial inoculum. Spent substrate from *P. sajor-caju* is also effective in decolorization of this dye in plain tap water condition but at lower rate than in PDB.

5. TRANSFER OF TECHNOLOGY

During 2009, the Directorate organized a total number of 15 on and off campus training programmes for farmers, farmwomen, entrepreneurs, officers and researchers.

One day Mushroom Mela was organized on 10th September, 2009 as regular activity of the Directorate. It was inaugurated by Dr K.R Dhiman Hon'ble Vice Chancellor, Dr. Y.S. Parmar UHF, Nauni, Solan. Dr S.K Pandey, Director, CPRI Shimla was the guest of Honour. It was attended by about 650 farmers, farmwomen, mushroom growers, researchers, extension workers and businessmen from various states viz., Himachal Pradesh, Haryana, Punjab, Uttar Pradesh, Maharashtra, Madhya Pradesh, Chattisgarh, Bihar, Jharkhand, Delhi, Uttarkhand, Sikkim, Gujarat, Tamilnadu and Orissa.

An exhibition on improved mushroom cultivation technologies and other related aspects was organized in which various Govt. Organisation, ICAR Institutes/Universities, Govt. financial organization, compost and spawn producers, mushroom product manufacturer, seed, pesticides, chemical producers and NGOs displayed their valuable information/technologies/products and provided their services to the participants of the 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 mushroom growers and farmers were replied by experts in a very systematic manner. During the Mushroom Mela, the Directorate awarded 8 progressive

mushroom growers for adopting innovative practices in mushroom cultivation on larger scale and mobilizing other farmers to adopt mushroom cultivation as source of income.

Directorate has also participated in many state and national level exhibitions and fairs including Kisan Mela at YSPUHF, Nauni from January 28-29, 2009 and 1st interstate Horticulture exhibition "SANGAM" held at Pragati Maidan, New Delhi from 22-05-2009 to 24-05-2009.

Advisory services through postal extension letters on various aspects of mushroom cultivation, training and marketing were provided. Queries on mushroom cultivation and training were replied through telephone and e-mail. On an average 5 queries per day were received and replied. Twelve (12) Phone-in and field based programmes were telecasted on Doordarshan Kendra from Shimla in Krishi Darshan.

6. PUBLICATIONS

During the year, scientists of Directorate published 12 research papers in referred national and international journals, 1 book, 2 book chapters and 2 technical bulletins.

Mushroom demand is high in Europe, America and East Asia and it is bound to increase in other parts of the world as well as domestic market. Therefore, there is ample scope for marketing of mushroom produce. However, we have to compete with China that is producing mushrooms at very low costs mainly through seasonal growing and state subsidies.

In India mushroom production system is mixed (seasonal farming and high-tech industry). Growth rate, both in terms of productivity and production remained phenomenal since 70's when mushroom production started in our country. In seventies and eighties button mushroom was grown only as a seasonal crop in the hills, but with the development of the technologies for environmental control, mushroom production shot up from mere 5000 tonnes in 1990 to over 1,00,000 tonnes in 2008. Commercially grown species are button, oyster, milky and paddy straw mushrooms. India produces over 600 million tonnes agricultural waste which is left out to decompose naturally or burnt *in situ*. This can effectively be utilized to produce high nutritive value mushrooms and spent mushroom substrate can be converted into organic manure/vermi-compost. However, for effective utilization major impetus should be on the introduction of high temperature tolerant varieties suiting to the seasonal growers.

For multi-locational testing of technologies under varied agro-climatic conditions, an All India Coordinated Research Project (AICRP) has been sanctioned and established with its Headquarter at Directorate of Mushroom Research, Solan (HP). The Director of DMR, Solan (HP) also functions as the Project Co-ordinator of the project. Presently, Centres of AICRP are located at Ludhiana (Punjab), Pantnagar (UP), Coimbatore (Tamil Nadu) Pune (Maharashtra), Raipur (MP) Faizabad (UP), Udaipur (Rajasthan), Thrissur (Kerala), Barapani (Meghalya), Ranchi (Jharkhand), Murthal (Haryana), Nauni, Solan (HP), Hisar (Haryana), Bhubaneswar (Orissa), Samastipur (Bihar) and Pasighat (AP).

Achievements

Crop improvement is a continous time consuming activity. During 2009, 20 single spore isolates of *Pleurotus sajor-caju* and 57 hybrids were compared for laccase activity and fruit body formation. Three parent strains of *Volvariella volvacea* and 4 single spore isolates were screened for various characteristics. Strain OE-272 produced the highest number of fruiting bodies.

Compost prepared by INRA and Anglo Dutch methods produced an average yield of 11.14 kg mushrooms per quintal compost in forty days of cropping. Compost preparation by long method using pasteurized compost as consortium of thermophilic organisms in 20 days was attempted with limited success.

Compost prepared with cotton ginning mill waste + paddy straw proved better substrate for paddy straw mushroom and gave same level of yield in 2 weeks time as was obtained in 4 weeks from spinning mill waste + paddy straw compost. Srain OE-274 and OE-55-08 gave higher mushroom yield and better quality fruiting bodies.

In *L. edodes* 20-25^{0}C temperature and pH 6.5-7.0 was optimum for the vegetative growth of all the strains. Corn cob was the best medium for the growth of most of the *L. edodes* strains and supported the maximum linear growth of all the strains. Cold shock treatment of substrate for 6 h proved to be the best and resulted in the maximum production of shiitake mushroom.

In *Cordyceps sinensis* there was maximum radial growth in Richards's synthetic agar medium.

Studies on residue analysis of Dichlorvos were conducted at various concentrations and safe period was worked out. Of the biopestides evaluated against different mycoparasites, all the neem pesticides inhibited the growth of *M. perniciosa, C. dendroides* and *T. harzianum* to varying degrees under *in vitro* conditions.

For dye decolorization using SMS of *A. bisporus* and *L. edodes,* pH 7.0 of medium and 25^{0}C as incubation temperature was optimum. Decolorization using *P. sajor-caju* spent substrate @ 1.0%, w/v in PDB medium occurs at higher rate with lower initial concentration of dye, on addition of carbon and nitrogen sources except cellulose, maintaining agitated growth condition, inoculation with pellets of *P. sajor-caju* mycelia, and in presence of enzyme mediator like veratryl alcohol, enzymes cofactor $MnSO_4$ and some heavy metals like Lead and Cadmium. Nearly 100% decolorization of Methyl Violet 2B can be achieved by maintaining the above mentioned parameters and using *P. sajor-caju* spent substrate as source of microbial inoculum.

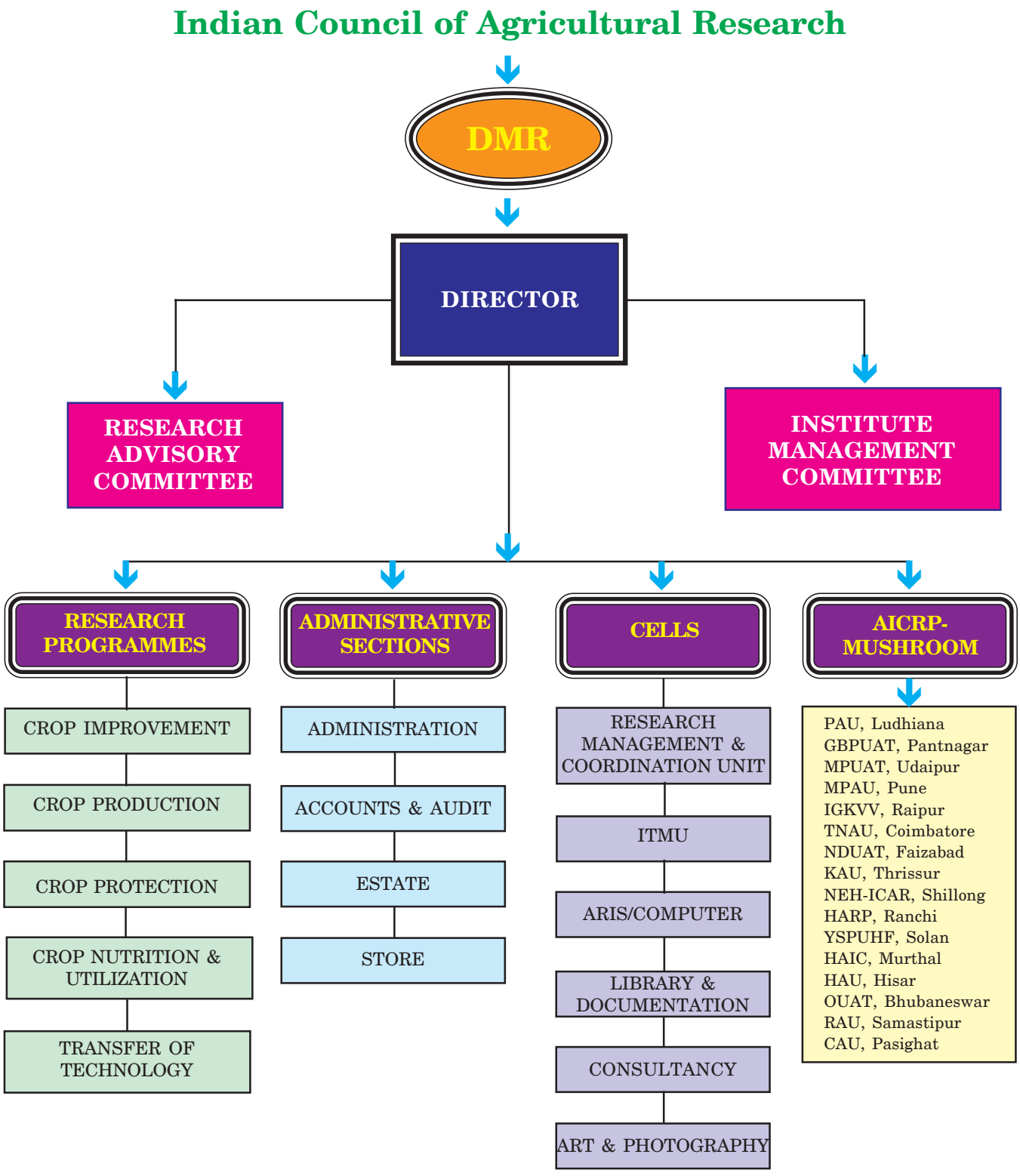
During the year Directorate organised 15 training programmes and one day Mushroom Mela on 10th September, 2009. Mushroom Mela was attended by about 650 farmers, farm women, mushroom growers, researchers, extension workers and businessmen from fifteen States. During the Mushroom Mela, Directorate awarded eight progressive mushroom growers for adopting innovative practices in mushroom cultivation.

Staff and Finance

The Directorate has a sanctioned strength of 16 scientists + 1 Director, 14 Technical, 16 administrative and 11 supporting staff. The staff in position on 31.12.2009 was 9 scientists, 14 technical, and 16 administrative and 9 supporting staff. The annual budget of the Directorate for the year 2009-2010 was Rs.180.00 Lakh (Plan) and Rs. 299.06 Lakh (Non Plan) which was fully utilized. The Directorate earned Rs.13.88 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, one polyhouse.
- Modern composting units comprising of 4 indoor bunkers, 4 bulk chambers, covered outdoor composting platform and related structures.
- Trainer's Training Centre
- Five well equipped laboratories with all sophisticated equipments.
- Excellent Library facilities with access to world literature on mushrooms through CeRA, internet, periodicals on mushroom and its related disciplines from all over the world, reference services and CD-ROM search service. It has presently 1289 books and 2500 back volumes of journals. It subscribes eight foreign journals and thirty-two Indian journals.


Indian Council of Agricultural Research
DMR
DIRECTOR
RESEARCH ADVISORY COMMITTEE
INSTITUTE MANAGEMENT COMMITTEE
RESEARCH PROGRAMMES
CROP IMPROVEMENT
CROP PRODUCTION
CROP PROTECTION
CROP NUTRITION & UTILIZATION
TRANSFER OF TECHNOLOGY
ADMINISTRATIVE SECTIONS
ADMINISTRATION
ACCOUNTS & AUDIT
ESTATE
STORE
CELLS
RESEARCH MANAGEMENT & COORDINATION UNIT
ITMU
ARIS/COMPUTER
LIBRARY & DOCUMENTATION
CONSULTANCY
ART & PHOTOGRAPHY
AICRP-MUSHROOM
PAU, Ludhiana
GBPUAT, Pantnagar
MPUAT, Udaipur
MPAU, Pune
IGKVV, Raipur
TNAU, Coimbatore
NDUAT, Faizabad
KAU, Thrissur
NEH-ICAR, Shillong
HARP, Ranchi
YSPUHF, Solan
HAIC, Murthal
HAU, Hisar
OUAT, Bhubaneswar
RAU, Samastipur
CAU, Pasighat

1. CROP IMPROVEMENT

1.1 Mushroom Genetic Resources

1.1.1 Survey, collection and identification of wild fleshy fungi

Fungal forays in the forest areas of Arunachal Pradesh, Himachal Pradesh, Uttarakhand, Bihar and Andeman and Nicobar islands were undertaken. A total 154 specimens were collected and 123 specimens have been identified upto genus level. The detailed anatomical description of some of the important specimens is described below:

Amanita rubescens

Basidiospores: [20/1/1] (5.4-) 6.3-7.2 (-9) x (4.5) 5.4-6.3 (-8.1) μm, **L**= 6.8 μm, **W**= 5.9 μm; **Q**= 1.15, subglobose, sometimes broadly ellipsoid or globose, amyloid, thin walled, smooth, hyaline, apiculous 0.9 μm long, contents multi-refractive oil droplets to mono-guttulate; spore deposit white. **Basidia**: 27-38 x 4.5-7.2 μm, clavate, 2-4-spored, sterigmata up to 5.5 μm long, thin walled, hyaline to multi-refractive oil droplets, basal septa without clamps. **Pileipellis**: 75-150 μm thick; suprapellis 50-100 μm thick, strongly gelatinized, hyphae parallel arranged, embedded in gelatinized matrix, 1.4-6.5 μm wide, thin walled, septate, branched, hyaline to yellowish or light yellowish brown pigmented, mixed with few vascular hyphae, 4.5-7.5 μm wide. **Pileus context**: made up of loosely arranged hyphae, 3.5-5.5 μm wide with sub-cylindric to sub-fusiform hyphae, often up to 28 μm wide, thin to slightly thick walled, hyaline; vascular hyphae few, up to 6.5 μm wide, septa without clamped. **Hymenophoral trama**: bilateral; mediostratum 15-25 μm thick, hyphae 4.5-9 μm wide, thin walled, septate; lateral stratum 20-40 μm thick, with cylindric to subfusiform hyphae, 9-24 μm wide, thin to slightly thick walled, hyaline; hyphae narrower towards subhymenium, 1.8-3 μm wide. **Subhymenium**: 20-40 μm thick; made up of 2-3 chains of globose, subglobose to irregular inflated cells, 6-23 x 5-18 μm diameter. **Marginal cells**: broadly clavate to pyriform, 22-32 x 15-22 μm, thin walled, arising in groups. **Volval remnants on cap**: made up of abundant inflated globose (25-70 μm), subglobose, pyriform to broadly clavate or broadly ellipsoid cells (45-100 x 26-70 μm), hyaline to yellowish brown pigmented, arising from branched, septate, non-clamped filamentous, hyaline to brownish yellow pigmented hyphae, 3.5-12.5 μm wide. **Volval remnants on stipe base**: with more abundant hyphae, 6-12.5 μm wide, thin walled, septate, branched hyaline brownish yellow pigmented, cylindric (45-140 x 20-40 μm) and long ellipsoid cells (60-115 x 25-65 μm), other cells similar to those on cap. **Annulus**: made up of abundant filamentous hyphae, thin to slightly thick walled, hyaline to light yellowish pigmented, branched, septa without clamps, 1.8-7.5 μm wide, mixed with few inflated broadly clavate, clavate or pyriform cells, 22-75 x 13-28 μm and cylindric to sub-fusiform cells, 8-24 μm wide, thin to slightly thick walled. **Stipe cuticle**: made up of longitudinally arranged cylindric to subfusiform cells, 8-26 μm wide, thin to slightly thick walled, mixed with filamentous hyphae 2.5-6.5 μm wide, thin walled, hyaline, septa clampless; vascular hyphae few, 8-11 μm wide.

Habit & habitat: scattered, growing on humicolous soil under the canopy of *Cedrus deodara*. Herbarium Acc. No. 26/08.

Comments: This specimen belongs to genus *Amanita* and section *Valideae* because of its bilateral lamella trama, white, smooth, amyloid spores, bulbous stipe base, volval remnants on pileus and stipe base small, floccose and

fugacious. This specimen similar to *A. rubescens* originally described from Europe (Jenkins, 1986).

2. *Cantharellus miniatescens* Heinem., BULL. Jard. Bot. Etat Brux. 28 (1958) 393, f. 36; Fl. Ic. Champ. Congo 8 (1958) 156, pl. 26, f. I. (Fig. 1.1 A).

Pileus: 3-5 cm wide, campanulate with papilla when young, later on more or less depressed, surface orange grey to grayish orange (6 B2-B3), appressed with light brown to brownish orange (7 D4-6 C4) fibrils in the center, greyish orange (5 B4-B3) outwards, cuticle half peeling or not; margin regular, non-striate; context thin, whitish. Lamellae: hymeniform not smooth, thick, decurrent, distant, light orange grey (5 B2), bifurcate at times, 2 mm broad, edges smooth, attachment to stipe distinct. Stipe: central, 3.5-6 x 0.4-0.8 cm, cylindric, with slightly broad base, concolourous to pileus, not smooth, stuffed, context off white, exannulate. Taste and Odour not examined. Spore deposit white.

Pileipellis: made up of parallel to suberectly arranged hyphae, 3.6-9 μm wide, thin to thick walled (upto 0.9 μm thick), wall yellowish, septate, branched, hyphal ends as narrowly clavate or rounded and contents with several small oil droplets to granulated. Basidia: 50-75 x 7.2-9 μm, long clavate, 2-4(-6) spored, sterigmata 4.5-5.4 μm long, contents granulated and with multi oil droplets, basal septa with clamps. Hymenophoral trama: irregular, made up of thin walled, clamped, and branched hyphae, 3.6-9 μm wide. Subhymenium: made up of none inflated hyphal cells, septate, branched, clamped. Pleurocystidia: none. Cheilocystidia: none. All hyphae are gleopleorus. Stipe cuticle: made up of longitudinally arranged thin walled, septate, branched, hyphae 3.6-10 μm wide, clamped, contents similar to pileipellis hyphae.

Basidiospores: [58/1/1] 7.2-9 (-9.5) x (4.1-4.5) 5.4 μm; L= 8.4 μm, W= 4.8 μm; Q= 1.74, ellipsoid, inamyloid, smooth, hyaline, apiculus upto 0.5 μm long, contents granulated (Fig. 1.1 A)

Collections examined: INDIA- Shimla-Dhalli Reserve forest of Himachal Pradesh, Collection no. 65/07.

Habitat and distribution: Solitary to gregarious; on soil under the mixed forest dominated by *Cedrus deodara.*

3. *Craterellus dubius* Peck, Rep. N.Y. St. Mus. 31 (1879) 38; Burt, Ann. Mo. Bot. Gdn (1914) 335; Lloyd, Mycol. Letters 63, note 494. (Fig. 1.1 B, C, D).

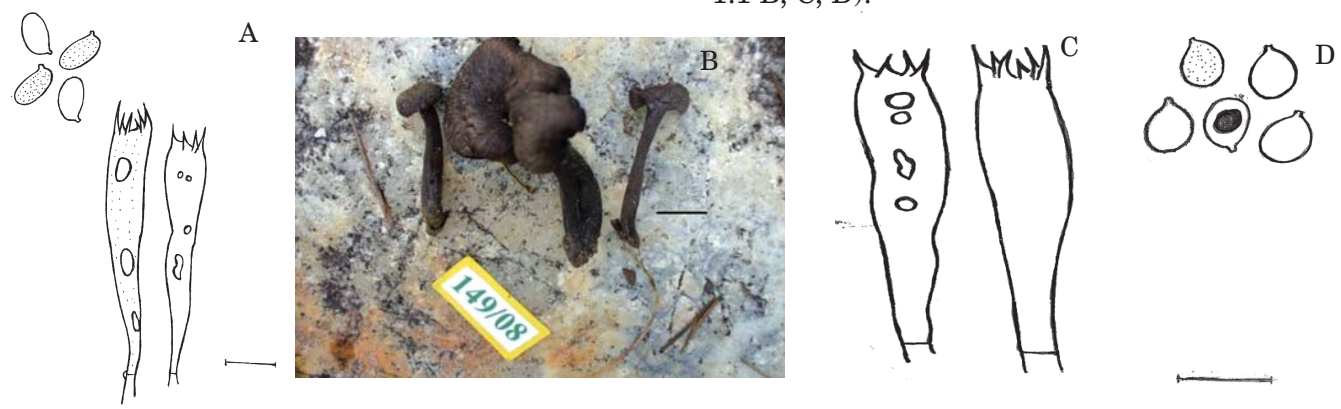


Fig. 1.1. A. basidia & basidiospores of *C. miniatescens* Heinem., B. basidiocarps of *Craterellus dubius* Peck., C. basidia of *Craterellus dubius* Peck. and D. basidiospores of *Craterellus dubius* Peck. The Bar of Fig. 1.1 A, C and D represents 10 μm and Fig. 1.1 B is 2 cm

Pileus up to 5 cm wide, infundibuliform, Copra (7 C8) to pony brown (15 A7), surface appressed with greyish black fibrillose to innate in the middle, dry, hygrophanous; margin wavy and lobed, crenulate, split; context thin. Lamellae: anastomosing, with folded hymeniform, interveined, Elephant skin (7 A2). Stipe: central, 2-3 x 0.2-1 cm, terete, Mauve taupe (7 C8), glabrous to thin hairy, compressed and appear as grooved in mature specimens; context blackish grey. Taste and Odour not examined. Spore deposit white (Fig. 1.1 B).

Pileipellis made up of septate, branched cylindric hyphae, 3.5-14 μm wide, hyphal ends rounded, upright and protruding beyond surface, larger hyphae often slightly constricted at septa, wall and cross walls thin to thick walled (0.5-1.2 μm thick), some hyphae encrusted with brownish yellow encrustations; clamp connection absent from all hyphae. Basidia 37-55 x 6-8 μm, narrowly clavate to clavate, developing basidia with granulose, light yellow content, 4-6 spored, sterigmata 3-5 μm long. Hymenophoral trama irregular to interwoven, hyphae branched, hyaline to faint yellowish color, cylindric constricted. Clamp absent. Subhymenium: made up of non-inflated, branched, septate and filamentous hyphae. Pleurocystidia: none. Cheilocystidia: none. Stipe cuticle made up of yellowish to brownish (3% KOH), cylindric to filamentous hyphae, thin to thick walled, branched, 3-8 μm wide.

Basidiospores: [42/2/2] 5.8-7.2 x 4.5-5.4 μm, L= 6.34 μm, W= 4.61 μm, Q= 1.37, broadly ellipsoid to subglobose, smooth, nonamyloid, noncyanophilic, light yellowish in 3% KOH (Fig. 1.1 C, D).

Collections examined: INDIA- Shimla-Mandi forest of Himachal Pradesh, RCU 149/08.

Habitat and distribution: Solitary to gregarious; on soil under the mixed forest dominated by *Quercus* species.

(Survey, collection and identification of wild fleshy fungi - NCM-15)

1.1.2 Germplasm Characterization

Twenty single spore isolates of *Pleurotus sajor-caju* and 57 hybrids evolved by compatible mating were grown on malt extract agar medium (2%) and incubated at 25°C. Average radial growth of mycelium per day was recorded. Similarly, 2 DG was also incorporated into culture medium and growth inhibition and tolerance of SSI and hybrids were determined. The qualitative estimation of laccase of SSI (Table 1.1) and hybrids (Table 1.2) using ABTS and fruit body formation in culture plates were recorded to find out any biochemical, physiological or growth markers for high yielding hybrids strains.

1.1.2.1 Morphological Characterization of *Pleurotus florida* strains

The Gene Bank of Directorate of Mushroom Research, has seventeen different strains of *P. florida* from various sources. All the strains were cultivated under uniform conditions for studying their phenotypic characterization. The detailed morphological features are described hereunder:

P-1

Pileus diameter up to 9.5 cm wide, flabellate, brownish cream, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color whitish, up to 1.2 cm thick. **Lamellae**: decurrent, crowded to subdistant, creamish

Table 1.1. Radial growth, % reduction in mycelial growth and laccase activity of SSIs

SSI. No.	Radial growth (mm/day)	Reduction in growth (%) with 2-DG	Laccase (using ABTS)
SSI-1	7.5	68.0	After 5 Min, +
SSI-2	6.5	66.7	After 2 Min, ++
SSI-3	7.0	100.0	After 5 Min, +
SSI-4	6.3	100.0	After 2 Min, +
SSI-5	10.5	68.7	After 4 Min, +
SSI-6	10.5	100.0	After 2 Min, +++
SSI-7	7.0	70.0	After 3 Min, +++
SSI-8	7.5	100.0	After 4 Min, ++
SSI-9	9.5	100.0	After 2 Min, +++
SSI-10	7.0	100.0	After 2 Min, ++++
SSI-11	5.5	100.0	After 4 Min, +++
SSI-12	12.0	72.8	After 5 Min, +++
SSI-13	6.2	100.0	After 2 Min, ++++
SSI-14	11.2	75.0	After 2 Min, +++
SSI-15	8.0	100.0	After 5 Min, ++
SSI-16	11.5	92.0	After 2 Min, ++
SSI-17	12.0	90.0	After 3 Min, ++
SSI-18	10.0	95.0	After 3 Min, ++
SSI-19	9.3	75.0	After 2 Min, +++
SSI-20	5.0	100.0	After 2 Min, +++

yellow to whitish, edges smooth, serrate, lamellulae of 7-8 ranks. **Stipe**: ecentric, stout 3-6 x 0.5-1.2 cm, tapering downwards, velvety with thin small white fibrils at the base. Context stuffed, fibrous, yellowish white. Taste: mild; odour: fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-15

Pileus diameter up to 9.5 cm wide, flabellate, creamish white to off white, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color white to creamish white, up to 1.3 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow to whitish, edges smooth, serrate, lamellulae of 6-7 ranks. **Stipe**: Ecentric, stout 4-4.5 x 0.5-1 cm, tapering downwards, velvety with thin small white fibrils at the base. Context stuffed, fibrous, white. Taste: Mild; odour: Fungoid. The species has characteristic tuff pileus.

Habit & habitat: Caespitose to gregarious.

Table 1.2. Radial growth, % reduction in mycelial growth, fructification and laccase activity of hybrids

S. No.	Radial growth (mm/day)	Reduction in growth (%) (2-DG)	Fruiting	Laccase
H-1	15.0	81.8	After 36 days, ***	After 5 Min, +
H-2	11.2	100.0	-- --	After 5 Min, +
H-3	15.5	100.0	After 35 days, **	After 2 Min, ++
H-4	9.7	92.0	After 38 days (Small Pin head)	After 3 Min, ++++
H-5	13.0	84.0	After 28 days, ***	After 3 Min, +++
H-6	13.5	65.0	After 35 days, ***	After 3 Min, ++
H-7	11.5	100.0	After 39 days (Small Pin head)	After 1 Min, ++++
H-8	14.0	60.0	-- --	After 4 Min, +
H-9	13.0	77.8	After 31 days, ***	After 5 Min, +
H-10	13.0	89.4	After 33 days, **	After 3 Min, ++

S. No.	Radial growth (mm/day)	Reduction in growth (%) (2-DG)	Fruiting	Laccase
H-11	8.0	56.5	_ _	After 4 Min, +
H-12	14.0	100.0	After 35 days, *	After 3 Min, ++
H-13	9.0	100.0	After 35 days, **	After 5 Min, ++
H-14	13.5	100.0	After 31 days, ****	After 7 Min, +
H-15	8.5	100.0	After 31 days, ***	After 3 Min, +++
H-16	14.0	100.0	After 33 days, ***	After 6 Min, +
H-17	10.0	94.4	_ _	After 4 Min, +
H-18	13.33	89.2	After 29 days, **	After 5 Min, +
H-19	7.0	100.0	After 30 days, ***	After 7 Min, +
H-20	9.0	100.0	After 33 days, ***	After 2 Min, ++++
H-21	12.5	100.0	After 37 days, *	After 5 Min, +
H-22	8.5	100.0	After 29 days, ****	After 2 Min, +++
H-23	16.0	100.0	After 33 days, **	After 2 Min, ++
H-24	8.0	100.0	After 28 days, ****	After 2 Min, ++++
H-25	9.0	100.0	After 28 days, ***	After 5 Min, +
H-26	15.5	97.1	After 35 days, *	After 2 Min, ++
H-27	14.5	100.0	_ _	After 4 Min, +
H-28	16.5	90.0	_ _	After 2 Min, ++
H-29	14.5	100.0	_ _	After 2 Min, ++++
H-30	13.5	100.0	_ _	After 5 Min, +
H-31	15.0	93.3	_ _	After 5 Min, +
H-32	16.0	93.3	_ _	After 2 Min, ++
H-33	14.0	100.0	After 32 days, ***	After 3 Min, ++++
H-34	14.5	87.5	After 38 days, *	After 3 Min, +++
H-35	7.2	100.0	_ _	After 3 Min, ++
H-36	13.0	100.0	After 29 days, **	After 1 Min, ++++
H-37	5.5	70.6	After 38 days, *	After 4 Min, +
H-38	11.5	100.0	After 38 days (Small Pin head)	After 5 Min, +
H-39	8.5	86.7	After 33 days, *	After 3 Min, ++
H-40	8.5	100.0	After 31 days, *	After 4 Min, +
H-41	12.5	100.0	After 31 days, **	After 3 Min, ++
H-42	11.2	100.0	After 35 days, *	After 5 Min, ++
H-43	13.5	100.0	After 35 days, ***	After 7 Min, +
H-44	10.7	100.0	After 33 days, *	After 3 Min, +++
H-45	12.5	93.3	After 32 days, **	After 6 Min, +
H-46	7.5	100.0	_ _	After 4 Min, +
H-47	7.0	90.0	_ _	After 5 Min, +

S. No.	Radial growth (mm/day)	Reduction in growth (%) (2-DG)	Fruiting	Laccase
H-48	9.5	100.0	After 28 days, **	After 7 Min, +
H-49	9.0	100.0	After 31 days, *	After 2 Min, ++++
H-50	11.5	96.3	After 33 days, **	After 5 Min, +
H-51	7.5	100.0	After 37 days, **	After 2 Min, +++
H-52	10.0	100.0	After 33 days, *	After 2 Min, ++
H-53	15.0	93.9	_ _	After 2 Min, ++++
H-54	6.0	100.0	After 31 days, ***	After 5 Min, +
H-55	10.0	100.0	After 36 days, **	After 2 Min, ++
H-56	10.0	100.0	After 31 days, ****	After 4 Min, +
H-57	5.5	100.0	_ _	After 2 Min, ++
Control	12.0	100.0	_ _	After 2 Min, ++++

*=1-2 fruit bodies, **=3-5 fruit bodies, ***=6-10 fruit bodies, ****=11 or more fruit bodies
+=very less activity, ++=less activity, +++=moderate activity, ++++=high activity

Pl-20

Pileus diameter up to 7.5 cm wide, flabellate, dirty white to bluish brown in the young stage, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color white to creamish white, up to 1 cm thick. **Lamellae**: decurrent, close to crowded, creamish yellow to whitish, edges smooth, lamellulae of 6-7 ranks. **Stipe**: Ecentric, stout 3-6.5 x 0.6-1.3 cm, tapering downwards, velvety with thin small white fibrils on the surface. Context stuffed, fibrous, white. Taste: Mild; odour: Fungoid. The species is similar to *Hypsizygus ulmarius*

Habit & habitat: Caespitose to gregarious.

Pl-30

Pileus diameter up to 11.5 cm wide, flabellate, light chocolate brown, surface hygrophanous, margin irregular, split, lobed, non-striate, moist, cuticle half peeling, covered with very thin, fine appressed fibrils; context color white, up to 1 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow: Whitish, edges smooth, lamellulae of 6-7 ranks. **Stipe**: Ecentric, stout (very thick), 2-4 x 1.5-1.9 cm, tapering downwards, velvety with thin small white fibrils on surface, context stuffed, fibrous, yellowish white. Taste: Mild; odour: fungoid. The species has light brown pileus like *P. sajor-caju* and pileus distinctly lobed.

Habit & habitat: Caespitose to gregarious.

Pl-250

Pileus diameter up to 11.5 cm wide, flabellate, dirty white to brownish cream, surface hygrophanous, dark brown to violet patches on the centre of pileus surface, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color creamish white, up to 1.3 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow to whitish, edges smooth, lamellulae of 7-8 ranks. **Stipe**: ecentric, stout 2.5-7.5 x 0.7-1.3 cm, tapering downwards, velvety with thin small white fibrils at the base. Context stuffed, fibrous, yellowish white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-450

Pileus diameter up to 12.5 cm wide, flabellate, dirty white to brownish cream, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color white, up to 1.5 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow to whitish, edges smooth, serrate, lamellulae of 7-8 ranks. **Stipe**: Ecentric, stout 3-6 x 0.8-1.7 cm, tapering downwards, velvety with thin small white fibrils at the surface. Context stuffed, fibrous, white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-550

Pileus diameter up to 13.5 cm wide, flabellate, dirty white to creamish brown color, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color creamish white, up to 0.7 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow: whitish, edges smooth, serrate, lamellulae of 6-7 ranks. **Stipe**: Ecentric, stout 3-5 x 0.5-1.2 cm, tapering downwards, velvety with thin small white fibrils on surface and pileus hairy at the stipe attachment. Context stuffed, fibrous, yellowish white to white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-610

Pileus diameter up to 12 cm wide, flabellate, infundibuliform, involutes, creamish white, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color white up to 1 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow to whitish, edges smooth, serrate, lamellulae of 7-8 ranks. **Stipe**: Ecentric, stout 2-4 x 0.7-2 cm, tapering downwards, velvety with hairy base but not conspicuously hairy. Context stuffed, fibrous, white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-670

Pileus diameter up to 11.5 cm wide, flabellate, brownish cream to creamish white, surface hygrophanous, margin regular, split, non-striate, moist, cuticle half peeling, covered with very thin, fine appressed fibrils; context color white, up to 1.4 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow to whitish, edges smooth, serrate, lamellulae of 7-8 ranks. **Stipe**: Ecentric, stout 3.5-6 x 0.5-1.5 cm, tapering downwards, velvety with thin small white fibrils at the base. Context stuffed, fibrous, white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-870

Pileus diameter up to 12.3 cm wide, involute, flabellate, brownish white to off white, surface hygrophanous, margin regular, split, non-striate, cuticle full peeling, covered with very thin, fine appressed fibrils; context creamish white to white, up to 1 cm thick. **Lamellae**: Close to subdistant, creamish yellow: decurrent, whitish, edges smooth, lamellulae of 6-7 ranks. **Stipe**: Ecentric, 2.5-3.5 x 0.5-2 cm, tapering downwards, velvety with thin small white fibrils on surface. Context stuffed, fibrous, yellowish white. Taste: mild; odour: Fungoid. The species has best acceptable morphology, Creamish yellow, fruit body harder and brittle, stipe base hairy.

Habit & habitat: Caespitose to gregarious.

Pl-880

Pileus diameter up to 11.5 cm wide, flabellate, depressed in the center, Creamish to brownish white, surface hygrophanous, margin regular, split, non-striate, cuticle full peeling, covered with very thin, fine appressed, light brownish fibrils; context whitish 1 cm thick. **Lamellae**: Close to subdistant, creamish yellow: Decurrent, crowded, whitish, edges smooth, lamellulae of 6-7 ranks. **Stipe**: Stout, ecentric, 2-7.5 x 1-1.8 cm, tapering downwards, velvety to glabrous with thin small white fibrils. Context stuffed, yellowish white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-890

Pileus diameter up to 13 cm wide, flabellate, brownish white to off white, uplifted, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color creamish white to off white, up to 1.3 cm thick. **Lamellae**: Decurrent, subdistant to close, creamish yellow to whitish, edges smooth, lamellulae of 6-7 ranks. **Stipe**: Ecentric, stout 2-7 x 0.5-1.5 cm, tapering downwards, velvety with thin small white fibrils at the base. Context stuffed, fibrous, Taste: Mild; odour: Fungoid. The pileus is characteristically is very big, broad and trumpet shape

Habit & habitat: Caespitose to gregarious.

Pl-900

Pileus diameter up to 13 cm wide, flabellate, uplifted, creamish white, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color creamish white, up to 1 cm thick. **Lamellae**: Decurrent, close to subdistant, creamish yellow to whitish, edges smooth, lamellulae of 7-8 ranks. **Stipe**: Ecentric, stout 4-4.5 x 0.5-1 cm, tapering downwards, velvety with thin small white fibrils at the base. Context stuffed, fibrous, yellowish white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-910

Pileus diameter up to 12.5 cm wide, flabellate, creamish white to brownish cream, surface slightly hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color white, up to 1.4 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow, edges smooth, lamellulae of 7-8 ranks. **Stipe**: Ecentric, stout 2-7.5 x 0.5-1.3 cm, tapering downwards, velvety with thin small white fibrils on surface and base. Context stuffed, fibrous, yellowish white to white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-920

Pileus diameter up to 9.5 cm wide, flabellate, brownish yellow, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color creamish white, up to 1.5 cm thick. **Lamellae**: decurrent, crowded to subdistant, creamish yellow to whitish, edges smooth, serrate, lamellulae of 6-7 ranks. **Stipe**: Ecentric, stout 2-7 x 0.8-1.9 cm, tapering downwards, velvety with thin small white fibrils on surface and base. Context stuffed, fibrous, yellowish white to white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

Pl-930

Pileus diameter up to 11.5 cm wide, flabellate, creamish white to off white, surface hygrophanous, margin regular, split, non-striate, moist, cuticle full peeling, covered with very thin, fine appressed fibrils; context color white to creamish white, up to 1.2 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow to whitish, edges smooth, lamellulae of 6-7 ranks. **Stipe**: Ecentric, stout 2.5-8 x 0.5-1.6 cm, tapering downwards, velvety with thin small white fibrils on surface. Context stuffed, fibrous, white. Taste: Mild; odour: Fungoid.

Habit & habitat: Caespitose to gregarious.

OE-43

Pileus diameter up to 8.5 cm wide, flabellate, creamish white to light brownish cream, surface hygrophanous, margin regular, split, non-striate, cuticle full peeling, covered with very thin, fine appressed fibrils; context color white to creamish white, up to 1 cm thick. **Lamellae**: Decurrent, crowded to subdistant, creamish yellow: Whitish, edges smooth, lamellulae of 7-8 ranks. **Stipe**: Ecentric, stout, 2.5-6.2 x 0.7-1.3 cm, tapering downwards, velvety with thin small white fibrils on surface, inehead plenty, context stuffed, fibrous, yellowish white. Taste: Mild; odour: Fungoid. The culture produces profuse number of pinheads.

Habit & habitat: Caespitose to gregarious.

(Improvement in cultivation of oyster mushroom and developing hybrid strains, - NCM-38)

1.2 Genetic Improvement

1.2.1 Evaluation of Paddy straw mushroom (*Volvariella volvacea*) strains for yield and pest resistance

Strains and Single spore isolates: Three parent strains (OE-272, OE-274 and OE-210) and 4 single spore isolates (OE-12-06, OE-12-22, OE-55-08 and OE-55-30; 2 each from parent strains OE-12 and OE-55, respectively) of *V. volvacea*, pre-screened for mycelial growth characteristics, extracellular lignocellulolytic enzymes activity profiles, genetic distinctness and superior yield potential on paddy straw substrate were used. Paddy straw based spawn was used in the study. First 3 trials were carried out by using paddy straw + blow-room-waste from cotton spinning mill in 1:1 ratio (w/w) as the substrate (w/w), while the 4th trial was carried out with paddy straw + cotton ginning mill waste in 1:1 ratio (w/w). Chicken manure and $CaCO_3$ were added @ 5.0% and 1.5% (dry wt. basis), respectively on 0 day and 3 day of stacking, while turnings were given on day 1, 2, 3 and 4 of out door composting. Beds of 180 cm x 70 cm x 12 cm (l x b x h) size were prepared with 35 kg wet substrate on shelves of iron racks in cropping room. Four replications were kept for each strain/SSI and the experiment was conducted in a randomized block design.

Mushroom yield: The data depicted in Table 1.3 reveal that in all 4 trials, mushrooms appeared at the earliest in strain OE-274. In overall average of 4 trials, the earliest harvest was in 11.38 day in strain OE-274, followed by 12.19 day in SSI OE-12-22. Amongst different trials, mushrooms were harvested at the earliest in trial 4. The mushroom yield obtained in different strains/ SSIs varied in different trials (Table 1.4) and it was significantly higher in strain OE-272 in trial 1, SSI OE-55-08 in trial 2 and strain, OE-274 (Fig. 1.2) in trial 3 and 4. In overall average of 4 trials, parent strain, OE-272 exhibited the highest yield, closely followed by strain OE-274 and SSI OE-55-08.

The numbers of fruiting bodies harvested from different strains/SSIs varied in different

Table 1.3. Time taken for first harvest in different strains of *Volvariella volvacea*

Strain	Time taken for first harvest (days post-spawning)				
	Trial-1	Trial-2	Trial-3	Trial-4	Mean
OE-272	14.25	11.75	11.33	12.25	12.40
OE-274	11.50	11.50	11.25	11.25	11.38
OE-210	13.75	12.25	12.50	11.50	12.50
OE-12-22	12.50	12.00	12.00	12.25	12.19
OE-12-06	14.25	13.00	12.00	NT	13.08
OE-55-08	NT	13.00	13.00	12.50	12.83
OE-55-30	NT	12.00	14.50	NT	13.25
Mean	13.38	12.09	12.37	11.95	12.45
CD (0.05%)	1.00	0.79	0.94	1.00	

NT=Not tested -

Table 1.4. Mushroom yield in different strains of *Volvariella volvacea*

Strain	Mushroom yield (kg/q dry substrate)				
	Trial-1	Trial-2	Trial-3	Trial-4	Mean
OE-272	39.85	28.09	23.79	25.73	29.37
OE-274	23.94	32.53	25.73	32.44	28.66
OE-210	24.72	23.58	16.21	23.57	22.02
OE-12-22	23.79	20.78	20.52	18.06	20.79
OE-12-06	14.38	11.61	9.75	NT	11.91
OE-55-08	NT	33.98	14.98	24.51	24.49
OE-55-30	NT	28.30	8.31	NT	18.31
Mean	22.94	25.29	17.04	24.86	22.53
CD (0.05%)	6.12	2.81	6.46	6.22	

NT=Not tested

trials and it was the highest in strain OE-272 in trial-1, SSI OE-55-08 in trial-2, SSI OE-12-22 in trial-3 and strain OE-210 in trial-4. In overall average of 4 trials, the highest numbers of fruiting bodies were recorded in strain, OE-272. This strain gave 57.74 to 61.20% of total yield during first week in first 2 trials (Fig. 1.3) and it increased to 74% in trial-3 as this trial was of much shorter duration. The trend for another high yielding strain OE-274 was slightly different as it gave almost 57 to 64% yield during first week in first 2 trials, but its yield level went on decreasing with increasing cropping time and it was almost negligible during 4th week. The high yielding SSI OE-55-08 gave bit lesser yield than the strains OE-272 and OE-274 during 1st week but its yield level was more consistent during later weeks (Fig. 1.3), which contributed towards its superior yield in trial 2 and 4. In all strains and SSIs, the yield level in trial 3 was very high (71.56 to 96.41%) during 1st week, the reason

Fig. 1.2. *V. volvacea* crop (strain, OE-274)

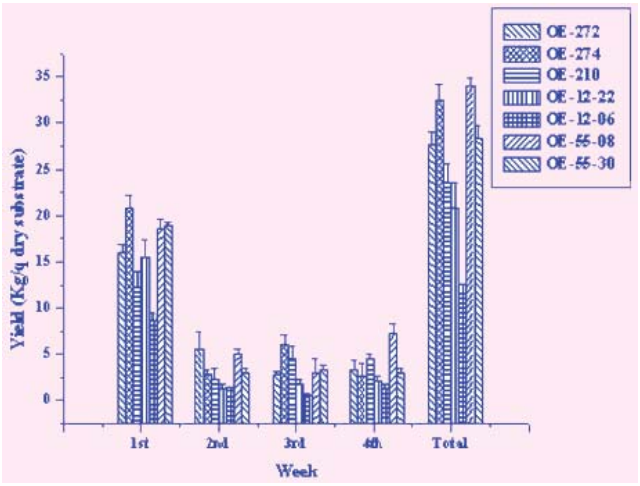


Fig. 1.3. Weekly yielding pattern of different strains of *V. volvacea* in trial-2

being more favourable temperature during early phase of the crop. In trial-4, cotton ginning mill waste and paddy straw based compost gave yield at par with paddy straw and cotton spinning mill waste but in a shorter duration of 2 weeks than 4 weeks in trial-1 and 2. The numbers of fruiting bodies harvested in different strains also varied during 2 flushes and majority were harvested during 1st flush. In 2nd flush, the number were the highest in strain OE-210, followed by SSI OE-55-08.

Mushroom quality: The average fruiting body weight in different strains varied in different trials and it was highest in strain, OE-274 in all 4 trials (Table 1.5). The second higher weight was in strain OE-272 in trial-1, 3 and 4. In overall average of 4 trials, weight was the highest of 16.47 g in strain OE-274, followed by 12.75 g in strain OE-272. The weight in rest of the strains and SSIs showed little variation. The fruiting bodies were whitish, oblong shaped and delicate in SSIs, OE-55-08 and OE-55-30 but with least tendency of veil opening (Table 1.6). The fruiting bodies in strain OE-272 were of average size, medium level toughness and typically match the birds' eggs but with bit higher tendency of veil opening on delayed harvesting. The toughest fruiting bodies with least tendency of veil opening along with the highest weight and size were harvested from strain OE-274. The higher weight of fruiting bodies of strain OE-274 contributed towards its superior yield even after lagging behind over other strains/SSIs in numbers of fruiting bodies harvested per unit area.

Resistance against diseases and insect-pests: *In vitro* studies for resistance against diseases and insect-pests were carried out first by growing different strains and SSIs on MEA medium in petridishes and then 5 larvae either of sciarid and phorid flies were released in separate plates, followed by incubation of the plates at 32 ± 2°C for 4 days in BOD incubator. Plates were recorded daily for mycelial-clearing zones created if any due to larval feeding of mushroom mycelia. The level of resistance in different strains was recorded based upon the diameter of mycelial clearing zone created by the feeding larvae. *In vivo* studies were carried out by observing the mushroom beds daily starting from spawn run to crop end for the growth of competitor moulds, and appearance of mites, nematodes, sciarid and phorid flies per unit area of the compost.

Table 1.5. Average fruiting body weight in different strains of *Volvariella volvacea*

Strain	Average fruiting body wt (g)				
	Trial-1	Trial-2	Trial-3	Trial-4	Mean
OE-272	13.87	10.75	13.23	13.15	12.75
OE-274	18.34	15.64	17.83	14.05	16.47
OE-210	13.45	12.36	10.21	9.62	11.41
OE-12-22	9.15	9.35	12.93	9.02	10.11
OE-12-06	10.32	9.00	11.75	NS	10.36
OE-55-08	NS	11.12	10.53	10.16	10.60
OE-55-30	NS	10.12	12.69	NS	11.41
Mean	12.54	11.19	12.74	11.20	11.87
CD (0.05%)	4.03	2.59	3.65	3.01	

Table 1.6. Fruiting bodies quality in different strains of *Volvariella volvacea*

Strain	Fruiting body colour	Fruiting body size (dia./length in cm)	Toughness	Veil opening
OE-272	Whitish with grayish spot	3-4/4-5	++++	+
OE-274	Brownish	4-5/5-6	Toughest	-
OE-210	Brownish	2-3//3-4	+++	-
OE-1206	Brownish	2-3/3-4	++	-
OE-1222	Brownish	3-4/4-5	+++	-
OE-55-08	Whitish	2.5-3/5-6	Delicate	
OE-55-30	Whitish	3-4/5-6	Delicate	

Among competitor moulds, ink cap (*Coprinus* sp.) was recorded as the major mould and it appeared during later stages of crop mainly on lower shelves (Table 1.7). Its appearance can be attributed to improper pasteurization of substrate and cropping conditions that existed in and around lower shelves rather than strains. However, beds of SSIs were more prone to ink cap growth than the parent strains. Growth of green mould was recorded mainly on cotton fibers during trial-1 and it is again attributed to improper pasteurization of substrate. Mites also appeared during trial-1 and their intensity was higher on beds of strain OE-210 and SSI OE-12-06. Nematodes were also recorded in compost and in damaged fruiting bodies during trial-1 and their intensity was the highest in beds on strains OE-272 and OE-274. The highest yield loss of 20-40% mainly due to nematodes infestation was in strain OE-272, followed by 20-30% in SSI OE-12-06. Nematodes infestation was also recorded in SSIs OE-55-08 and OE-55-30. Under *in vitro* screening of different strains and SSIs, the SSI OE-12-06 and strain OE-272 were recorded to be more resistant against sciarid larvae, while strain OE-210 and SSI OE-55-08 were more resistant against

Table 1.7. Incidence and yield loss due to competitor moulds and insect-pests in different strains of *V. volvacea*

Strain	Incidence												Yield loss (%)	
	Coprinus sp.*			Green mould**			Mites***			Nematodes				
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2&3
OE-272	+	+	+	++	-	-	+	-	-	+	-	-	1-1.13	20-40
OE-274	-	+	+	+	-	-	-	-	-	+	-	-	0.83-1.04	1-2
OE-210	+	+	+	+	-	-	++	-	-	-	-	-	0.61-0.81	2-3
OE-12-22	-	+	++	+	-	-	-	-	-	-	-	-	0.34-0.42	3-5
OE-12-06	++	+	+	+	-	-	++	-	-	-	-	-	0.69-0.83	20-30
OE-55-08	NT	+	++	NT	-	-	NT	-	-	NT	-	-	NT	2-20
OE-55-30	NT	+	+++	NT	-	-	NT	-	-	NT	-	-	NT	2-40

* *Coprinus* appeared during later stage of crop mainly in lowest shelves, ** Green mould appeared after 1st flush only on cotton waste, *** Mites appeared after 5-6 d of bed opening; NT=Not tested; +=Low incidence, ++=Medium incidence, +++=High incidence

Table 1.8. Susceptibility of different strains of *Volvariella volvacea* against larvae of sciarid and phorid flies under *in vitro* and *in vivo* conditions

Strain	*In vitro* conditions		*In vivo* conditions	
	Sciarid larvae	Phorid larvae	Sciarid larvae	Phorid larvae
OE-272	+	+++	-	+
OE-274	+	+++	-	-
OE-210	++	-	-	-
OE-12-06	-	+++	-	+
OE-12-22	+	++++	-	+
OE-55-8	++	+	-	-
OE-55-30	++	++	-	+

phorid larvae (Table 1.8). Under *in vivo* conditions, infestation of only phorid flies was recorded and it was lowest in strains, OE-274 and OE-210, and SSI, OE-55-08.

(Integrative use of cultivation technologies and molecular techniques for enhancing yield and quality of paddy straw mushroom, Volvariella spp. –NCM-40)

2.1 Button Mushroom

2.1.1 Indoor composting using combination of INRA and Anglo Dutch methods

Experiment was conducted by taking wheat straw as the base material. Compost was prepared using following formulation and time schedule.

Compost ingredients	Quantity
Wheat straw	1000 kg
Chicken manure	700 kg
Wheat bran	70 kg
Urea	15 kg
Cotton seed cake	20 kg
Gypsum	40 kg

Time schedule	Operation
-2 day	Wetting and mixing of the ingredients out door
-1 day	Turning, trampling by Bobcat and thorough mixing of the ingredients, addition of water
0 day	Filling in the phase-I tunnel
+6 day	Emptying the tunnel, turning and mixing of the compounding mixture and filling the compost in Phase-II tunnel.
+13 day	Phase-II operation over

Ingredients were thoroughly mixed and properly wetted so as to achieve around 75% moisture percentage. 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 the mass was transferred to phase-I bunker, for phase-I operation. This material weighed around 4 tons and height of the compost in the bunker was kept up to 1.8- 2 meters. Temperature sensors were installed on the top and in the center of the pile in the bunker and blower fan switched on for 15 min./ 2 hours with the help of a timer installed for the purpose. A temperature between 72-75°C was recorded in the centre of the pile and at top to 8" deep of the pile. Temperature on the sides of the compost mass along the walls was in the range of 45-52°C. Full penetration of air was noticed in the compost. Further no foul smell was noticed while performing phase -1 in bunker. After 6 days of partial fermentation in phase-I tunnel, entire compost mass was taken out and was transferred to phase-II tunnel for usual phase-II operations. Standard methodology was employed thereafter for compost production. Phase-II operation was over in 7 days time.

Physical parameters and yield

Moisture of the compost at filling was 68 % while it came down to 64 % at spawning however, pH at filling was 7.7 while it was 7.4 at spawning. Wheat straw to compost conversion ratio was 3.6 times (Table 2.1). An average yield

Table 2.1. Physical parameters and yield obtained with indoor compost

Trial	pH at filling	pH at spawning	Moisture at filling (%)	Moisture at spawning (%)	Conversion ratio	Yield kg/q compost
1.	7.70	7.40	68.0	64.0	3.6	11.14

of 11.14 kg mushrooms per quintal compost was obtained from the trial in forty days of cropping.

Total indoor compost production using consortium of thermophlic fugi

Compost was prepared using following formulation.

Compost ingredients	Quantity
Wheat straw	1000 kg
Chicken manure	400 kg
Wheat bran	60 kg
Urea	15 kg
Cotton seed cake	10 kg
Cotton seed meal	20 kg
Gypsum	50 kg

Ingredients were thoroughly mixed and properly wetted so as to achieve around 75% moisture percentage. 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 inoculated with consortium of thermophilic fungi and was trampled hard by running Bobcat several times over the wetted ingredients. This mixture was then made up into a heap and left as such for two days when the heap attains a temperature of 70–75^{0}C. After 3-4 days of thorough mixing and wetting, entire mass was shifted to phase-II tunnel for performing usual phase-II operations including conditioning and pasteurization. Here compost temperature was kept in the range of 45-56^{0}C excepting at 59-60^{0}C for 6 hours for pasteurization (cold process). Entire operation lasted for 6 days. Next day compost was taken out and spawned with U-3 strain for raising the crop.

Physical parameters and yield

Moisture of the compost at filling was 65 % while it came down to 60 % at spawning. pH at filling was 8.4 while it was 7.3 at spawning. Wheat straw to compost conversion ratio was 3.25 times (Table 2.2). Compost production by cold process escaping phase –I condition was highly successful as very good yield of 15.43 kg/q compost was obtained in 20 days of cropping and mushrooms kept on coming regularly with out any flush break.

2.1.2 Commercialization of thermophilic fungi in long method compost

An experiment was conducted with a view to exploit pasteurized compost as consortium of thermophilic organisms instead of usual thermophilic fungi for shortening the composting phase and also to increase the yield. For this purpose four compost piles of under mentioned ingredients were prepared.

Compost ingredients	Quantity
Wheat straw	300 kg
Wheat bran	30 kg
Urea	7 kg
Gypsum	20 kg

Table 2.2. Physical parameters and yield obtained from indoor compost prepared by cold process

Trial	pH at filling	pH at spawning	Moisture at filling (%)	Moisture at spawning (%)	Condition of spawn run	Conversion ratio	Yield kg/q compost
Cold compost	8.4	9.3	65	60	Excellent	3.25	15.43

All the four piles were inoculated with the pasteurized compost @ 30 kg each on 0 day, 4th day and on 8th day while 4th pile served as control. Duration of the composting period was kept as 20 days against 28 days normally taken for long method compost. Turning schedule followed was as follows: 0 day, +4 day, +6 day, +8 day, +10 day, +12 day, +14 day, + 16 day, +18day, +20 day and spawn. On 20th day pile was opened and spawned with S-11 strain of *A. bisporus*. Physical parameters and thermophilic fungal population of short method compost used as inoculum is presented in Table 2.3. This compost harboured the usual thermophilic population including *S. thremophilum*. Thermophilic and mesophilic flora isolated at various intervals in 4 piles is presented in Tables 2.4 and 2.5, respectively.

Among the thermophilic fungi *A. fumigatus*, M. *pussilus,* S. *thermophilum*, *H. grisea*, *H. insolens* and *Coprinus* sp were isolated from different piles at various intervals. Maximum cfu of different fungi was obtained from pile 1 which was inoculated with pasteurized compost on 0 day. Rest of the treatments showed almost similar cfu and all the piles had maximum population of *S. thermophilum* on 20th day (Table 2.4).

A. fumigatus, *M. pussilus, Rhizopus* sp. *Coprinus sp., T. viride*, unidentified sp. and *Fusarium* sp. were isolated among the mesophilic fungi. Minimum population of these fungi were isolated from pile –1 followed by pile –3 which was inoculated with pasteurized compost on 8th day. All the piles showed very heavy population of *T. viride* at last turning (Table 2.5).

Table 2.3. Physical parameters of ready compost used as inoculum

S. No.	Moisture	pH	N-%	CFU/g of Compost 10^{-4}	Dominant Flora
1.	66	7.80	1.80	11.0	*S. thermophilum, H.insolens, H.grisea, A. fumigatus*

Table 2.4. Thermophilic flora (cfu x 10^4) isolated from different piles at different intervals

Piles	Turnings					Mean count
	I	II	III	IV	V	
1	1.33 a,m	2.33 a,m	10.66 st,hi,a	5.33 st,hi	13.00 st	6.53
2	1.00 a	4.00 a,c	3.66 hi, a	3.66 st,hi,a	7.20 st,hi,a	3.90
3	2.66 a,m	4.33 a,c	4.00 st,af	5.00 st,hi,hg	5.33 st,a	4.20
4	4.00 a,m	3.0 st	2.00 a,b	7.00 af	7.00 hi,st,a	4.60

a- *A. fumigatus*, m- *M. pussilus*, st- *S. thermophilum*, hg- *H.grisea*, hi- *H. insolens*, c- *Coprinus* sp.

Table 2.5. Mesophilic flora (cfu x 10^4) isolated from different piles at different intervals

Piles	Turnings (cfu/fungi)					Mean count
	I	II	III	IV	V	
1	0.33 a	3.00 a,m	2.30 a,f	7.00 t	12.33 t	4.99
2	7.33 a,m	15.66 a	4.66 a,c	15.00 t	16.66 t	11.99
3	11.00 a,f	9.00 a	4.33 c,r	6.33 t,p,a	15.00 t,a	9.13
4	12.33 a,m	7.00 a	2.00 u,c	15.00 t	21.00 t	11.41

a. A. fumigatus, m- *M. pussilus,* .c- *Coprinus sp.,* t- *T. viride*, u- Unidentified, f- *Fusarium* sp., r- *Rhizopus* sp.

Table 2.6. Physical parameters and yield obtained in different composts

Pile	pH	Moisture (%)	Total Compost produced (kg)	Condition of spawn run	No. of bags infected with competitors		Yield kg/q compost
					Coprinus sp.	*P. bysinna*	
1	7.2	60.0	510	+++	8 +	7 +	7.40
2	7.2	65.0	560	++++	8 ++	3 ++	4.50
3	7.3	61.5	510	++	7 ++	4 ++	3.90
4	7.27	63.0	550	+	20 ++	30 ++	2.90

+ mild infection ++ severe infection

Compost production by long method in 20 days using short method compost, as inoculum was a partial success. Physical parameters, incidence of competitors and yield obtained is presented in Table 2.6. Moisture varied in different piles between 60-65%. Maximum being in pile-2 (65%), this also gave the highest quantity of compost (560 kg). Average temperature during composting hovered between 60-64^{0}C and the highest temperature was exhibited by pile-3 (63.4^{0}C) while control showed the lowest temperature (60.7^{0}C). Mild to severe incidence of *Coprinus* sp. and brown plaster mould was noticed in different treatments. When observations were taken at casing it was reveled that 90% of the control bags had severe infestation of these two moulds (Table-6) leading to almost crop failure (2.9 kg/ 100 kg compost). The highest yield in the experiment was obtained in pile –1, which was inoculated by pasteurized compost at 0 day (7.4 kg/q compost). Experiment gave indication that pasteurized compost can be effectively utilized for better long method compost production.

2.1.3 Use of thermophlic organisms to shorten the duration of long method compost

The experiment was conducted with a view to explore thermophilic fungi isolated from compost for shortening the composting phase under long method of composting and also to increase the yield. For the above purpose five compost piles of under mentioned ingredients were prepared.

Compost ingredients	Quantity
Wheat straw	200.0 kg
Wheat bran	50.0 kg
Urea	4.5 kg
Cotton seed meal	16.0 kg
Gypsum	20.0 kg

Inocula of *S. thermophilum* (X-21), *H. insolens*(I-33) *H. insolens* (I-3),and consortium of all the three were used.

Four piles were inoculated with above mentioned fungi and their consortium @ 0.5 % on 0 day. Fifth pile served as un inoculated control. Duration of the composting period was kept as 20 days against 28 days normally taken for long method compost. Thermophilic flora isolated at various intervals in 5 piles, physical parameters and yield obtained are presented in Table 2.7 and Table 2.8, respectively.

In all eight thermophilic fungi were isolated from the various treatments. The highest count was obtained in the treatment, which was inoculated with *H. insolens* (I-3) (21.27x10^4). Respective inoculated fungi dominated in the isolations made in various treatments.

Table 2.7. Thermophilic flora (cfu x 10^4) isolated from different piles at different intervals

Piles	Turnings						Mean count
	I	II	III	IV	V	VI	
H. insolens (I-3)	13.0 st,a	39.66 st,hi,ch	20.00 a,ch	27.66 st,a	27.33 st,hi	17.66 hi	21.27
H. insolens (I-33)	11.6 a,c,hi	20.33 hi,st,a	14.00 a,ch,m	17.00 hi,st,a	21.33 hi,st,a,hg	15.66 hi,st	16.65
S. thermophilum (X-21)	15.33 hi,a,cp	28.33 hi,cp,a,st	13.66 a,ch	18.00 hg,st,a	27.00 hi,st,a	17.66 st,	19.99
Consortium	17.33 hi,st,a	21.33 a,st	11.66 a,st,hi	9.33 a,st	12.00 st,hi,a	14.33 st,hi	14.33
Control (Uninoculated)	9.33 m,st,hi	17.33 c,st,a,th,ch	18.66 a,ch	15.33 st,a	36.33 st,a	16.00 st,a	18.83

a.- A. fumigatus, ch- *C. thermophile,* hi- *H. insolens*, cp- *C. Coprinus* sp st- *S.thermophilum,* m – *M. pusillus,* hg- *H. grisea,* th – *T. lanuginosus*

Table 2.8. Physical parameters and yield obtained in composts prepared with thermophilic fungi

Pile	pH	Moisture (%)	Total compost produced (kg)	Condition of spawn run	Competitors		Yield kg/q compost
					Coprinus sp.	*P. bysinna*	
1 (I-3)	8.18	65.0	550	++	-	-	9.30
2 (I-33)	8.04	64.0	510	++	-	-	10.33
3 (X-21)	7.69	58.0	580	+++	-	-	12.30
4(Cons.)	7.72	63.0	630	++	-	-	9.30
5 (Cont.)	7.50	62.0	540	+	++	+	6.93

Physical parameters and yield obtained in the experiment is presented in Table 2.8. Slightly higher pH was observed in different treatments and it ranged between 7.5 to 8.18. Moisture % ranged between 58.0 to 65%. Higher compost was obtained with the consortium while the lowest was obtained with *H. insolens* I-33 strain. Incidence of competitors viz., *Coprinus* sp. and *Papulaspora bysinna* was observed only in control treatment Excellent spawn run was observed with *S. thermophilum* (X-21) which also gave the highest yield (12.30kg/q compost). Control treatment gave very low yield (6.93kg).

(Improved methods of composting for white button mushroom, Agaricus bisporus -NCM-16)

2.2 Paddy Straw Mushroom

2.2.1 Role of composted substrates in yield and nutritional attributes of paddy straw mushroom (*V. volvacea*)

Compost preparation

The 3 basal ingredients viz., paddy straw (PS), cotton ginning mill waste (CGMW) and poultry manure (PM) along with paddy straw based spawn of putative strain, OE-274 of *V. volvacea*, were used in the study. Three different formulations used for compost preparation were: PS + CM (5.0%, w/w) + $CaCO_3$ (1.5%, w/w); CGMW + $CaCO_3$ (1.5%, w/w) and PS + CGMW (1:1, w/w) + CM (5.0%, w/w) + $CaCO_3$

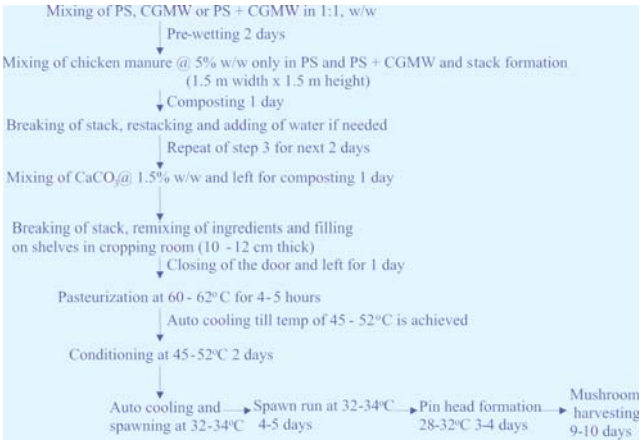


Fig. 2.1. Flow chart of composting and cropping process

(1.5%, w/w). The composting was carried out by following two-phase composting method (Fig. 2.1). The compost was analyzed for pH, moisture, nitrogen, potassium, sodium and calcium contents. The compost samples were also analyzed for microbial counts of thermophilic fungi and bacteria.

Compost characteristics

Compost from different formulations varied for moisture, nitrogen, potassium, sodium and calcium, and pH (Table 2.9). The highest nitrogen was in compost prepared with CGMW in both the trials and it was followed by compost of 1:1 combination of PS + CGMW. However, it did not show much variation in compost from a specific formulation in 2 trials. Moisture was the highest in PS compost, followed by 1:1 combination of PS + CGMW and CGMW in both the trials. In general, moisture was much higher in trial-2 compost than the respective compost in trial-1. The pH of compost from 3 different formulations in trial-1 did not show much variation, however, it did vary in trial-2 and it was the lowest in CGMW compost, followed by PS + CGMW and the highest in PS compost. Sodium and potassium contents were the lowest in compost prepared from CGMW, while calcium content in it was the highest. The contents of sodium, potassium and calcium did not vary much in compost prepared with PS and PS + CGMW.

In both the trials, population counts of thermophilic fungi and bacteria varied in compost from different formulations and also in compost from a specific formulation. The compost used in trial-2 did harbor 4-85 folds

Table 2.9. Physico-chemical properties of compost prepared from different basal ingredients

Compost	Physico-chemical properties of compost								
	Phase-II						Minerals (Average of 2 trials)		
	Nitrogen (%)		pH		Moisture (%)		Sodium(%)	Potassium(%)	Calcium(%)
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2			
Paddy straw	1.03	1.06	7.62	8.72	67.9	79.16	0.882	1.737	1.229
Cotton waste	1.38	1.37	7.66	7.75	61.5	63.76	0.025	1.475	1.972
Paddy straw +Cotton waste	1.23	1.18	7.79	8.61	60.3	76.47	0.835	1.778	1.932
CD (0.05%)	0.10	0.09	0.09	0.76	3.62	5.65	0.268	0.287	0.327

higher fungal population than compost of trial-1 and it was the highest in PS compost in trial-1 and PS + CGMW compost in trial-2 (Table 2.10). The dominant fungus in trial-1 was *Humicola insolens*, while in trial-2 it was *Scytalidium thermophilum*. In both the trials, the difference in fungal population of the compost prepared with different basal ingredients can be attributed to the varied physicso-chemical properties of the compost with respect to pH and moisture, and varied temperature regimes during phase-I of composting, which largely depend upon the environmental temperature conditions. In both the trials, the highest bacterial population counts were in PS compost and the colony morphology of dominant isolates was similar in compost from different formulations.

Crop raising

Two crops of *V. volvacea* were raised under indoor cultivation conditions. Compost beds of 180 cm x 70 cm x 12 cm (L x B x H) were prepared on the shelves of iron racks keeping 35 kg wet substrate/bed. Spawning was done @ 1.5% of wet compost 2 inch beneath the top of the bed and the beds were covered with clean plastic sheets. Eight replications were kept for each treatment and the experiment was conducted in a randomized block design. Data was recorded for the mycelial colonization in substrate, pinhead formation, growth of contaminants on mushroom beds, time taken for first harvest, number of fresh fruiting bodies harvested, mushroom yield per quintal dry substrate and average fruiting body weight. The cropping trial was conducted under environment controlled growing facility at the Directorate to eliminate the effect of other factors and different treatments were distributed using randomized block design.

Mycelial colonization was uniform, thick and intense in CGMW compost; while in PS + CGMW compost it was less dense, fluffier and uneven (Table 2.11). The mycelial spread in PS compost was very thin and unevenly spread. Pinhead formation was most intense in PS + CGMW compost, followed by CGMW compost in both the trials. Competitor mould, *Coprinus*, appeared in PS and CGMW compost beds only in trial-1. First harvest was at the earliest (9 days) in CGMW compost. Significantly higher

Table 2.10. Microbial population dynamics in compost prepared from different basal ingredients

Compost	Number and characteristics of fungal and bacterial colony forming units					
	Fungal CFU ($\times 10^5$)		Dominant fungi		Bacterial CFU	
	Trial-1	Trial-2	Trial-1	Trial-2	Number ($\times 10^7$)	Characteristics
Paddy straw	4.2	15.5	*Humicola insolens*, *Scytalidium thermophilum*	*Scytalidium thermophilum*	33	Creamy and irregular
Cotton waste	2.3	8.33	*H. insolens*	*S. thermophilum*, *Paeciliomyces* sp.	1	Creamy and irregular
PS + CW	0.2	17.33	*H. insolens*, *H. grisea*	*S. thermophilum*	2	Creamy and irregular
CD (0.05%)	0.96	3.43	-	-	3.6842	-

Table 2.11. Mycelial colonization of substrate, pinning and incidence of competitors in compost prepared with different basal ingredients

Compost	Substrate colonization		Pinning		Contaminants		First harvest (days post-spawning)	
	Trial-1	Trial-2	Trial-1	Trial-2	Trial-1	Trial-2	Trial-1	Trial-2
Paddy straw	Thin, unevenly spread	++	+	+	+ (*Coprinus* sp.)	-	11.11	11.00
Cotton waste	Spread, thick, fluffy	+++	+ + +	+++	+ (*Coprinus* sp.)	-	9.375	9.00
Paddy straw + Cotton waste	Unevenly spread, fluffy	+++	+ + + +	+++	-	-	10.00	10.00
CD (0.05%)	-	-	-	-	-	-	0.98	0.48

-, absence; +, present but in lower quantity; ++, higher; +++, still higher; ++++, highest

mushroom yield (36.60 and 39.34 kg q^{-1} dry substrate) in 2 trials was obtained in CGMW compost (Table 2.12). The numbers of fruiting bodies did not show much variation in the highest yielding compost of CGMW and the second highest yielding compost of PS + CGMW during trial 1, while it was lowest in PS compost. Same was the situation between the highest yielding compost of CGMW and the second highest yielding compost of PS in trial-2. The average fruiting body weight during flush 1 was significantly higher in CGMW compost in both the trials, followed by PS and PS + CGMW compost in trial-1 and 2, respectively.

Table 2.12. Effect of compost prepared with different basal ingredients on mushroom yield

Compost	Mushroom yield (kg/q dry substrate)			Number of fruiting bodies/ q dry substrate			Fruiting body weight (g)		
	Flush 1	Flush 2	Total	Flush 1	Flush 2	Total	Flush 1	Flush 2	Total
Trial 1									
Paddy straw	19.37	5.24	24.61	1436	302	1738	13.59	17.59	14.25
Cotton waste	30.30	6.30	36.60	1818	549	2367	17.00	12.06	16.08
Paddy straw +Cotton waste	23.16	7.13	30.29	1882	551	2418	12.50	13.07	12.60
CD (0.05%)	2.95	1.26	3.35	245	146	331	1.58	3.60	1.88
Trial 2									
Paddy straw	24.83	5.47	30.30	2387	480	2867	10.40	11.44	10.56
Cotton waste	32.72	6.62	39.34	2354	616	2970	14.30	10.97	13.44
Paddy straw +Cotton waste	21.10	1.52	22.62	1804	137	1941	11.82	14.12	11.74
CD (0.05%)	3.43	1.25	4.33	286	112	378	1.35	2.59	1.62

In flush 2, the fruiting body weight was the lowest in CGMW compost in both trials, while it was the highest in PS and PS + CGMW composts in trial 1 and 2, respectively.

Nutritional Attributes

Different nutritional attributes of the mushrooms obtained from various treatments viz., dry matter, protein, potassium, sodium and calcium contents were analyzed from 10 fresh unopened average size mushrooms. Mushrooms obtained from compost prepared with different formulations differed significantly in many of the important attributes, most significant being the high protein content recorded in those from the CGMW compost, which could be attributed to higher nitrogen content of CGMW compost (Table 2.13). In trial-1, potassium and calcium was the highest in mushrooms from CGMW compost. Contrary to this, sodium was the lowest in mushrooms from CGMW compost, while the highest in mushrooms from PS compost. In trial-2, mushrooms from CGMW compost were again recorded to contain the lowest sodium. However, potassium and calcium contents were higher only in flush 2. Overall the mushrooms from CGMW compost had a very high K: Na ratio (12.02-15.96) in comparison to mushrooms from other treatment (6.73-11.48). The mushrooms from CGMW compost also contained higher quantity of Ca than mushrooms from other composts.

Table 2.13. Quality characteristics of fruiting bodies harvested from compost prepared from different basal ingredients

Compost	Quality characteristics									
	Dry matter (%)		Protein (%) (dry wt basis)		K/Na (mg/100g dry mushroom)		K/Na ratio		Ca (mg/100g dry mushroom)	
	Flush 1	Flush 2	Flush 1	Flush 2	Flush 1	Flush 2	Flush 1	Flush 2	Flush 1	Flush 2
Trial 1										
Paddy straw	10.40	9.15	23.89	25.60	2340/ 292.5	2505/ 372.0	8.00	6.73	139.5	145.5
Cotton waste	9.80	8.61	28.90	28.25	2633/ 219.0	2647/ 214.5	12.02	12.34	157.5	148.5
Paddy straw + Cotton waste	11.73	9.68	27.30	27.50	2334/ 244.5	2570/ 282.0	9.55	9.11	139.5	148.5
CD (0.05%)	0.8774	0.6826	0.3826	0.2978	126/ 32.8	84/ 46.8	—	—	18.5	2.3
Trial 2										
Paddy straw	9.00	11.15	24.25	27.06	2433/ 258.75	2418/ 249.00	9.40	9.71	133.5	124.5
Cotton waste	11.2	10.00	29.12	30.23	2410/ 151.00	2556/ 179.25	15.96	14.26	130.5	129.0
Paddy straw + Cotton waste	10.53	10.67	27.16	28.75	2410/ 210.00	2490/ 244.50	11.48	10.18	128.0	127.5
CD (0.05%)	0.73	0.46	1.47	1.15	26/ 25.89	46/ 38.65*s*	—	—	3.6	2.9

(Integrative use of cultivation technologies and molecular techniques for enhancing yield and quality of paddy straw mushroom, Volvariella spp. –NCM-40)

2.3 Specialty Mushrooms

Physiological studies on *Lentinula edodes*

Physiological studies conducted on various strains (OE-142, OE-388, OE-329, OE-17 and OE-38) of *L. edodes* revealed that 20-25°C is optimum for the vegetative growth of all the strains. Strain OE-38 showed wide adaptability to pH and could grow even at pH 4.0, whereas, pH 6.5-7.0 was optimum for the growth all the strains. Malt extract agar was the most preferred medium by all the strains.

Effect of different substrates on the linear growth of different strains of *Lentinula edodes*

Data presented in Table 2.14 revealed that corn cobs is the best medium for the growth of most of the *L. edodes* strains which supported the maximum linear growth except strain OE-2, OE-13 and OE-27. However, the growth recorded in strain OE-13 and OE-27 on pine needles was almost at par with growth recorded in corn cobs. OE-388 strain was the fastest growing strain among all the strains tested.

Table 2.14. Effect of different substrates on the linear growth of different strains of *Lentinula edodes*

Strains	Average linear growth (mm) on different substrates after 30 days			
	Corn cobs	Paddy straw	Soybean straw	Pine needles
OE-2	62.0	37.0	87.7	105.8
OE-8	114.6	57.6	110.3	110.0
OE-9	120.0	54.0	78.0	110.0
OE-13	98.3	36.3	50.3	100.3
OE-16	120.0	46.0	90.0	110.0
OE-17	80.6	40.3	55.6	71.0
OE-20	110.0	40.0	69.6	109.0
OE-21	110.3	43.3	89.3	104.6
OE-22	110.0	39.0	76.6	108.0
OE-23	130.0	28.6	74.0	110.0
OE-24	122.0	56.3	100.0	120.0
OE-26	126.3	53.6	67.0	62.3
OE-27	104.6	45.6	53.3	106.0
OE-38	123.3	54.0	89.6	83.0
OE-45	111.6	35.3	80.0	110.0
OE-329	126.6	40.0	105.6	110.0
OE-388	140.0	37.5	89.0	120.0
X-1121	128.3	88.3	92.6	110.0
CD (0.05)	3.5	2.6	2.9	5.1

Table 2.15. Effect of cultivation substrates on the productivity of *Lentinula edodes*

Substrate	Days taken for spawn run	Days taken for primordial initiation	No. of fruit bodies	Yield (kg/kg dry substrate)
Saw dust (SD)	70	90	95	1.25
Wheat straw (WS)	65	83	92	1.03
SD + WS (50: 50 w/w)	62	80	75	1.14
CD 0.05				0.18

Effect of cultivation substrates on the productivity of *Lentinula edodes*

Different cultivation substrates viz., wheat straw and saw dust alone or in combination were tried for the cultivation of OE-38 strain of shiitake (Table 2.15). It was observed that OE-38 strain took shortest time to colonize wheat straw + saw dust (50:50) substrate (62 days) followed by 65 days on wheat straw and saw dust (70 days). The primordial initiation begins after 80, 83 and 90 days on wheat straw + saw dust (50:50), wheat straw and saw dust alone, respectively.

Effect of shock treatment duration on the productivity of shiitake

Cultivation substrate was exposed to cold water (4-5°C) for different duration's viz., 5 min., 10 min., 20 min., 1 h, 2 h, 6 h, 12 h and 24 h and arranged in cropping rooms for fruiting. Optimum conditions were maintained during cropping. The data presented in Table 2.16 revealed that shock treatment for 6 h is the best which resulted in the maximum production. Yield data was recorded for three months.

Cultivation of oyster mushroom using Chinese method

This trial was laid out following Chinese method of cultivation. Six flushes of crop were recorded , thereby giving BE of more than 70%.

Table 2.16. Effect of different shock durations treatments on the productivity of shiitake

Shock treatment duration	Days taken for primordial initiation	No. of fruit bodies	Yield (kg dry substrate)
5 min.	11	17	0.86
10 min.	11	22	0.94
20 min.	11	25	0.95
1 h	10	30	0.90
2 h	10	34	1.04
6 h	8	48	1.06
12 h	8	32	0.96
24 h	8	27	0.94
CD 0.05			0.23

Studies on *Cordyceps sinensis*

Twelve solid (Table 2.17) and 5 broths (Table 2.18) were evaluated for the mycelial growth. Maximum radial growth was recorded on Richards's synthetic agar medium while potato dextrose agar medium supported minimum growth. Among the different broths Czapdox broth yielded maximum mycelial mass. In addition saw dust was also inoculated which was successfully colonized by *Cordyceps* sp. In on other case, *Cordyceps* was exposed to 8°C for 15 h and then kept at 25°C for 12 days in order to initiate fruiting but no success was achieved. In another study, *Cordyceps* was initially exposed to 25°C for 10 days and after that it

Table 2.17. Evaluation of different media for mycelial growth of *C. sinensis*

S. No.	Medium	Av. growth (mm) after 7 days
1	Malt extract agar	68.3
2	Asthana & Hawkers medium	66.8
3	Brown's medium	58.6
4	Czapekdox agar medium	52.8
5	Rice extract agar	60.0
6	Potato malt agar	71.0
7	Starch casein agar	59.6
8	Sabourands dextrose maltose agar	68.0
9	Richards synthetic agar	71.2
10	Potato dextrose agar	38.0
11	Nutrient agar	62.4
12	Dextrose peptone agar	70.4

Table 2.18. Evaluation of different media for the *C. sinensis* (after 7 days)

S. No	Broth	Av. mycelial mass (g)
1	Nutrient broth	0.015
2	Beef extract broth	0.15
3	Czapekdox broth	0.64
4	Malt extract broth	0.16
5	Dextrose peptone broth	0.26

was exposed to 16^{0}C for 5 days for initiating fruit body formation.

(Standardization of cultivation technology of specialty mushrooms - NCM-18)

3.1 Insect Pests and Diseases of Mushrooms

Studies on the succession of pests and diseases during cultivation of white button mushroom

In order to assess the succession of pests and diseases during different growth stages, a trial was laid out during the month of June, 2009. *Peziza* appeared 5 days after casing. Bacterial blotch and cobweb were also recorded. Among the insect-pests, sciarids and phorids were recorded after 15 days of casing. However, no significant yield loss was recorded. Another general trial on white button mushroom was also laid out in the month of Augusrt, 2009. However, due to improper pasteurization no spawn run took place. Severe incidence of *Chaetomium* and brown plaster mould was recorded.

Effect of dichlorvos on the yield of white button mushroom

Crop of white button mushroom, *Agaricus bisporus* (S-11) was raised on pasteurized compost following standard cultural practices. Ten kg compost was filled per bag and spawning was done @0.5%. Each treatment was replicated ten times. Control bags were sprayed with water only. Dichlorvos at seven different concentrations (0.001, 0.005, 0.01, 0.03, 0.05, 0.07, and 0.1%) was sprayed at the time of casing and seven days after casing.

Data presented in Table 3.1 revealed that when 0.001% dichlorvos was sprayed immediately after casing, it resulted in yield of 11.50 kg whereas, application of 0.03% concentration seven days after casing resulted in 12.78 kg mushroom yield. Data also revealed that application of different concentrations seven days after casing resulted in non significant difference in yield.

Table 3.1. Effect of dichorvos on the yield of white button mushroom

Conc. (%)	Application at the time of casing	Application 7 days after casing
Control	9.255	
0.001	11.500	11.475
0.005	10.780	10.230
0.01	10.535	10.505
0.03	9.210	12.780
0.05	9.515	11.215
0.07	9.375	10.560
0.10	10.745	11.160

For analysing the persistence of dichlorvos in white button mushroom, samples were collected, extracted, cleaned up and injected in GLC. FID was not able to detect dichlorvos residues.

Effect of formalin on soil bacterial population

To assess the effect of formalin on soil bacterial population, *in vitro* studies were carried out at 5 different concentration of formalin at varying time intervals. Data presented in Table 3.2 revealed that even two minutes exposure to formalin significantly reduced the bacterial population.

Effect of neem pesticides for the management of mycoparasites

Evaluation of different neem pesticides against various mycoparasite (Table 3.3) revealed that Neemol resulted in 100% inhibition of *M. perniciosa*. Achook resulted in 75% and 38.47% inhibition of *C. dendroides*, and *V. fungicola,* respectively. Whereas, Achook was the only product giving inhibition (22.22%) against *T. harzianum*. All the neem pesticides

Table 3.2. Effect of formalin on soil bacterial population

Time (min)	Concentration (%)				
	0.5	1.0	2.0	3.0	4.0
	(Number of bacterial colonies)				
2	7.0	5.0	2.5	3.5	3.0
5	4.0	8.4	7.8	6.4	3.0
10	3.5	4.2	5.0	5.0	2.5
Control	29.6				

Table 3.3. Effect of different neem products on mycilial growth of mycoparasites

Neem products	Average mycelial growth (cm) of different mycoparasites after 7days			
	Cladobotryum dendroides	*Mycogone perniciosa*	*Verticillium fungicola*	*Trichoderma harzianum*
Neemol	2.5 (37.5)	0.0 (100.00)	6 (7.69)	9.0 (0.0)
Neem Jeevan	2.0 (62.5)	5.5 (16.6)	7.2 (-10.76)	9.0 (0.0)
Neem oil	2.2 (45.0)	3.0 (54.00)	6.6 (-1.53)	9.0 (0.0)
Achook	1.0 (75.0)	0.2 (96.9)	4.0 (38.47)	7.0(22.22)
Neem cake	3.2 (20.0)	4.5 (31.8)	7.0 (-7.69)	9.0 (0.0)
Control	4.0	6.6	6.5	9.0

Figures in parenthesis represent per cent inhibition

inhibited the growth of *M. perniciosa, C. dendroides* and *T. harzianum* to varying degrees.

The data presented in Table 3.4 indicate that *C. dendroides*, *M. perniciosa, V. fungicola* and *T. harzianum* resulted in 43.2, 87.6, 48.1 and 25.9 per cent loss, respectively in inoculated but unsprayed treatment (control-I). When the crop was inoculated with different mycoparasites and sprayed with various neem pestides the loss vary between 37.0-41.2 %, 81.5-88.8%, 40.7-50.6% and 12.2-24.7% in *C. dendroides*, *M. perniciosa, V. fungicola* and *T. harzianum* inoculations, respectively thereby clearly indicating little or no effectiveness of neem pesticides against mycoparasites under mushroom house conditions.

Yield loss due to *Verticillium* isolates in button mushrooms

Studies conducted on yield loss by different isolates (V1, V2, V3, V5) of *Verticillium fungicola* in various strains of *Agaricus bisporus* (A-15, U-3, S-11) revealed (Table 3.5) that V-2 isolate resulted in maximum yield loss in all the three strains. Maximum (38.39%) yield loss was recorded in A-15 strain followed by U-3 and S-11 strains.

(Exploitation of indigenous microbes, plant products and pesticides for the management of pests and diseases associated with mushrooms - NCM-34)

Table 3.4. Effect of neem pesticides for the management of different mycoparasites

Neem products	Yield of fresh mushrooms (kg/10 kg compost) when inoculated with			
	Cladobotryum dendroides	*Mycogone perniciosa*	*Verticillium fungicola*	*Trichoderma harzianum*
Neemol	0.98 (39.5)	0.30 (81.5)	0.80 (50.6)	1.22 (24.7)
Neem Jeevan	1.00 (38.2)	0.20 (87.6)	0.84 (48.1)	1.16 (28.4)
Neem oil	0.94 (41.2)	0.22 (86.4)	0.90 (44.4)	1.30 (19.7)
Achook	1.02 (37.0)	0.26 (83.9)	0.90 (44.4)	1.30 (19.7)
Neem cake	0.98 (37.0)	0.18 (88.8)	0.96 (40.7)	1.42 (12.2)
Control-I*	0.92 (43.2)	0.20 (87.6)	0.84 (48.1)	1.20 (25.9)
Control-II**	1.62			
CD (0.05)	0.30	0.24	0.24	0.32

Figures in parenthesis represent per cent inhibition
*=inoculated and without neem pesticide, **=uninoculated and without neem pesticide

Table 3.5. Yield loss due to *Verticillium* isolates in button mushrooms

Verticillium isolate	Yield (Kg) of *A. bisporus* strains/ 10 kg compost		
	A-15	U-3	S-11
V1	1.35 (23.72)	1.35 (23.72)	1.05 (15.32)
V2	1.08 (38.89)	1.12 (36.72)	0.89 (28.22)
V3	1.20 (32.20)	1.20 (32.20)	1.10 (11.29)
V5	1.30 (26.55)	1.30 (26.55)	1.05 (15.32)
Control	1.77	1.77	1.24
CD 0.05	0.09	0.09	0.07

Figures in parentheses represent per cent loss in yield over control

Table 3.6. Yield loss by different bacterial isolates in oyster mushroom

Bacterial Isolate	Disease incidence (%)	Yield Kg/ 2 kg dry substrate	Yield loss (%)
B 1	47	1.02	37.0
B 5	72	0.41	74.7
B 9	68	0.90	44.4
B 10	43	1.10	32.1
Control	-	1.62	-
CD 0.05		0.03	

Yield loss by different bacterial isolates in oyster mushroom

Yield loss by four isolates viz., B 1, B 5, B 9, and B 10 of *Psedomonas tolassii* was studies by inoculating with *Pleurotus sajor-caju*. The data presented in Table 3.6 revealed that B 5 isolate resulted in maximum (74.7%) yield loss followed by B 9, B 1 and B 10 isolates. B 5 isolate also resulted in maximum disease incidence.

Interaction of different mushrooms with different isolates of bacteria

Interaction studies conducted between ten bacterial isolates of *P. tolassii* with five mushroom species namely, *Agaricus bisporus, Pleurotus sajor-caju, Flammulina velutipes, Calocybe indica* and *Volvariella volvacea* revealed that BI-5 and BI-9 resulted in maximum inhibition of *A.bisporus* among all

the isolates tested (Table 3.7). Similarly BI-9 isolate resulted in maximum inhibition of *P. sajor- caju;* however, the inhibition was less as compared to that of *A. bisporus*. In *F. velutipes* BI-5 isolate resulted in maximum inhibition whereas isolates BI-2 and BI-8 did not affect the mycelial growth of this mushroom. In *C. indica* the inhibition was least among all the mushrooms tested and maximum was with BI-5 isolate. All the ten isolates of bacteria inhibited the growth OE-12 strain of *V. volvacea* and isolate BI-9 resulted in maximum inhibition in this mushroom. Keeping in view the susceptibility of *V. volvacea* eight more strains were also included in the studies. The data presented in Table 3.8 indicated that all the strains were susceptible to the two bacterial isolates and strain 5 was most susceptible.

(Etiology, molecular characterization and management of bacterial diseases of mushrooms - NCM-41)

Table 3.7. Interaction of different mushrooms with different isolates of bacteria

Mushroom Type	Different isolates of *Pseudomonas* species									
	Average diametric growth (cm)									
	Control	BI-1	BI-2	BI-3	BI-4	BI-5	BI-6	BI-7	BI-8	BI-9	BI-10
Agaricus bisporus	9.0	5.2	8.2	7.0	6.5	3.5	5.0	6.0	9.0	3.5	5.5
Pleurotus sajor- caju	9.0	9.0	9.0	9.0	8.5	6.5	8.5	9.0	9.0	5.5	8.0
Flammulina velutipes	9.0	6.3	9.0	7.3	6.5	4.5	5.5	6.3	9.0	5.5	6.0
Calocybe indica	9.0	7.8	9.0	9.0	8.2	7.4	8.2	9.0	9.0	9.0	8.2
Volvariella volvacea OE-12	9.0	5.5	8.5	7.5	7.0	3.5	5.0	6.0	8.5	3.0	6.5

Table 3.8. Interaction of different strains of *Volvariella volvacea* with two isolates of bacteria

Bacterial isolate	*Volvariella* strains								
	OE-12	S2	S 3	S 4	S 5	S 6	S 7	S 8	S 9
BI-6	5.0	8.5	8.0	8.5	5.0	8.5	7.5	4.5	6.5
BI-9	3.0	4.5	6.5	8.5	3.0	6.0	5.0	3.0	4.5
Control	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0

4.1 SMS and decolonization of dyes

Influence of cultural and environmental conditions on decolorization of synthetic dyes through spent substrate of different mushrooms was studied. Some of the important results are described here.

4.1.1 Substrates and chemicals

Four dyes [Rhodamine B ($C_{28}H_{31}N_2O_3Cl$), Methyl Violet 2B ($C_{25}H_{30}ClN_3$), Quinaldine Red ($C_{21}H_{23}IN_2$) and Chicago Sky Blue 6B ($C_{34}H_{24}N_6Na_4O_{16}S_4$)] procured from Sigma-Aldrich along with spent substrates of button mushroom (*Agaricus bisporus* strain, A-15), shiitake mushroom (*Lentinula edodes* strain OE-142) and oyster mushroom (*Pleurotus sajor-caju* strain PL-1140) were used in the study. Heavy metal salts viz., Cadmium acetate, Lead nitrate, Mercuric iodide, Cobaltous sulfate, Zinc sulfate, Nickel chloride procured from Merck, while manganese sulphate and veratrly alcohol procured from s d Fine-Chem Limited and Hi-media Lab., respectively were used.

4.1.2 Measurement of decolorization

Sample (3 ml) collected each time from each replication and centrifuged at 10000 rpm for 10 min was used for measuring decolorization extent by measuring absorbance of supernatant at specific λ_{max} for each dye by using UV-Visible double beam Spectrophotometer (Unico-3802). Decolorization extent was calculated as:

$$\text{Decolorization extent (\%)} = [100 \times (OD_1 - OD_t)]/OD_1$$

Where OD_1 is initial absorbance at 0 day, OD_t is absorbance after incubation for different periods under different experimental conditions, t is incubation time.

4.1.3 Cultural media studies

Among response of cultural media towards dye decolorization, the highest decolorization of Methyl Violet 2B (63%) and Quinaldine Red (76%) after 24 h of incubation was in plain water. However, the highest decolorization of Chicago Sky Blue 6B (46%) and Rhodamine B (17%) was in PDB. Although decolorization of dyes increased with time up to 4 days of incubation, however, major enhancement (90% in case of Rhodamine B and Methyl Violet 2B, 93% of Chicago Sky Blue 6B and 88% of Quinaldine Red) was recorded up to 3 days of incubation. Preferences towards cultural media remained same throughout the 5 days of incubation (Fig. 4.1).

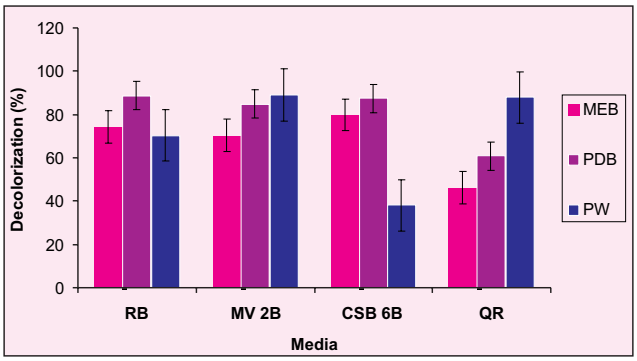


Fig. 4.1. Effect of cultural media in decolorization of different dyes using spent substrate of *P. sajor-caju*

4.1.4 pH studies

In decolorization of Rhodamine B and Methyl Violet 2B, SMS of different mushrooms was effective in decolorization at different pH values; SMS of *L. edodes* was most effective at pH 7.0 and 10.0, while of *A. bisporus* and *P. sajor-caju* at 4.0 and 7.0. The highest decolorization of Rhodamine B (95-95%) and Methyl Violet 2B (91-100%) was with *A. bisporus* SMS, followed by *L. edodes* + *P. sajor-caju* after 3 days of incubation (Table 4.1). In case of Chicago Sky Blue 6B and Quinaldine

Table 4.1. Effect of pH on decolorization of Rhodamine B and Methyl Violet 2B with spent mushroom substrates

Spent substrate	Dye decolorization (%) at different pH and intervals (days)											
	Rhodamine B						Methyl Violet 2B					
	Day 1			Day 3			Day 1			Day 3		
	pH 4.0	7.0	10.0	4.0	7.0	10.0	4.0	7.0	10.0	4.0	7.0	10.0
L. edodes	42	51	57	83	87	92	61	71	65	75	98	97
A. bisporus	66	73	58	93	95	93	87	65	0	100	98	91
P. sajor-caju	28	37	47	57	75	76	94	72	46	98	92	84
L.edodes + A.bisporus	1	1	0	67	64	43	0	0	16	91	95	74
L.edodes + P. sajor-caju	77	83	53	91	93	84	85	82	71	94	96	85
A.bisporus + P. sajor-caju	2	0	0	87	89	85	59	74	70	98	94	91

CD $_{0.05}$: pH – 8.29, Days – 9.59, Dyes – 7.08, Spent substrates – 6.708, Spent substrates x dyes x pH x days – 6.17

Red, decolorization was almost similar at pH 4.0 and 7.0 on using SMS of all 3 mushrooms and it was higher in comparison to decolorization at pH 10.0. The combined inoculums of SMS of different mushrooms did not show much superiority over SMS from individual mushroom, with an exception of *L. edodes + P. sajor-caju* SMS for Chicago Sky Blue 6B and Quinaldine Red (Table 4.2). The highest decolorization of Chicago Sky Blue 6B (95-99%) and Quinaldine Red (98-100%) after 3 days on incubation was with SMS of *L. edodes* and *L. edodes + P. sajor-caju*, respectively. In all dyes, decolorization increased only marginally from 3 days up to 5 days of incubation.

4.1.5 Temperature studies

At an initial stage (after 1 day), decolorization of Rhodamine B and Methyl

Table 4.2. Effect of pH on decolorization of Chicago Sky Blue 6B and Quinaldine Red with spent substrates of different mushrooms

Spent substrate	Dye decolorization (%) at different pH and intervals (days)											
	Chicago Sky Blue 6B						Quinaldine Red					
	Day 1			Day 3			Day 1			Day 3		
	pH 4.0	7.0	10.0	4.0	7.0	10.0	4.0	7.0	10.0	4.0	7.0	10.0
L. edodes	20	38	5	95	99	82	82	75	71	86	87	80
A. bisporus	58	46	11	84	79	41	85	90	36	90	88	80
P. sajor-caju	27	35	6	95	92	61	86	86	77	90	88	83
L.edodes + A.bisporus	49	61	0	67	71	7	6	8	3	94	96	72
L.edodes + P. sajor-caju	44	71	13	94	93	38	99	88	85	100	98	93
A.bisporus + P. sajor-caju	68	71	22	88	88	58	98	78	74	98	96	89

CD $_{0.05}$: pH – 9.17, Days – 8.322, Dyes – 8.044, Spent substrates – 5.8, Spent substrates x dyes x pH x days – 6.05

Violet 2B was higher at 35°C than 15 and 25°C. However, at later stage (after 3 days of incubation), there was marginal difference in levels of decolorization at 25 and 35°C. In some treatments (*P. sajor-caju* SMS and *P. sajor-caju* + *L. edodes* SMS), decolorization recorded at 15°C was also comparable to that of other temperatures (Table 4.3). Combined SMS treatments did not show any superiority over individualized SMS treatments; as decolorization of Rhodamine B was at par in *A.bisporus* alone (90%) and *A.bisporus* + *L. edodes* (91%) SMS treatments, while in Methyl Violet 2B, it was the highest in SMS treatments of *A. bisporus* (97%) and *P. sajor-caju* (93%). In Chicago Sky Blue 6B and Quinaldine Red, almost similar trend was recorded at initial stage of decolorization. However, at later stage, incubation temperatures of 25 and 35°C were equally effective in decolorization of these two

Table 4.3. Effect of incubation temperature on decolorization of Rhodamine B and Methyl Violet 2B with spent mushroom substrates

Spent substrate	Dye decolorization (%) at different temperatures (°C) and interval (days)											
	Rhodamine B						Methyl Violet 2B					
	Day 1			Day 3			Day 1			Day 3		
	15	25	35	15	25	35	15	25	35	15	25	35
L. edodes	2	4	43	50	52	73	37	63	77	79	82	93
A. bisporus	0	33	83	81	85	90	19	44	79	87	97	97
P. sajor-caju	2	16	6	50	46	51	64	80	83	93	93	88
L. edodes + *A. bisporus*	0	0	70	86	91	87	1	13	82	69	84	89
L. edodes + *P. sajor-caju*	0	10	49	79	90	84	46	59	66	82	84	79
A. bisporus + *P. sajor-caju*	0	1	56	72	85	88	27	67	89	78	85	84

$CD_{0.05}$: Temperatures – 7.472, Days – 9.982, Dyes – 7.22, Spent substrates – 2.698, Spent substrates x dyes x temperatures x days – 6.42

Table 4.4. Effect of incubation temperature on decolorizaton of Chicago Sky Blue 6B and Quinaldine Red with spent mushroom substrates

Spent substrate	Dye decolorization (%) at different temperatures (°C) and interval (days)											
	Chicago Sky Blue 6B						Quinaldine Red					
	Day 1			Day 3			Day 1			Day 3		
	15	25	35	15	25	35	15	25	35	15	25	35
L. edodes	4	26	55	54	94	97	40	45	67	64	81	88
A. bisporus	6	50	65	87	86	98	3	91	93	91	94	95
P. sajor-caju	22	79	94	73	98	98	66	84	81	80	86	82
L. edodes + *A. bisporus*	8	49	77	50	86	87	16	54	84	58	84	86
L. edodes + *P. sajor-caju*	34	47	65	68	79	88	55	65	70	62	79	74
A. bisporus + *P. sajor-caju*	21	69	71	70	79	80	25	70	79	70	80	84

$CD_{0.05}$: Temperatures – 9.013, Days – 8.458, Dyes – 6.293, Spent substrates – 5.337, Spent substrates x dyes x temperatures x days – 4.99

dyes, particularly with SMS of *L. edodes*, *P. sajor-caju* and *L. edodes* + *A. bisporus* for Chicago Sky Blue 6B, and *A. bisporus*, *P. sajor-caju* and *L. edodes* + *A. bisporus* for Quinaldine Red (Table 4.4). Here again, individualized SMS treatments proved more effective than combined SMS treatments; as SMS treatment of *L.edodes*, *A.bisporus* and *P. sajor-caju* decolorized Chicago Sky Blue 6B in the range of 97-98%, compared with only 80-88% in combined SMS treatments. Similar was the case with Quinaldine Red; wherein individualized SMS supported decolorization of 86-95%, compared with 84-86% in combined SMS treatments.

4.1.6 Dye concentration

Five concentrations (25, 50, 100, 150 and 200 ppm) of Methyl Violet 2B were used for evaluating the effect of initial dye concentration on its decolorization. Potato Dextrose Broth (PDB) was used as the growth medium. Fresh spent substrate of *P. sajor-caju* was added aseptically @ 1%, w/v to dye mixed sterilized PDB and mixed thoroughly. Flasks devoid of spent substrate but with dye were kept as control. Studies revealed that after 1 and 3 days of spent substrate mixing, the highest decolorization was in 100 ppm dye concentration. However, after 5 days of SMS mixing, the relationship between initial dye concentration and its decolorization was inversely proportional, as it was near 100% in lowest concentration (25 ppm), while only 90% in the highest dye concentration (150 ppm) (Fig. 4.2).

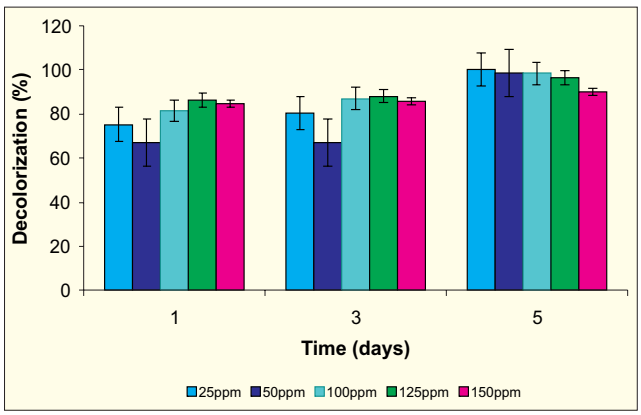


Fig. 4.2. Effect of initial concentrations of dye on its decolorization through *P. sajor-caju* spent substrate (ppm, part per million)

4.1.7 Carbon and Nitrogen Source

Data depicted in Table 4.5 reveal that decolorization of Methyl Violet 2B at different stages was higher in presence of different carbon sources, except cellulose, where it was lesser than control. Decolorization stimulatory effect was more pronounced at early stage (after 1 and 2 days) of SMS mixing, which became lesser significant at later stages (after 3 and 4 days). At the end of experiment, sucrose and starch added media exhibited the highest decolorization of Methyl Violet 2B. The highest decolorization was recorded with sucrose (87.75%), followed by starch (87.48%), while only 80.29% in control. Amongst different concentrations of carbon and nitrogen sources,

Table 4.5. Effect of different carbon sources in growing medium on decolorization of Methyl Violet 2B through *Pleurotus sajor-caju* spent substrate

Carbon source	Decolorization (%) at different time interval (days)			
	1	2	3	4
Fructose	61.00	85.85	86.00	86.00
Glucose	60.44	84.89	85.38	86.37
Lactose	65.85	84.89	85.38	86.37
Sucrose	65.85	84.69	86.83	87.75
Starch	62.98	83.40	87.23	87.48
Cellulose	37.57	64.02	75.93	77.46
Control	16.29	65.00	80.16	80.29

25 ppm concentration each of glucose, starch and ammonium carbonate, while 100 ppm of urea supported the highest decolorization of dye (Table 4.6). Nearly 100% decolorization of dye was achieved on addition of 25 ppm either of glucose or starch. Amongst nitrogen and carbon sources, enhancement in decolorization was more pronounced on addition of carbon sources than nitrogen sources (urea and ammonium carbonate).

4.1.8 Veratryl alcohol and Manganese sulphate ($MnSO_4$)

At an early stage, lower concentration of veratryl alcohol (0.025%) supported the highest dye decolorization, while at later stages, the highest concentration (0.1%) supported the highest decolorization. Manganese sulphate also exhibited similar trend, as at initial stage, slightly enhanced decolorization was with lower concentration of $MnSO_4$ compared with other concentrations including control. However, at a later stage (5 days), all $MnSO_4$ treatments supported almost equal level of decolorization but slightly higher than control. Compared with control, both veratryl alcohol and $MnSO_4$ supported higher decolorization, though more with lower concentration (0.025%) at initial stage and with higher concentrations at later stages.

4.1.9 Heavy Metal

Data depicted in Table 4.7 reveal that out of 6 heavy metals, presence of only Mercuric chloride and Zinc sulfate decreased the decolorization of Methyl Violet 2B compared to control. Contrary to this, presence of Lead acetate and Cadmium acetate @ 0.5% in growing medium separately has enhanced dye decolorization and 94.6 to 100% decolorization of Methyl Violet 2B was recorded after 4 days of mixing of spent substrate along with

Table 4.6. Effect of different concentrations of carbon and nitrogen sources on decolorization of Methyl Violet 2B through *Pleurotus sajor-caju* spent substrate

Carbon / Nitrogen Source	Concentration (ppm)	Dye decolorization (%) at different time interval (days)			
		1	2	3	4
Glucose	25	23.08	63.74	89.01	100.00
	50	66.34	70.30	71.29	89.11
	100	16.03	79.39	93.1	94.66
	Control	12.50	23.78	27.62	37.85
Starch	25	22.00	70.00	100.00	100.00
	50	33.99	41.83	99.35	100.00
	100	39.52	69.46	94.01	99.40
	Control	13.33	22.22	35.55	42.89
Urea	25	0.00	0.00	0.00	0.00
	50	0.00	0.00	0.00	0.00
	100	25.25	27.02	44.19	49.75
	Control	13.94	28.33	29.04	40.59
Ammonium carbonate	25	18.34	55.62	75.15	76.41
	50	0.00	7.00	10.50	10.61
	100	0.00	0.00	0.00	0.00
	Control	14.50	26.85	31.00	41.56

Table 4.7. Effect of heavy metals on decolorization of Methyl Violet 2B with spent substrate of *Pleurotus sajor-caju*

Heavy metal	Decolorization (%) at different intervals (days)				
	1	2	3	4	5
Cadmium acetate	61.70	62.00	68.1	93.6	94.6
Lead nitrate	15.71	84.00	84.3	100.00	100.00
Mercuric iodide	0.00	0.00	2.79	29.05	34.58
Cobaltous sulfate	54.00	62.7	64.00	70.6	71.00
Zinc sulfate	44.00	44.5	44.7	45.62	48.53
Nickel chloride	33.71	39.33	52.81	65.17	68.54
Control	0.00	43.83	46.30	59.88	62.35

aforesaid heavy metals. Normally presence of heavy metals in growing medium is considered as detrimental for the growth of microorganisms including fungi. However in present study, presence of Lead, Cadmium, Cobalt and Nickel has supported higher decolorization compared to control. It is attributed to their ability to provide more stability to laccase, which is considered as the potential ligninolytic enzyme having role in dye decolorizatiom by the white rot fungi.

4.1.10 Agitated/Stationary Growing Conditions

Experiment was conducted by keeping dye mixed and *P. sajor-caju* inoculated PDB medium flasks at 2 sets of conditions; one at stationary condition of 25 ± 1°C for 15 days in BOD incubator, while another in incubator shaker at 25 ± 1°C and 50 rev/min for 15 days. Flasks devoid of *P. sajor-caju* inoculation were kept as control for both sets of treatments. Rest of the protocol was similar to earlier steps of the study.

Under both the growing conditions (agitated and stationary), decolorization of Methyl Violet 2B was almost similar after 3 days of inoculation of *P. sajor-caju*. However, their onward decolorization under agitated growth condition was higher than stationary growth condition. Difference in decolorization at initial stage was less significant mainly because of the lag phase of growth of mushroom mycelia, as it took few days to attain appreciable mycelial growth and to show its effect on dye decolorization. The uniform suspension of mycelial biomass along with greater contact of fungal biomass with dye and nutrients were attributed as reasons behind higher decolorization under shaking growth condition.

4.1.11 Intact/Pellet Form of Mycelia

Dye decolorization potential of intact and pellet forms of mycelia of *P. sajor-caju* was studied by inoculating pre-grown intact and homogenized forms of mycelia in 2 different sets of PDB medium flasks, pre-mixed with of Methyl Violet 2B @100 ppm. Flasks devoid of *P. sajor-caju* inoculation were kept as control for both sets of treatments. Both sets of flasks were incubated at 25±1°C for next 15 days in BOD incubator. Rest of the protocol was similar to earlier steps.

Again under both the growth conditions (intact and pellet forms of mycelia), inoculation of dye supplemented medium with pellet form of mycelia supported higher decolorization from very beginning than inoculation with intact form of mycelia and same trend was maintained up to end of the experiment (15 days). Difference in decolorization was more significant in middle of the experiment (9 days). Nearly 100% decolorization of dye was recorded in pellet form of mycelia treatment after 15 days of inoculation compared with 96% in intact form of mycelia.

4.1.12 Laboratory Scale Study with Plain Water

Spent substrate mixed and maintained under similar conditions was kept as control. Data plotted in Fig. 4.3 show that nearly 70% decolorization was achieved just after 1 day of spent substrate mixing and it increased with time and reached to near 90% after 8 days of spent substrate mixing. Decolorization in control was very low and it was hardly 3-4% after 8 days of dye mixing in plain water.

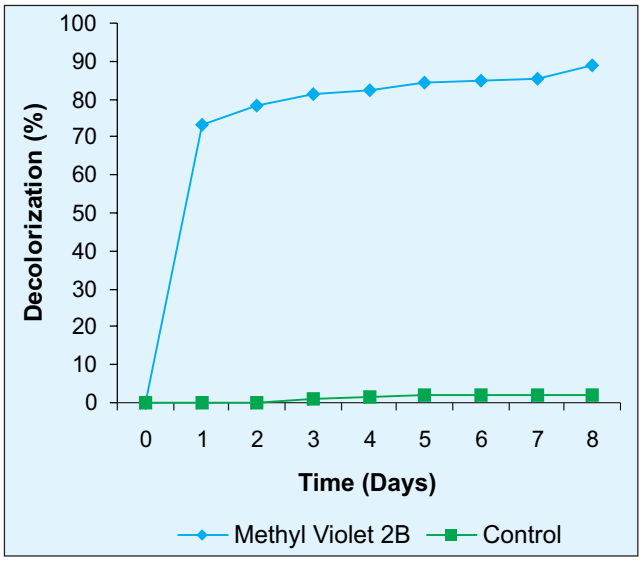


Fig. 4.3. Methyl Violet 2B decolorization in plain water medium through *P. sajor-caju* spent substrate

Present study proves that even if no additional source of nutrition, enzyme mediator/cofactor, heavy metals etc. are added in dye contaminated waste water, an appreciable level of decolorization can be achieved on addition of *P. sajor-caju* spent substrate.

5.1 Training Programmes Conducted

During 2009, Directorate organized a total number of 15 on and off campus training programmes for farmers, farmwomen, entrepreneurs, officers and researchers.

5.2 Mushroom Mela-2009

One day Mushroom Mela was organized on 10th September, 2009 as regular activity of the Directorate. It was inaugurated by Dr. K.R Dhiman Hon'ble vice chancellor, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan. Dr. S.K. Pandey, Director, CPRI Shimla was the guest of Honour. Vice Chancellor visited the exhibition (Fig. 5.1) and also released (Fig. 5.2) three publication of the Directorate. Mushroom Mela was attended by about 650 farmers, farmwomen, mushroom growers, researchers, extension workers and businessmen from various states viz, Himachal Pradesh, Haryana, Punjab, Uttar Pradesh, Maharashtra, Madhya Pradesh, Chattisgarh, Bihar, Jharkhand, Delhi, Uttarkhand, Sikkim, Gujarat, Tamil Nadu and Orissa.

Fig. 5.1. Dr. K.R.Dhiman, Hon'ble Vice Chancellor, Dr. Y.S. Parmar University of Horticulture and Forestry Solan visiting the exhibition stalls during Mushroom Mela

Fig. 5.2. Hon'ble Vice Chancellor releasing publications during Mushroom Mela

An exhibition on improved mushroom cultivation technologies and other related aspect was organized in which various Govt. Organisation, ICAR Institutes/Universities, Govt. financial organization, compost and spawn producers, mushroom product manufacturer, seed and pesticides and chemical producers and NGOs displayed their valuable information/technologies/products and provided their services to the participants of the Mushroom Mela.

In order to create awareness to the participants, various improved technologies/ practices of mushroom cultivation, farm visit of the growing units of the Directorate 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 (Fig. 5.3) was held to answer the problems in mushroom cultivation faced by mushroom growers. The problems raised by mushroom growers and farmers were replied by experts.

Fig. 5.3. Farmers attending Kishan Goshthi organized during Mushroom Mela

During the Mushroom Mela, the Directorate awarded 8 progressive mushroom growers (Fig. 5.4) for adopting innovative practices in mushroom cultivation on larger scale and mobilizing other farmers to adopt mushroom cultivation as source of income.

Fig. 5.4. Dr. S.K. Pandey, Director CPRI, Shimla felicitating Mrs. Dhan Laxmi from Tamil Nadu as progressive farmer during Mushroom mela 2009

5.3 Participation in National/State Level Exhibitions

In order to create awareness about mushroom cultivation the Directorate participated in many state and national level exhibitions and fairs by establishing a stall and by distributing the free literature of the Directorate. The Directorate participated in Kisan Mela at YSPUHF, Nauni from January 28-29. 2009 and in 1st interstate Horticulture exhibition "SANGAM" held at Pragati Maidan, New Delhi from 22-05-2009 to 24-05-2009.

5.4 Foreign Consultancy

Dr. S.R. Sharma trained the trainees from Sri Lanka during March 23-27, 2009 about the cultivation technology of mushrooms (Fig. 5.5).

Fig. 5.5. Dr. S.R. Sharma showing mushroom growing facilities to Sri Lankan trainees

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 provided. Queries on mushroom cultivation, training were replied through telephone and e-mail. On an average 5 queries per day were received and replied. Twelve phone-in and field based programmes were telecasted on Doordarshan Kendra from Shimla on Krishi Darshan.

6. TRAINING COURSES ORGANISED

S. No.	Name of training programme	Date	Sponsoring agency	No. of benefaceries	Course Director & Course Co-ordinator
1.	Training on Mushroom Cultivation Technology	15-21st Jan., 2009	ATMA Kangra (HP)	32	Dr. V.P. Sharma Sh. Sunil Verma
2.	Training on Mushroom Cultivation Technology for the farmers of Uttarakhand state	17-21st Feb., 2009	Deptt. of Horticulture, Uttarakhand	22	Dr. B. Vijay Dr. M.P. Sagar
3.	Study visit & training of Sri Lankan trainees	23-27th March, 2009	Govt. of Sri Lanka	02	Dr. S.R. Sharma
4.	Off-campus training on MCT for Officers of Dept. of Hort. Mizoram at Aizwal	30th March to 1st April, 2009	ICAR	26	Dr. B. Vijay Dr. M.P. Sagar
5.	Training on Mushroom Cultivation Technology for Entrepreneurs	21-30th April, 2009	ICAR	36	Dr. S.R. Sharma Dr. Satish Kumar
6.	Off-campus training on Mushroom Production Technology at Imphal, Manipur	4-6th May, 2009	ICAR	30	Dr. B. Vijay Dr. M.P. Sagar
7.	Off-campus training on Mushroom Production Technology at West Sinng, Distt. Arunachal Pradesh	25-27th May, 2009	ICAR	25	Dr. B. Vijay Dr. M.P. Sagar
8.	Farmers Training on Mushroom Cultivation Technology-I	16-22nd June, 2009	ICAR	100	Dr. B. Vijay Sh. Sunil Verma
9.	Training on Mushroom Cultivation Technology	9-11th Sept., 2009	Deptt. of Horticulture, Sikkim	07	Dr. B. Vijay Sh. Mahantesh Shirur
10.	Training on Mushroom Cultivation Technology-II	16-22nd Sept., 2009	ICAR	53	Dr. O.P. Ahlawat, Dr. Goraksha Chimaji Wakchaure
11.	Training on Mushroom Cultivation for Farmers	16-22nd Sept., 2009	NABARD, Shimla	30	Dr. B. Vijay Sh. Sunil Verma
12.	Training on Mushroom Cultivation for Farmers	5-9th Oct., 2009	NABARD, Solan	35	Dr. O.P. Ahlawat Sh. Mahantesh Shirur
13.	Training on Mushroom Cultivation for farm women of Rajasthan	26-30th Nov., 2009	Dy. Director(Extn.), Sri Ganganagar, Rajasthan	48	Dr. R.C. Upadhyay Sh. Sunil Verma

S. No.	Name of training programme	Date	Sponsoring agency	No. of benefaceries	Course Director & Course Co-ordinator
14.	Training for the farmers of Sikkim under TMNE-I	16-20th Nov., 2009	DMR, Solan	38	Dr. B. Vijay Sh. Mahantesh Shirur
15.	Off Campus Training on Mushroom Cultivation Technology for the Officers of State Dept. of Horticulture, Nagaland at Dimapur	26-30th Nov, 2009	DMR, Solan	35	Dr. B. Vijay Sh. Mahantesh Shirur

Fig. 6.1. Practical demonstration of mushroom cultivation during farmers training

Fig. 6.2. Trainees learning to prepare mushroom pickles during a training course

7. EDUCATION AND TRAINING

1. Summer Training of scientist/ Students during the year under report

Following 11 students completed their Summer Projects from the Directorate.

1. Sh. Vijay Kumar Negi, SILB, Solan w.e.f. 5.1.2009 to 5.3.2009.
2. Kumari Anjali Sharma, SILB, Solan w.e.f. 5.1.2009 to 5.3.2009.
3. Kumari Archna Devi, SILB, Solan w.e.f. 5.1.2009 to 5.3.2009.
4. Kumari Vijay Kumar, SILB, Solan w.e.f. 5.1.2009 to 5.3.2009.
5. Kumari Rakesh Kumar, SILB, Solan w.e.f. 5.1.2009 to 5.3.2009.
6. Kumari Monika Bhanu, SILB, Solan w.e.f. 5.1.2009 to 5.3.2009.
7. Kumari Sunita Thakur, SILB, Solan w.e.f. 9.1.2009 to 9.2.2009.
8. Kumari Varsha Jain, Lovely Professional Univrsity Phagwara, Punjab w.e.f. 15.06.2009 to 14.09.2009 & 10.05.2009 to 10.06.2009.
9. Kumari Arpana Aggarwal, Amity University, Noida w.e.f. 6.4.2009 to 6.10.2009.
10. Kumari Nahid Parveen, Sai Inst. Paramedical & Allied Sciences, Dehradun w.e.f. 11.05.2009 to 11.08.2009.
11. Kumari Kanika Thakur, M.Sc (Biotechnology), Lovely Professional University Phagwara, Punjab w.e.f. 15.06.2009 to 14.09.2009.

8. AICRP-MUSHROOM CENTRES

The All India Coordinated Research Project (AICRP) on Mushroom came into existence during VIth Five-Year Plan on 01.04.1983 with its Headquarters at Directorate of Mushroom Research, Solan (HP). The Director of DMR, Solan (HP) also functions as the Project Co-ordinator of the project. Initially the AICRP 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, during VIIIth Five Year Plan three new Centres and during IXth Five Year Plan one co-operating Centres have been added to the existing list of Centres. At present, 14 Co-ordinating and two co-operating Centres are working under AICRP programme with its Headquarters at DMR, 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, Thrissur (Kerala).
- ICAR Research Complex for NEH Region, Barapani (Meghalya).
- Horticulture and Agroforestry Research Programme (ICAR Research Complex for Eastern Region), Ranchi (Jharkhand).
- CCS Haryana Agricultural University, Hisar, (Haryana).
- Orissa University of Agriculture & Technology, Bhubaneswar, (Orissa).
- Rajendra Agricultural University, Samastipur, (Bihar).
- Central Agricultural University, Passighat, Arunachal Pradesh.
- Dr. Y.S. Parmar University of Horticulture & Forestry, Nauni, Solan – Co-operating Centre.
- HAIC Agro R&D Centre, Murthal (Sonepat), Haryana – Co-operating Centre.

9. PUBLICATIONS

A. Research Papers

1. Ahlawat, O.P., Raj, Dev, Indurani, C., Sagar, M.P., Gupta, Pardeep and Vijay, B. 2009. Effect of spent mushroom substrate recomposted by different methods and of different age on vegetative growth, yield and quality of tomato. *Indian J. Horticulture* 66(2): 208-214.

2. Ahlawat, O.P., Singh, Rajender and Rai, R.D. 2009. Influence of different composted substrates on yield and nutritional attributes of paddy straw mushroom, *Volvariella volvacea*. *International J. Medicinal Mushroom* 11(4): 427-436.

3. Ahlawat, O.P. and Singh, Rajender. 2009. Influence of pH, temperature and cultural media on decolorization of synthetic dyes through spent substrate of different mushrooms. *Journal of Scientific and Industrial Research* 68(12): 1068-1074.

4. Kumar, S. 2009. Effect of some insecticides on edible fungi and sciarid fly larvae. *Insect Environment* 15: 21-22.

5. Kumar, S., Sharma, S.R. and Sharma, V.P. 2008. Status of carbendazim residue in processed and marketable mushrooms. *Mush. Res.* 17(1):43-46.

6. Kumar, S., Sharma, S.R. and Sharma, V.P. 2008. Persistence and effect of processing on the residues of malathion and decamethrin in white button mushroom, *Agaricus bisporus*. *Indian J. Mush.* 27:19-24.

7. Sagar, M.P., Ahlawat, O.P., Raj, D., Vijay, B. and Indurani, C. 2009. Indigenous technical knowledge about the use of spent mushroom substrate. *Indian J. Traditional Knowledg*e 8(2): 242-248.

8. Sharma, V.P. and Kumar, Rajesh. 2008. Management of *Sepedonium* yellow mould through chemicals. *Mush. Res.* 17 (1): 19-23.

9. Sharma, V.P., Singh, S.K., Kumar, Satish and Anjali. 2009. Impact of neem pesticides for the management of mycoparasites. *Indian J. Mush.* 27: 38-40.

10. Sharma, V.P., Singh, S.K., Kumar, Satish and Sharma, S.R. 2008. Molecular diagnosis of *Fusarium* rot and shaggy stipe disease associated with the cultivation of *Agaricus bisporus* mushroom. *Mush. Res.* 17 (2): 87-90.

11. Upadhyay, R.C. Semwal, K.C., Tripathi, A. and Kumari, Deepika 2008. Studies on *Amanita hemibpha* complex from North Western Himalaya (India). *Mush. Res.* 17(1):1-7.

12. Vijay, B., Singh, P. Sharma, N. and Pathak, A. 2008. Studies on thermophilic fungi of *Agaricus bisporus* compost. *Indian J. Mush.*26 (1&2):1-9.

B. Books

1. Sharma, V.P. and Rai, R.D. 2009. Research Workers of D.M.R. Directorate of Mushroom Research, Solan (HP), India p. 80.

C. Book Chapters

1. Sagar, M.P., Ahlawat, O.P., Vijay, B., Raj, Dev and Pardeep, Gupta. 2008.

Development of Mushroom Based Integrated Farming Systems for Resource Poor Farmers and Farm Women. In: *Social Science Perspective in Agriculture:* A thrust for Integration (C. Prasad and Suresh Babu eds.). Vardan, E.B. 106, Maya Enclave, New Delhi pp.474-485.

2. Sharma, V.P., Tewari, R.P. and Sharma, S.R. 2010. Impact of global warming on mushroom cultivation and integrated pest and disease management strategies. In: *Challenges of climate Change Indian Horticulture* (H.P. Singh, J.P. Singh and S.S. Lal eds.) Westville Publishing house New Delhi, pp. 124-130.

D. Technical Bulletins

1. Ahlawat, O.P. and Sagar, M.P. 2009. Spent khumb poshadhar ka prabandhan (in Hindi). Directorate of Mushroom Research, Solan (HP), India. p. 52.

2. Sharma, V.P., Kumar, Satish and Tewari, R.P. 2009. *Flammulina velutipes*, the culinary medicinal winter mushroom. Directorate of Mushroom Research, Solan (HP), India. p. 53.

E. Reports

1. Ahlawat, O.P. and Kumar, Satish. 2009. Compiled and edited AICRP-Mushroom Annual Report 2008-09, DMR, Solan (HP). pp. 65.

2. Sharma, V.P., Kumar, Satish and Verma, Shailja. 2009. Compiled and edited DMR's Annual Report 2008. DMR, Solan. p. 82.

G. Abstract

1. Singh, Rajinder, Upadhyay, R.C. and Atri, N. S. 2009. Evaluation of different vitamins and growth regulators for mycelial growth of *Lentinula squarrosulus* (Mont.) Singer. National Symposium on Botanical Research.Punjbi Univ. Patiala.18-19th Feb.2010.

2. Sharma, V.P., Kumar, Satish and Sharma, S.R. 2009. Need based use of fungicides in mushroom disease management. National Symposium on Rational use of fungicides in management of Horticultural crop diseases held at UHF Nauni, Solan w.e.f. July 5-6, 2009. pp. 5-6.

10. APPROVED ONGOING RESEARCH PROJECTS

On-going Research Projects of DMR

Institute Code	Title of the Project	Researchers
NCM-15	Survey, collection and identification of fleshy fungi	Dr. R.C. Upadhyay
NCM-16	Improved methods of composting for button mushroom	Dr. B. Vijay Dr. O.P. Ahlawat
NCM-18	Standardization of cultivation technology of specialty mushrooms	Dr. S.R. Sharma Dr. V.P. Sharma Dr. Satish Kumar
NCM-29	Genetic characterization of mushroom germplasm of DMR, Gene Bank	Dr. M.C. Yadav Dr. R.C. Upadhyay
NCM-31	Organic mushroom production and quality produce	Dr. O.P. Ahlawat Dr. J.K. Dubey Dr. S.K. Patyal
NCM-32	Molecular and physiological characterization of moulds associated with mushrooms	Dr. V.P. Sharma Dr. S.R. Sharma Dr. Satish Kumar
NCM-33	Molecular characterization and genetic improvement in medicinal mushroom shiitake (*Lentinula edodes*)	Dr. M.C. Yadav Dr. R.D. Rai
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
NCM-35	Modified atmosphere packaging and storage of mushrooms	Dr. R.D. Rai
NCM-36	Genetic enhancement for higher yield and better quality in milky mushroom	Dr. M.C. Yadav Dr. R.C. Upadhyay
NCM-37	Genetic manipulations for high yield and better quality in button mushroom (*Agaricus* species)	Dr. M.C. Yadav Dr. V.P. Sharma
NCM-38	Improvement in cultivation of oyster and developing hybrid strains	Dr. R.C. Upadhyay
NCM-39	Development of expert system for cultivation of different types of mushrooms.	Dr. Y. Gautam
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
NCM-41	Etiology, molecular characterization and management of bacterial diseases of mushrooms	Dr. V.P. Sharma Dr. S.R. Sharma Dr. O.P. Ahlawat Dr. Satish Kumar

Externally Funded Projects

Title of the Project	PI of the Project
1. Agrowaste Management, Bioremediation and Microbes in Post Harvest Processing : Refinement in indoor compost technology for white button mushroom using thermophilic organisms. (ICAR, AMAAS)	Dr. B. Vijay
2. Microbial diversity and Identification : Strengthening, authentication and exploitation of mushroom biodiversity at the National Mushroom Repository for human welfare. (ICAR, AMAAS)	Dr. R.C. Upadhyay
3. Standardization of conditions for exploitation of spent mushroom substrate for decolourization of colouring dyes.(ICAR, DST)	Dr. O.P. Ahlawat
4. Screening and evaluation of ascomycetous and basidiomycetous macro-fungi of Uttarakhand and Himachal Pradesh for new drug discovery and ligninolytic enzymes. (CSIR)	Dr. R.C. Upadhyay
5. Biodiversity, genetic improvement and cultivation of medicinal mushroom Reishi (*Ganoderma lucidum*). (AMAAS)	Dr. R.D. Rai

Consultancy Provided by the Scientists of DMR

The Consultancy to the following organizations was given during the period under report.

1. Sh. Deepak Tewary, Vill. Ghidha, P.O. Nilgunj Bazar, Distt. 24 Parganas (North), West Bengal – 700 121.(TEFR) TEFR for preparation of white button mushroom project costing upto Rs.20.00 lakh for which an amount of Rs.5,618.00 was deposited in the office on dated 05.03.2009.
2. Mr. Amit Kumar S/o Sh. Karam Chand, Vill. Kami, P.O. Barwala, Distt. Panchkula – 134118 (Haryana) TEFR for white button mushroom upto the project costing Rs.20.00 lakh for which an amount of Rs.5,515.00 was deposited in the office on dated 23.05.2009.
3. Sh. Pankaj Goyal, Goyal Mushroom Farm, Book No.64, New Grain Market, Rajpura Town – 140401 (Pb.) TEFR for preparation of white button mushroom upto the project costing Rs.30.00 lakhs for which an amount of Rs.11224.00 was deposited in the office on 06.06.2009.

11. COMMITTEE MEETINGS

(a) Institute Management Committee: Two meetings of IMC were held on 09.02.2009 and 07.12.2009.

1.	Dr. Manjit Singh Director, Directorate of Mushroom Research, Chambaghat, Solan (H.P.) – 173213	-	Chairman
2.	Dr. Umesh Srivastava, Assistant Director General (Hort.II), Indian Council of Agricultural Research, Krishi Anusandhan Bhavan-II, PUSA, New Delhi – 110 012.	-	Member
3.	Dr. D.K. Arora, Director, National Bureau of Agriculturally Important Microorganisms (NBAIM), Kusmaur, MAU Nath Banjan (U.P.).	-	Member
4.	Dr. Prakash Nayak, Principal Scientist / Project Coordinator, Central Potato Research Institute, Shimla (H.P.).	-	Member
5.	Dr. Meera Pandey, Principal Scientist (Mushroom), Indian Institute of Horticulture Research, Bangalore.	-	Member
6.	Dr. V.P. Sharma, Principal Scientist (Pl. Path.), Directorate of Mushroom Research, Chambaghat, Solan (H.P.) – 173213.	-	Member
7.	Dr. Gurdev Singh, Director of Horticulture, Deptt. of Horticulture, Govt. of Himachal Pradesh, Shimla-2	-	Member
8.	Dr. Ajay Yadav, Incharge HAIC Agro Research & Development Centre, Murthal (Haryana)	-	Member

9.	Dr. S.K. Sharma Director of Research, Dr.Y.S. Parmar Univ. of Hort. & Forestry, Nauni, Solan (HP)	-	Member
10.	Sh.Vikas Benal, Vikas Mushroom Farm, Vill. Shamlech, PO. Barog, Tehsil & Distt. Solan (HP)	-	Member
11.	Sh.Ram Dass Shinde, Tirupati Balaji Mushroom, Vill. Someshwarnagar (Nimbut), Tal. Baramati, Distt. Pune – 412 306 (Maharastra)	-	Member
12.	Finance & Accounts Officer, Central Potato Research Institute, Shimla (HP)	-	Member
13.	Sh. Raj Kumar, Administrative Officer, Directorate of Mushroom Research, Chambaghat, Solan (H.P.) – 173213.	-	Member Secretary

Fig. 11.1. Dr. Manjit Singh, Director, conducting IMC meeting at DMR

(b) Research Advisory Committee: One meeting was held on 15-16 April, 2009.

1.	Dr. T.N. Lakhanpal, Ex-Dean & Head, Deptt. of Biosciences, H.P. University, Summer Hill, Shimla – 171 005.	-	Chairman
2.	Dr. C.L. Jandaik, Ex-Head, Deptt. of Mycology and Plant Pathology, UHF, Nauni Geeta Bhavan, House No.142, Ward No.6, Oak's Street, Solan – 173 213 (HP).	-	Member
3.	Dr. S.S. Sokhi, Ex. Addtitional Director of Extension Education (PAU), 318-D, BRS Nagar, Ludhiana – 141 012.	-	Member
4.	Dr. Satyavir, Ex-Dean, College of Agriculture, EG-15, Ashiana Gardens, Bhiwadi – 301 019, Distt. Alwar (Rajasthan)	-	Member
5.	Prof. (Dr.) N. Samajpati, Prof. & Head (Retd.), Flat No.9, First Floor, Telirbag Bhawan, P-3, Sashi Bhusan De Street, Kolkata – 700 012, India.	-	Member
6.	Dr. Manjit Singh, Director, Directorate of Mushroom Research, Chambaghat, Solan (HP).	-	Member
7.	Dr. U. Srivastava, Asstt. Director General (H-II), Indian Council of Agricultural Research, Krishi Anusandhan Bhavan-II, Pusa, New Delhi – 110 012.	-	Member
8.	Dr. B. Vijay, Principal Scientist Directorate of Mushroom Research, Solan – 173 213 (HP).	-	Member Secretary

Fig. 11.2. Dr. T.N. Lakhanpal, Chairman and other RAC members visiting mushroom production facilities

(c) Institute Research Council (IRC)

Five meeting of Institute Research Committee (IRC) were held on 2nd June, 2009, 12-13th August, 2009, 15th September, 2009, 13th October, 2009 and 9th- 10th December, 2009 and attended by all the Scientists under the Chairmanship of the Director, DMR, Solan.

(d) Core Committee

Nine meetings of Core Committee were held on 06.02.2009, 25.02.2009, 25.03.2009, 25.04.2009, 25.06.2009, 25.07.2009, 23.09.2009, 20.10.2009, 25.11.2009 under the Chairmanship of Dr. Manjit Singh, Director.

Members

(i)	Dr. Manjit Singh, Director	-	Chairman
(ii)	Dr. V.P. Sharma, Principal Scientist/E.O.	-	Member
(iii)	Sh. Raj Kumar, A.O.	-	Member Secretary
(iv)	Sh. Rishi Ram, AAO	-	Member
(v)	Sh. Jiwan Lal, AFACO	-	Member

(vi)	Sh. Sh. R.K. Bhatnagar, Asstt. (Audit)	-	Member
(vii)	Sh. Rajinder Sharma, Asstt. (Store Purchase)	-	Member
(viii)	Sh. Bhim Singh, Asstt. (Estate)	-	Member
(ix)	Sh. Dharam Dass Sharma, Dealing Asstt. (Cash)	-	Member

(e) Senior Officer's Meetings

Seven meetings of Senior Officer's of this Directorate were held on 02.03.2009, 20.03.2009, 21.05.2009, 27.07.2009, 31.08.2009, 23.09.2009 and 03.11.2009 under the Chairmanship of Dr. Manjit Singh, Director. All the scientists, AAO, AFACO are the members and Administrative Officer is the Member Secretary.

(f) Institute Joint Staff Council (IJSC)

Three meetings of IJSC were held under the Chairmanship of Dr. Manjit Singh, Director. The Members of IJSC are:

I. Official Side Members

Dr. Manjit Singh, Director

Dr. B. Vijay, Principal Scientist

Dr. V.P. Sharma, Principal Scientist.

Dr. O.P. Ahlawat, Principal Scientist

Sh. Raj Kumar, Admn. Officer, Secretary

Sh. Rishi Ram, AAO

Sh. Jiwan Lal, AFACO

II. Staff Side Members

Sh. R.K. Bhatnagar, Assistant, Member CJSC

Sh. Bhim Singh, Assistant

Sh. Gian Chand, Boiler Attendant (T-4)

Sh. Lekh Raj Rana, Tech. Asstt. (T-3), Secretary

Sh. Tej Ram, SS Gr.II, Member IJSC

Sh. Ajeet Kumar, SS Gr.II

(g) Grievance Cell

1. Grievance committee members

Dr. R.C. Upadhyay, Principal Scientist	-	Chairman
Dr. Satish Kumar, Sr. Scientist	-	Member
Sh. Raj Kumar, Admn. Officer	-	Member
Sh. Jiwan Lal, AFACO	-	Member
Sh. Rishi Ram, AAO	-	Member Secretary
Sh. Rajinder Sharma, Asstt.	-	Member (Admn. category)
Sh. Guler Singh, T-2 (Electrician)	-	Member (Technical category)
Sh. Raj Kumar, SSG-II	-	Member (Supporting staff)

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

(h) Consultancy Processing Cell (CPC)

Three meetings of Consultancy Processing Cell (CPC) were held on 16.03.2009, 04.06.2009 and 30.06.2009.

Members of the CPC

1.	Dr. R.C. Upadhyay, Principal Scientist	-	Chairman
2.	Dr. O.P. Ahlawat, Principal Scientist	-	Member Secretary
3.	Sh. Raj Kumar, Administrative Officer	-	Member
4.	Sh. Jiwan Lal, AFACO	-	Member
5.	Sh. Deep Kumar Thakur, Steno	-	Dealing Assistant

(i) Institute Technology Management Unit

As per the guidelines received from ICAR for Intellectual Property Management and Technology Transfer/Commercialization, the DMR has constituted the following Committee for the establishment of ITMU under the Chairmanship of the Director.

Dr. Manjit Singh, Director	-	Chairman
Dr. R.C. Upadhyay, Principal Scientist	-	Member
Dr. B. Vijay, Principal Scientist	-	Member
Dr. Jai Gopal, Principal Scientist, CPRI, Shimla	-	Member
Dr. V. P. Sharma, Principal Scientist	-	Member Secretary

(j) Institute Variety Release Committee

Dr. Manjit Singh, Director, DMR	-	Chairman
Director, CPRI, Shimla	-	Member
Director of Horticulture, H.P.	-	Member
Dr. R.C. Upadhyay, Principal Scientist	-	Member
Dr. B. Vijay, Principal Scientist	-	Member
Dr. V. P. Sharma, Principal Scientist	-	Member
Dr. O.P. Ahlawat, Principal Scientist	-	Member

(k) Women Employees Complaint Committee

Mrs. Reeta Bhatia, Technical Officer	-	Chairperson
Admin. Officer	-	Member
Mrs. Shailja Verma, Technical Officer	-	Member
Mrs. Shashi Poonam, LDC	-	Member
Mrs. Sunila Thakur, Stenographer Grade III	-	Member Secretary

(l) Other events organized

Science Day

Science day was celebrated on 28th Feb., 2009. On this day different events like painting competition, science quiz and declamation contest were held in which 55 students from five schools participated (Fig. 11.3).

Fig. 11.3. Children participating in painting competition on science day

Fig. 11.4. Scientist-Industry-Farmer Interface organized at DMR

Science-Industry-Farmer Interface

Science-Industry-Farmer Interface meeting was held on 8th June, 2009. In this meeting Dr. D.R. Gautam, Director extension, Dr. Y.S. Parmar university of Horticulture and Forestry, Solan, Dr. Gurdev Singh, Director Horticulture, Himachal Pradesh, Dr P.S. Naik, Project Coordinator, CPRI Shimla, Dr M.L Dhiman, Mushroom Project Chmbaghat, all the scientists of DMR and 30 progressive mushroom growers participated (Fig. 11.4).

(m) Rajbhasa Implementation Committee (Hindi Committee)

राजभाषा कार्यान्वयन समिति (हिन्दी समिति)

डा. मनजीत सिंह, निदेशक	-	अध्यक्ष
डा. आर.सी. उपाध्याय, प्रधान वैज्ञानिक	-	सदस्य
श्री राज कुमार, प्रशासनिक अधिकारी	-	सदस्य
श्री ऋषि राम, सहायक प्रशासनिक अधिकारी	-	सदस्य
श्रीमती रीता, तकनीकी अधिकारी	-	सदस्या
श्रीमती सुनीला ठाकुर, आशुलिपिक	-	सदस्या
श्री दीप कुमार ठाकुर, आशुलिपिक	-	सदस्य सचिव

राजभाषा कार्यान्वयन समिति द्वारा वर्ष 2009-10 के दौरान किये गए कार्यों का संक्षिप्त विवरण

भारत सरकार की राजभाषा नीति के कार्यान्वयन को सुनिश्चित करने तथा निदेशालय द्वारा संपादित किये जाने वाले कामकाज में हिन्दी का प्रयोग सुनिश्चित करने के उद्देश्य से निदेशालय में राजभाषा कार्यान्वयन समिति का गठन किया गया है। राजभाषा कार्यान्वयन के लिए निदेशालय में अलग से कोई अधिकारी व कर्मचारी न होने के बावजूद राजभाषा कार्यान्वयन समिति द्वारा किए गये प्रयासों के फलस्वरूप निदेशालय में हिन्दी के कामकाज व प्रचार-प्रसार में अपेक्षित सफलता प्राप्त हुई है। निदेशालय द्वारा वर्ष 2009 के दौरान किये गये कार्यों का संक्षिप्त विवरण निम्नानुसार है:-

राजभाषा वार्षिक कार्यक्रम पर कार्यान्वयन

राजभाषा विभाग, गृह मंत्रालय, भारत सरकार द्वारा जारी राजभाषा वार्षिक कार्यक्रम पर निदेशालय की राजभाषा कार्यान्वयन समिति की त्रैमासिक बैठकों में चर्चा हुई तथा दिए गए दिशा-निर्देशों के अनुरूप लिए गए निर्णयों के अनुसार कार्रवाई की गई तथा निदेशालय के सभी अधिकारियों व कर्मचारियों को वार्षिक कार्यक्रम के अनुसार निर्धारित लक्ष्य प्राप्त करने हेतु पत्राचार किया गया।

राजभाषा विभाग, नई दिल्ली एवं भारतीय कृषि अनुसंधान परिषद्, नई दिल्ली से प्राप्त पत्रों/परिपत्रों पर कार्रवाई

इस अवधि में राजभाषा कार्यान्वयन सम्बन्धी नवीनतम निर्देशों/नियमों से सम्बन्धित विभिन्न प्रकार के पत्र/परिपत्र आदि राजभाषा विभाग, भारतीय कृषि अनुसंधान परिषद से प्राप्त हुए जिन पर कार्रवाई वांछित थी, के ऊपर कार्रवाई की गई तथा उन्हें सभी संबंधित अधिकारियों व कर्मचारियों को उनकी जानकारी व आवश्यक कार्रवाई हेतु परिचालित किया गया।

तिमाही हिन्दी प्रगति रिपोर्ट का संकलन तथा समीक्षा

निदेशालय में राजभाषा कार्यान्वयन सम्बन्धी प्रगति के आँकड़े प्राप्त कर जारी त्रैमासिक रिपोर्ट प्रोफार्मा में सभी आँकड़ों को संकलित कर निदेशालय की समेकित हिन्दी प्रगति रिपोर्ट तैयार की गई। इस समेकित रिपोर्ट को भारतीय कृषि अनुसंधान परिषद को भेजा गया। इस रिपोर्ट की समीक्षा की गई तथा पाई गई कमियों को इंगित कर दूर करने के लिए सभी अधिकारियों व कर्मचारियों को प्रेषित किया गया।

हिन्दी प्रोत्साहन योजना का क्रार्यान्वयन

राजभाषा विभाग द्वारा जारी निर्देशों के अनुरूप निदेशालय में सरकारी कामकाज मूल रूप में हिन्दी में करने के लिए प्रोत्साहन योजना सभी अधिकारियों व कर्मचारियों के लिए लागू की है। पूरे वर्ष में किए गए कार्यों को मध्य नजर रखते हुए एक मूल्यांकन समिति का गठन किया जाता है जो फाईलों व अन्य कार्यों का अवलोकन कर प्रथम, द्वितीय व तृतीय पुरस्कारों का निर्णय करती है।

त्रैमासिक बैठकों का आयोजन

राजभाषा कार्यान्वयन समिति की त्रैमासिक बैठकों का नियमित आयोजन किया गया। बैठकों में राजभाषा वार्षिक कार्यक्रम में निर्धारित किए गए लक्ष्यों को प्राप्त करने, समय-समय पर राजभाषा विभाग एवं भारतीय कृषि अनुसंधान परिषद् से प्राप्त निर्देशों/आदेशों के अनुपालन पर चर्चा की गई तथा इन बैठकों में लिए गए निर्णयों को लागू करने के लिए कार्रवाई की गई।

त्रैमासिक राजभाषा कार्यशालाओं का आयोजन

निदेशालय में त्रैमासिक राजभाषा कार्यशालाओं का नियमित आयोजन किया गया। इन कार्यशालाओं में हिन्दी में कार्य करने में आ रही बाधाओं पर चर्चा की गई तथा उनका निराकरण करने के लिए उपाए सुझाए गए।

निदेशालय के सभी अधिकारियों व कर्मचारियों के लिए सभी प्रकार के प्रपत्र द्विभाषी रूप में तैयार किए गए व सभी के कंप्यूटरों पर डाउनलोड किए गए ताकि वे दिन-प्रतिदिन कार्यालय प्रयोग में इन प्रपत्रों को प्रयोग में लाएं।

हिन्दी सप्ताह का आयोजन

14-19 सितम्बर, 2009 तक 'हिन्दी सप्ताह' के दौरान विभिन्न प्रतियोगिताओं का आयोजन किया गया और वर्ष में सर्वाधिक कार्य करने वाले अधिकारियों/कर्मचारियों एवं विजेताओं को पुरस्कृत किया गया (चित्र 11.5)।

चित्र 11.5.

निदेशालय की वार्षिक हिन्दी प्रगति संबंधी मुख्य गतिविधियाँ एवं उपलब्धियाँ

राजभाषा कार्यान्वयन समिति की प्रमुख-प्रमुख गतिविधियों और उपलब्धियों का सार-गर्भित संक्षिप्त-विवरण वार्षिक हिन्दी प्रगति रिपोर्ट के रूप में प्रस्तुत किया जाता है।

1. निदेशालय के 80 प्रतिशत से अधिक कार्मिक हिन्दी में प्रवीणता/कार्यसाधक ज्ञान प्राप्त है इसलिए यह निदेशालय राजभाषा नियम 10(4) के अंतर्गत भारत सरकार के गजट में हिन्दी कार्यालय के रूप में अधिसूचित किया जा चुका है।

2. दिनांक 18.04.2009, 25.07.2009, 21.10.2009 व 29.01.2010 को राजभाषा कार्यान्वयन समिति की बैठकें संपन्न हुई। सभी बैठकों की कार्यसूची वार्षिक कार्यान्वयन की अपेक्षाओं के अनुसार एवं अध्यक्ष महोदय, राजभाषा कार्यान्वयन समिति के अनुमोदन के बाद ही तय की गई।

3. दिनांक 18.04.2009, 18.07.2009, 19.09.2009 व 12.02.2010 को राजभाषा कार्यशालाओं का आयोजन किया गया जिसमें निदेशालय के सभी अधिकारियों व कर्मचारियों ने स्वेच्छा से भाग लेकर कार्यशालाओं के लक्ष्यों को सफलतापूर्वक प्राप्त किया।

4. हिन्दी में प्राप्त या हिन्दी में हस्ताक्षरित सभी पत्रों में से जिन पत्रों का उत्तर देना अपेक्षित समझा गया, उन पत्रों का उत्तर केवल हिन्दी में अथवा हिन्दी-अंग्रेजी द्विभाषीय रूप में दिया गया।

5. निदेशालय की अधिकतर बैठकों के कार्यवृत्त हिन्दी में तैयार किए गए।

6. राजभाषा अधिनियम, 1963 की धारा 3(3) तथा अन्य नियमों की अनुपालना के संदर्भ में निदेशालय के प्रत्येक अधिकारी व कर्मचारी को समय-समय पर कार्यालय आदेश जारी किए गए व इनकी शत-प्रतिशत अनुपालन सुनिश्चित करवाने के प्रयास किए जा रहे है।

7. हिन्दी पत्राचार के निर्धारित लक्ष्यों को प्राप्त करने की दिशा में सतत्-प्रयास जारी है।

8. सभी 46 मानक फॉर्मों को द्विभाषी रूप में तैयार कर लिया गया है तथा सतत् कोशिशें की जा रही है की सभी कार्मिक इन्हें हिन्दी में ही भरें।

9. निदेशालय के सभी 22 कम्पयूटरों में हिन्दी सॉफटवेयर को डाउनलोड किया गया है। इससे कम्पयूटर पर काम करने वाले प्रत्येक अधिकारी व कर्मचारी को अपनी इच्छानुसार हिन्दी में अथवा हिन्दी और अंग्रेजी दोनों में किसी भी भाषा में एक साथ काम कर सकते है।

10. निदेशालय के सभी अधिकारियों का हिन्दी की जानकारी संबंधी रोस्टर तैयार किया गया है।

11. श्री दीप कुमार, सदस्य सचिव, राजभाषा कार्यान्वयन समिति व श्रीमती सुनीला ठाकुर, सदस्या, राजभाषा कार्यान्वयन समिति ने केन्द्रीय मात्स्यिकी शिक्षा अनुसंधान संस्थान, मुबंई में दिनांक 11-16 जनवरी, 2010 तक अल्पकालीन प्रशिक्षण एवं कार्यशाला जिसका विषय हैः (1) हिन्दी का बढ़ता हुआ स्वरूप व (2) राजभाषा कार्यान्वयन की समस्याएं एवं समाधान) में भाग लिया तथा इस कार्यशाला में श्री दीप कुमार ठाकुर द्वारा निदेशालय में हो रहे हिन्दी के कार्यों को इस कार्यशाला में प्रस्तुत किया तथा कार्यशाला में अपना लेख 'राजभाषा कार्यान्वयन की समस्याएं एवं समाधान' लिखा।

12. निदेशालय के सभी साईन बोर्ड, सूचना बोर्ड, नाम पट्ट व अन्य इसी प्रकार के बोर्ड द्विभाषी रूप में तैयार करवाए गए हैं।

13. निदेशालय के प्रशिक्षण कार्यक्रमों के लिए प्रशिक्षण सार-संग्रह (ट्रेनिंग कम्पेडियम) हिन्दी व अंग्रेजी दोनो भाषाओं में उपलब्ध है।

14. कोड मैनुअलों और अन्य कार्यविधि साहित्य हिन्दी में उपलब्ध है।

15. निदेशालय के अधिकारियों तथा कर्मचाारियों के हिन्दी शब्द ज्ञान को बढ़ाने के उद्देश्य से पुस्तकालय में श्यामपट्ट (ब्लैक बोर्ड) पर तथा ई-मेल के माध्यम से कम्पयूटर पर 'आज का शब्द' शीर्षक के अन्तर्गत प्रतिदिन हिन्दी का एक शब्द उसके अंग्रेजी समानार्थ के साथ लिखा जाता है ताकि अधिकारियों व कर्मचारियों के शब्द ज्ञान में वृद्धि हो सके।

16. निदेशालय में प्रत्येक वर्ष की भांति इस वर्ष भी मशरूम मेले का आयोजन 10 सितम्बर, 2009 को आयोजित किया गया। इस अवसर पर मुख्य पंडाल के सभी चित्रों के शीर्षक, ग्राफ, हिस्टोग्राफ आदि हिन्दी में प्रदर्शित किए गए। मल्टीमीडिया के माध्यम से मशरूम संबंधी जानकारी आकर्षक ढंग से प्रस्तुत की गई तथा किसानों, छात्रों व अन्य अंगतुकों को मशरूम साहित्य हिन्दी में उपलब्ध कराया गया।

17. हिन्दी पुस्तकों की खरीद के लिए एक समिति बनाई गई है जो हिन्दी पुस्तकालय के लिए पुस्तकें खरीदने की सिफारिश करती है। पुस्तकालय में प्रत्येक वर्ष राजभाषा विभाग द्वारा निर्धारित लक्ष्य के अनुसार पुस्तकें खरीदने का प्रयास किया जा रहा है। निदेशालय की पुस्तकालय में हिन्दी में उपलब्ध सभी प्रकाशनों की सूची में निदेशालय की वेबसाइट पर उपलब्ध कराई गई है।

18. दूरदर्शन तथा आकाशवाणी पर भी निदेशालय के वैज्ञानिकों व तकनीकी अधिकारियों की मशरूम विषय पर हिन्दी में वार्ताएं प्रसारित होती रहती है जिनसे मशरूम उत्पादकों की समस्याओं का समाधान होता है।

19. इसके अतिरिक्त खुम्ब संबंधी प्रौद्योगिकियों पर अनेक फोल्डर हिन्दी में भी प्रकाशित किए।

20. इसके अतिरिक्त डा. मनजीत सिंह, निदेशक एवं अध्यक्ष, राजभाषा कार्यान्वयन समिति के सतत् निजी-सहयोग और मार्गदर्शन के तहत हिन्दी की तिमाही बैठकों व कार्यशालाओं का समय पर आयोजन व निदेशालय में कार्यरत सभी अधिकारियों व कर्मचारियों के आपसी सहयोग और मेलमिलाप के साथ राजभाषा कार्यान्वयन संबंधी गतिविधियां निरंतर प्रगति की ओर अग्रसर हो रही है।

12. WINTER/SUMMER SCHOOL/SEMINARS/ SYMPOSIA/ CONFERENCES ATTENDED/ORGANISED

Dr. Goraksha Chimaji Wakchaure

- Attended summer school on "Advances in Mushroom Biology and Biotechnology" at DMR, Solan, w.e.f. 26.08.2009 - 15.09.2009.
- Attended winter school on "Quality assurance and shelf-life enhancement of fruits and vegetables through novel packaging technologies " organized by CIPHET, Ludhiana (Punjab), w.e.f. 26th Aug., 2009 - 15th Oct., 2009.
- Attended RAEP (Recent Advances in Environmental Protection)-2009, an international conference with exhibition for presenting the paper on "Saving Environment: Study on physical properties of biomass briquettes for efficient energy use in rural India" organized by the Chemistry Department, St. John's College, Agra with the focal theme 'Environmental Protection Strategies for Sustainable Development w.e.f. 17th-19th Dec., 2009.

Dr. Maniknadan

- Attended Summer School on "Advances in Mushroom Biology and Biotechnology" at DMR, Solan, w.e.f. 26th Aug., 2009 - 15th Sept., 2009.
- Attended winter school on "Efficient farm waste utilization for sustainable agriculture and enhancing soil and produce quality' at IISS, Bhopal, MP, w.e.f. 1st Dec., 2009 - 21st Dec., 2009.

Dr. O.P. Ahlawat

- Attended Conference on Organic Farming on July 24, 2009 at Confederation of Indian Industries Headquarters, Chandigarh.
- Attended International Conference on Biotechnology Based Sustainable Agriculture organized by International Life Sciences Institute-India, New Delhi and ILSI International Food Technology Committee, Washington DC on December 19, 2009 at Hotel Le Meridien, New Delhi

Dr. R.C. Upadhyay

- Attended one day seminar on mushroom cultivation in Haryana organized by Department of Horticulture, Panchkula on 9th Jan., 2009.
- Attended two days workshop on "Intellectual Property Rights in Biotechnology" organized by Dept. of Biotechnology, Govt. of India on 19-20th March 2009 at Chandigarh.
- Attended two days workshop at Institute of Microbial Technology, Chandigarh on 10th and 11th Aug 2009 on Standardization of Microbial extract preparation for bioactive molecule screening.
- Attended one day workshop on "Information Technology in Horticulture" at CPRI, Shimla on 24th Aug.
- Attended one day International conference on 'Biotechnology based sustainable Agriculture" on 19th Dec. 2009 in New Delhi.

Dr. V.P. Sharma

- Dr. V.P Sharma, organized Summer School on "Advances in Mushroom Biology and Biotechnology" w.e.f. 26th Aug. - 15th Sept, 2009 as Course Director.
- Attended National Symposium on "Rational use of fungicides in management of Horticultural crop diseases" held at UHF Nauni, Solan w.e.f. 5th-6th July, 2009.

13. DISTINGUISHED VISITORS

- Dr. Mangala Rai, Secretary (DARE) and DG, ICAR visited DMR, Solan on 24.05.2009

Fig. 13.1. Dr Mangla Rai, Hon'ble DG, ICAR and secretary DARE, inaugurating TTC building at DMR

- Dr. M. Mahadevappa, Ex-Chairman, ASRB visited DMR, Solan on 04.06.2009.
- Members of Board of Management of Andhra Pradesh Agricultural University, Hyderabad visited DMR, Solan on 04.05.2009
- Dr. Pawan Kapur, Director, CSIO, Chandigarh alongwith his team members visited DMR, Solan on 27th June, 2009 regarding the collaborative project on "Automation and Instrumentation in mushroom growing".
- Sh. Giriraj Singh, Cooperative Minister, Bihar State visited DMR, Solan on 20.07.2009.
- Members of Board of Management of University of Agricultural Sciences, Bangalore visited DMR, Solan on 03.08.2009.

Fig. 13.2. Sh. Giriraj Singh, Cooperative Minister, Bihar visiting Crop Production Laboratory of DMR

- Dr. A.K. Mohapatra, IFS, Chief Executive, Regional Plant Resource Centre, Bhubaneshwar visited DMR, Solan on 11.08.2009 regarding the collaboration between Regional Plant Resource Centre (RPRC) and DMR, Solan to take up characterization and bio-chemical analysis of wild mushrooms.
- Dr. C.D. Mayee, Chairman, ASRB visited DMR, Solan on 17.08.2009.

Fig. 13.3. Dr C.D. Mayee, Chairman ASRB visiting mushroom house

- Dr. H.P. Singh, DDG (Hort.), ICAR, New Delhi visited DMR on 23.8.2009
- Dr. Mathura Rai, Director, IIVR, Varanasi visited DMR on 23.8.2009.
- Dr. H.P. Singh, DDG (H) and Dr. Umesh Srivastava, ADG (H-II) visited DMR on 25.08.2009.
- Dr. Kouassi Auguste, Geneticien, Universite & Alidjan, COTE d IVOIRE visited DMR, Solan on 12.11.2009.

Fig. 13.4. Dr. H.P. Singh, DDG (Hort.) visiting mushroom house

14. PERSONNEL AND FACILITIES

Name	Designation
Scientific	
Dr. Manjit Singh	Director
Dr. S.R. Sharma	Principal Scientist (Pl.Path.) (upto 30.06.2009)
Dr. R.D. Rai	Principal Scientist (Biochemistry) (upto 31.07.2009)
Dr. R.C. Upadhyay	Principal Scientist (Pl.Path.)
Dr. B. Vijay	Principal Scientist (Pl.Path.)
Dr. V.P. Sharma	Principal Scientist (Pl.Path.)
Dr. O.P. Ahlawat	Principal Scientist (Biotechnology)
Dr. M.C. Yadav	Senior Scientist (Genetics) (upto 31.08.2009)
Dr. Satish Kumar	Senior Scientist (Entomology)
Dr. M.P. Sagar	Senior Scientist (Agril.Extension) (upto 18.06.2009)
Sh. Yogesh Gautam	Scientist (SS)(Computer Application)
Dr. Goraksha Chimaji Wakchaure	Scientist (Agril. Structure & Processing Engg.)
Sh. Mahentesh Shirur	Scientist (Agril. Extension)
Dr. Maniknadan	Scientist (Soil Science)
Technical	
Sh. Sunil Verma	Technical Officer (T-6)
Smt. Reeta Bhatia	Technical Officer (T-6)
Smt. Shailja Verma	Technical Officer (T-6)
Sh. Jia Lal	Technical Officer (T-5)
Sh. Gian Chand	T-4
Sh. Lekh Raj Rana	T-1-3
Sh. Ram Swaroop	T-2
Sh. Parmanand	T-1-3
Sh. Dala Ram	Driver T-3
Sh. Ram Lal	Driver T-3
Sh. Ram Ditta	Driver T-3
Sh. Deepak Sharma	T-3
Sh. Jeet Ram	T-2
Sh. Guler Singh Rana	T-2

Name	Designation
Administrative	
Sh. Raj Kumar	Administrative Officer
Sh. Jiwan Lal	Asstt.Finance & Accounts Officer
Sh. Rishi Ram	Asstt. Administrative Officer
Sh. R.K. Bhatnagar	Assistant
Sh. Rajinder Sharma	Assistant
Sh. Bhim Singh	Assistant
Sh. Surjit Singh	PA
Smt. Sunila Thakur	Steno Gr.III
Sh. Deep Kumar Thakur	Steno Gr.III
Sh. T.D. Sharma	UDC
Sh. N.P. Negi	UDC
Sh. Satinder Thakur	UDC
Sh. Dharam Dass	LDC
Smt. Shashi Poonam	LDC
Sh. Roshan Lal Negi	LDC
Sh. Sanjeev Sharma	LDC
Supporting	
Smt. Dayawanti	SSG-IV
Sh. Naresh Kumar	SSG-III
Sh. Nika Ram	SSG-III
Sh. Tej Ram	SSG-II
Smt. Meera Devi	SSG-II
Sh. Raj Kumar	SSG-II
Sh. Ajeet Kumar	SSG-II
Sh. Arjun Dass	SSG-I
Sh. Vinay Sharma	SSG-I

Promotions

- Mrs. Shailja Verma, Artist got merit promotion from Technical Officer (T-5) to Technical Officer (T-6) w.e.f. 26.08.2009.
- Sh.Lekh Raj Rana, Technical Assistant (T-1-3) granted advance three increments w.e.f. 20.10.2009 under Old Technical Service Rules.

- Sh. Deepak Sharma, got merit promotion from Electronic cum Computer Operator T-2 to T-3 (Cat. II) w.e.f. 27.10.2009.

The following staff members were granted MACPS w.e.f. 01.09.2008.

Sh. R.K. Bhatnagar	Assistant
Sh. Rajinder Sharma	Assistant
Sh. Surjit Singh	PA to Director
Sh. T.D. Sharma	UDC
Sh. N. P. Negi	UDC

Transfers

- Dr. M.P. Sagar, Sr. Scientist transferred from DMR on 18.06.2009 to join his duties at Central Avian Research Institute, Izatnagar (UP) 243 122
- Dr. R.D. Rai, Principal Scientist transferred from DMR on 31.07.2009 to join his duties at IARI, New Delhi.
- Dr. M.C. Yadav, Sr. Scientist was relieved from DMR on 31.08.2009 to join his duties at National Bureau of Plant Genetic Resources, New Delhi as Principal Scientist.

Retirement

- Dr. S.R. Sharma, Principal Scientist retired from Council's services on 30.06.2009.

New Appointments

- Dr. Manjit Singh joined at DMR on 01.01.2009 as Director.
- Dr. Goraksha Chimaji Wakchaure joined at DMR on 20.06.2009 as Scientist (Agril. Structure & Processing Engineer)
- Sh. Mahentesh Shirur joined at DMR on 28.08.2009 as Scientist (Agril.Extension).
- Dr. K. Manikandan joined at DMR on 29.08.2009 as Scientist (Soil Science/chem./ Fertility).

Study leave

- Sh. Yogesh Gautam, Scientist (SS) Computer Application granted Study leave for 3 years w.e.f. 08.02.2008 to 07.02.2011 for completing Ph.D on Computer Applications from HP University, Shimla.

Sports

- Contingent of 25 men from DMR participated in ICAR Zonal Sports Meet held at Indian Institute of sugarcane Research, Lucknow w.e.f. 6-7th July, 2009

Infrastructural facilities developed

- To improve the research and other Infrastructure of the Directorate, the renovation and special repair/ incomplete work were undertaken and completed.The allocated funds under Plan worth Rs.11.00 Lakhs and under non Plan Rs.18.96 Lakhs were utilized. The details of major works are as under:-

(1) C/O Type-III one Quarter completed

(2) C/O Spawn laboratory started

(3) Electrification of parking in front of Main building