25 YEARS OF AICRP (MUSHROOM)

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All India Coordinated Research Project on Mushroom

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FOREWARD

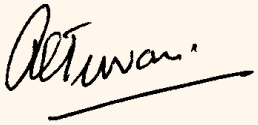
Mushroom cultivation is a potential biotechnological process wherein the waste plant materials or negative value crop residues can be converted into valuable food. Protein conversion efficiency and productivity of mushrooms per unit land area and time is far superior than plant and animal sources. In recent years mushroom cultivation in India has witnessed a tremendous growth with respect to the type of mushrooms and their producitivity. The mushroom market is growing continously mainly due to increasing interest in their culinary, nutritional and health benefits. On recognizing the importance of mushroom as an eco-friendly alternative for agro-waste recycling, capability to provide better nutrition for the vast vegetarian population, employment generation and a good income source, organized research on mushroom was initiated in India with the establishment of National Research Centre for Mushroom and All India Coordinated Research Project on Mushroom in 1983 at Solan (HP).

During the past 25 years of its implementation, the project had been instrumental in bring out superior strains of white button mushroom, paddy straw mushroom, milky mushroom, oyster mushroom, superior casing materials for button mushroom, post harvest technology and standardization of cultivation technology of specialty mushrooms which are needed to diversify the mushroom cultivation scenario in the country.

Optimizing the yield of oyster, button, milky, paddy straw and shiitake mushrooms by way of using different substrates, chemicals, casing materials and supplements, identifying safer chemicals for improving shelf-life of button mushroom, packaging and drying of mushrooms, isolation and identification of thermophilic fungi, germplasm collection and conservation, and survey and surveillance for diseases and insect-pests of mushrooms will further improve the production and productivity of mushrooms and will foster socio-economic upliftment of the mushroom growers throughout the country. The extension services along with supply of quality spawn has

equally contributed in popularizing the mushroom even in remote areas of the country.

The present publication aims at highlighting organizational set up and major achievements made under the AICRP (Mushroom) during the last 25 years. The authors, Dr. O.P. Ahlawat, Dr. Satish Kumar and Dr. T. Arumuganathan have done a commendable job in compiling and editing the information. The valuable contribution from the Scientist Incharges of all the AICMIP Centers in bringing out this publication is gratefully acknowledged. I am very sure, this publication will be of immense use to Indian mushroom growers and mushroom scientists for their efforts to make the world a healthier place to live.



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EXECUTIVE SUMMARY

1. All India Coordinated Research Project on Mushroom (AICRPM) was initiated during VIth Five-Year Plan on 01.04.1983 with its Headquarters at National Research Centre for Mushroom, Solan (HP).

2. Presently, there are 10 Co-ordinating and one co-operating Centres working under AICRP (Mushroom) located in 11 states. Of these, 9 Centres are based at State Agricultural Universities, while 2 at ICAR institutes. The AICRP (Mushroom) network covers major distinct agro-climatic zones in the country.

3. Presently, there are 16 scientific, 12 technical, 7 administrative and 9 supporting staff working at various AICRP Centres.

4. The financial outlay of the project since its inception in VIth plan till Xth plan had been Rs. 838.13 Lacs.

5. The activities of the AICRP Centres are monitored through the visits of Project Coordinator, monitoring teams, quarterly and annual reports, regular group meetings / workshops and high powered Quinquennial Review Teams (QRTs) constituted by the Indian Council of Agricultural Research. Since the inception of the project, 10 workshops/ group meetings have been held in such a manner that venues are evenly distributed through out the country. During these meetings recommendations for release of varieties, cultivation technologies, and crop protection measures are brought out. Based on the previous results and keeping in view the emerging problems, new technical programmes are also worked out in these meetings.

6. The project had been instrumental in coordinating and monitoring multilocational trials with improved mushroom varieties / hybrids, cultivation practices related to crop production, crop protection measures and post harvest technologies, all aimed at increasing production, productivity and utilization of mushroom in the country.

7. As many as 914 wild mushroom specimens were collected by different Centres under the AICRP (Mushroom) since its inception. The specimens were preserved in dry and wet forms, and most of their cultures along with database were deposited in gene bank at NRCM, Solan.

8. At present, four mushroom varieties namely, *Agaricus bisporus, Calocybe indica, Pleurotus* spp. and *Volvariella* spp. have been recommended for round the year cultivation in the country.

9. Species and strains of different mushrooms performing better in eastern Uttar Pradesh conditions are *Agaricus bisporus* (CM-3, CM-13 and S-11), *Pleurotus florida, P. sajor-caju, P. sajor-caju* (hybrid strain-1), *Hypsizygus ulmarius*, *Calocybe indica* (CI-7, CI-6, CI-1 and APK-2) and *Volvariella volvacea* (Vv-3, Vv-2, Vv-12 and Vv-8).

10. Indira Gandhi Agricultural University, Raipur under All India Coordinated Research Project on Mushroom released a variety of oyster mushroom (*Pleurotus florida*) NMS-7 strain as Indira Sweta (OM-1) for commercial cultivation throughout the state of Chhattisgarh.

11. Ananthan, an interstock hybrid of *Pleurotus petaloides* developed at the AICRP, Vellayani Centre was released by the Kerala State Government and is widely acclaimed by the farmers of Kerala.

12. Ten mushroom varieties were released by TNAU, Coimbatore under AICRPM for the benefit of the mushroom growers of Tamil Nadu.

13. Amongst different strains of *Agricus bisporus*, strains P-1, NCS-12 and 310 were observed to be high yielding in Maharashtra. *Agaricus bitorquis* strain NCB-6 can be grown successfully at natural temperature (22 to 26°C) during monsoon under Pune conditions.

14. Application of Phosphotika biofertilizer @ 1.0 % at the time of spawning gave maximum average button mushroom yield of 1251 g/ 10 kg compost. Strain U-3 interacted well with Phosphotika biofertilizer. The application of Veradix-2 spray @ 0.15 % at pinning stage recorded highest button yield of 1361 g/10 kg compost.

15. Chemical treatment (Formalin 15 ml + Bavistin 0.5 g/10 kg compost) was developed for long method compost to avoid the moulds effectively in cultivation of *A. bisporus*.

16. Compost inoculated with mixed inoculum of *Gilmaniella humicola* + *Scytalidium thermophilum* + *Thermomyces lanuginosus* at the time of spawning enhanced the button mushroom yield.

17. In casing materials evaluation, 2 years old spent compost, FYM + spent compost (1:1, v/v) and FYM+ soil+ sand+ spent compost (1:1:1:1, v/v) out yielded the other treatments.

18. The hot water treatment of the substrate resulted into significantly higher yield of oyster mushroom (720 g/kg dry substrate) than other two methods of pasteurization (chemical and solar pasteurization) of substrate.

19. Chemical treatment of paddy straw using carbendazim 75 ppm + formalin 500 ppm increased the yield of *P. citrinopileatus* by 38 per cent over control.

20. Supplementation treatment with deoiled soybean meal @ 2% of dry weight of substrate resulted into giving maximum oyster mushroom yield of 733 g/kg dry substrate as compared to other supplementation treatments in both the species *viz*., *Pleurotus sajor-caju* and *P. florida* of oyster mushroom.

21. *Pleurotus fossulatus* and *Pleurotus florida* were successfully grown on wheat straw substrate and *P. florida* gave maximum yield of 966.67 g/ kg substrate (96.66 % biological efficiency) and *P. fossulatus* with the yield of 886 g/ kg substrate (88.60 % biological efficiency).

22. Dipping of oyster mushroom substrate in the solutions of 0.4 and 0.6 % of effective microorganisms preparations was found to significantly increase the mushroom yield by 50 %.

23. Blue oyster mushroom (*Hypsizygus ulmarius*) was successfully grown on wheat straw with 57.80% biological efficiency.

24. In oyster mushroom cultivation, hollow beds resulted in substantial increase in yield of different species of *Pleurotus* due to increase in aeration and wetting of the inner surface of the substrates. Chopping of straw in the length of 6-9" were extremely helpful in significant increase in yield of *Pleurotus* spp. than straw length of 3" may be due to increased air space, surface area and effective penetration of water.

25. An improvised air cooling system was developed by Vellayani Centre for speedy sporocarp induction in dormant beds of oyster mushrooms during the cropping phase.

26. Amendment of substrate with cotton waste followed by neem cake and chicken manure increased the yield of *Volvariella volvacea* by 46, 33 and 30 per cent over control.

27. The highest biological efficiency was recorded in milky mushroom strain CI-6 (107 %) followed by CI-7 (88.9 %), CI-1 (80.2 %), CI-3 (73.8 %) and APK-2 (72.8 %).

28. Silver oak saw dust+wheat bran (8 %) was found to be the best substrate for the cultivation of *Auricularia polytricha* with an average yield of 811.7 g/ kg of substrate.

29. Supplementation of wheat straw with wheat bran and rice bran was found to enhance the yield of black ear mushroom.

30. Cultivation of *Lentinula edodes* was standardized with wheat straw and popular sawdust substrates supplemented with wheat bran @ 20 per cent.

31. Cultivation technology of *Ganoderma lucidum* was standardized using sterilized wheat straw supplemented with wheat bran (5 %) substrate. The medium MEA, pH 5-6 and temperature range of 26±2°C recorded maximum growth of *Ganoderma lucidum*.

32. The acceptable white colour of button mushroom was retained upto 48 h on packaging mushrooms in 100 gauge PP bags followed by storage at both refrigerated and ambient conditions.

33. At refrigerated conditions, dipping treatment in 100 ppm EDTA and 100 ppm EDTA + 0.02% KMS showed retention of good milky white colour of button mushroom upto 48 h. However, at ambient temperature, desired colour was retained in 100 ppm EDTA + 0.02% KMS treatment upto 48 h.

34. Dipping of the fruiting bodies of button mushroom (strain S-11) in 125 ppm EDTA solution showed best results by increasing the shelf life and maintaining good colour and texture both under refrigerated and ambient storage conditions up to 72 h.

35. Blanching followed by sun drying was found best method for drying of *Pleurotus sajor-caju* in comparison to cabinet drying-unblanched and blanched methods.

36. Wheat straw compost was found better than paddy straw compost for growing *Agaricus bisporus*. Initial level of 1.5 % N in the compost proved to be optimum for getting higher yield of *A. bisporus* strain, S-11.

37. Paddy straw mushroom could be successfully cultivated in the inter row spaces of maize (30 days after sowing), sugarcane (8 months after planting) and banana (5 months after planting).

38. Most of the pathogens and pests of white button mushroom can be managed by sound hygiene and sanitation measures which are the best available options with a grower at the moment. The use of chemicals namely Bavistin and Sporgone should be applied only under extremely unavoidable circumstances.

39. Survey and surveillance of diseases and insect-pests are carried out at regular intervals and the growers are advised for various components of IPM. They are (i) Farm hygiene, (ii) Providing doors, windows and ventilators with 35 mesh nylon net to prevent entry of the flies in the cropping room, (iii) Use of light and yellow sticky traps for monitoring and killing mushroom flies, (iv) Cooking out at 70- 80^{0}C at least for 2 hours before removing the beds to kill all stages of pests and diseases,

(v) Safe disposal of spent compost and casing materials in isolated manure pits to check the breeding of flies.

40. All the Centres carried out the extension activities by participating in State/National level Exhibitions, Melas, Kisan Gosthies, mass communication through AIR & TV programmes, replying letters, telephones, e-mails and on the spot guidance during farm visits. Almost all the Centres conducted training programmes of different durations for farmers, farmwomen, unemployed youths and the entrepreneurs of their areas.

ABBREVIATIONS

AICRPM	- All India Coordinated Research Project on Mushroom
HP	- Himachal Pradesh
NRCM	- National Research Centre for Mushroom
UP	- Uttar Pradesh
ICAR	- Indian Council of Agricultural Research
UGC	- University Grants Commission
DSR	- Days taken for Spawn Run
sq. ft.	- Square Feet
Rs.	- Rupees
TNAU	- Tamil Nadu Agricultural University
Govt.	- Government
R & D	- Research and Development
MT	- Metric Tons
%	- per cent
m. ha.	- Million Hectare
C.G.	- Chhattisgarh
kg	- kilo gram
spp.	- species
viz.	- namely
IGAU	- Indira Gandhi Agricultural University
g	- gram
i.e.	- that is
FYM	- Farm Yard Manure

h - hour

@ - at the rate

EDTA - Ethylene di-amine tetra acetic acid

ppm - parts per million

KMS - potassium meta bisulphate

PP - polypropylene

PE - polyethylene

K_2HPO_4 - Di-potassium Hydrogen Phosphate

LMC - Long Method Compost

DDVP - Dichlorvos (Nuvon)

°C - degree Celsius

BE - Biological Efficiency

DCSR - Days for Spawn Run

MEA - Malt Extract Agar

pH - Hydrogen ion concentration

cm - centimeter

q - quintal

“ - inch

etc. - etcetera

Fig. - Figure

N - Nitrogen

m^2 - Square meter

DAS - Days After Sowing

P - phosphorous

K - potassium

C/N ratio - Carbon to Nitrogen ratio

CO_2	- carbon dioxide
BHC	- Benzene Hexa Chloride
IPM	- Integrated Pest Management
KVK	- Krishi Vigyan Kendra
CD	- Compact Disc
T.V.	- Television
Ph.D.	- Doctor of Philosophy
M.Sc.	- Master of Science
ODL	- Open Distance Learning
HARP	- Horticulture and Agro forestry Research Programme
DBT	- Department of Biotechnology
NSS	- National Social Service
NHB	- National Horticultural Board
min	- minute
M.P.	- Madya Pradesh
NGO	- Non Governmental Organisation
IFFCO	- Indian Farmers Fertilizer Cooperative Organisation
MHS	- Mushroom Hitgrahi Sangh
VHSE	- Vocational Higher Secondary Examination
PAU	- Punjab Agricultural University
<	- lesser than
>	- greater than
SHG	- Self Help Group
BPL	- Below Poverty Line

1. ALL INDIA COORDINATED RESEARCH PROJECT ON MUSHROOM : AT A GLANCE

1.1. Genesis and Network

The All India Coordinated Research Project on Mushroom (AICRPM) came into existence during VIth Five-Year Plan on 01.04.1983 with its Headquarters at National Research Centre for Mushroom, Solan (HP). The Director of NRC for Mushroom, Solan (HP) also functions as the Project Co-ordinator of the project. Initially the AICRPM started with six Centres one each at Punjab Agricultural University, Ludhiana (Punjab), G.B.Pant University of Agriculture and Technology, Pantnagar (Uttarakhand), 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 (Chhattisgarh) was added and two existing Centres at Kanpur (UP) and Kalyani (West Bengal) were dropped. However, three new Centres during VIIIth Five Year Plan and 3 Co-ordinating and one co-operating Centre during IXth Five Year Plan were added to the existing list of Centres by dropping one at Goa. At present, 10 Co-ordinating and one co-operating Centres are working under AICRPM programme with its Headquarters at NRCM, Solan (Table 1).

All the Co-ordinating Centres and HQrs. at NRCM, Solan work in co-ordination on common objectives and mandate. The technical programme for conducting participatory research at all the Centres and the HQrs. is finalized in a biennial workshop organised at any of the Centre or HQrs. During the biennial workshop the progress reports for the previous years are presented and discussed to monitor the progress made in the project during the previous years. The technologies generated are also assessed for their release and adoption at all India level.

Table 1: Details of Centres under AICRP on Mushroom

Location (Institute/University)	Latitude/Longitude	Year of establish-ment	Current status
Headquarters			
Solan, PC, NRCM, Solan (HP)	30° 55" 0' N, 77° 7" 0' E	1983	Continued
Coordinating Centres			
· Punjab · Punjab Agricultural University, Ludhiana	30° 41' 15" N, 76° 1' 45°E	11.01.1984	Continued
· Tamil Nadu · Tamil Nadu Agricultural University, Coimbatore	10° 59' 47" N, 76° 57' 40" E	01.04.1983	Continued
· Uttarakhand · G.B. Pant University of Agriculture and Technology, Pantnagar	29° 3' 0" N, 79° 31' 0" E	4.10.1984	Continued
· Weat Bengal · Bidhan Chandra Krishi Vishwa Vidyalaya, Kalyani	22° 59' N, 88° 28' E	01.04.1983	Closed w.e.f. 01.04.1990
· Uttar Pardesh · C.S. Azad University of Agriculture & Technology, Kanpur	26° 28' N, 80° 21' E	12.10.1984	Closed w.e.f. 1986
· Maharashtra · Mahatma Phule Agricultural University, Pune	18° 32' N, 73° 51'E	22.08.1983	Continued
· Uttar Pradesh · N.D.University of Agriculture and Technology, Faizabad	26° 31' 0"N, 82° 35' 0" E	01.10.1993	Continued
· Chhattishgarh · Indira Gandhi Krishi Vishwa Vidyalaya, Raipur	17° 48N and 24°5N 80° 15-84°20E	1.03.1988	Continued
· Rajasthan · Maharana Pratap University of Agriculture and Technology, Udaipur	24° 36' 16" N, 73° 49' 6" E	17.09.1993	Continued

Location (Institute/University)	Latitude/Longitude	Year of establish-ment	Current status
· Goa · ICAR Research Complex, Goa	15° 30' N, 73° 48' E	not initiated	Closed
· Kerala · Kerala Agricultural University, Thrissur	80° 18' and 120° 48' N, 740° 52' and 770° 22' E	4.09.2000	Continued
· Megalaya · ICAR Research Complex for NEH Region, Barapani	25° 34' 16" N, 91° 53' 48" E	4.09.2000	Continued
· Jharkhand · Horticulture and Agroforestry Research Programme (ICAR Research Complex for Eastern Region), Ranchi	22° 58' 0" N, 85° 32' 0" E	4.09.2000	Continued
· Himachal Pradesh · Dr.Y.S.Parmar University of Horticulture & Forestry, Nauni, Solan – Co-operating Centre	30° 55" 0' N, 77° 7" 0' E	4.09.2000	Continued

1.2. Mandate and Objective

The mandate of AICRP (Mushroom) is to coordinate and monitor multilocation trials with improved mushroom varieties / hybrids, cultivation practices related to crop production, crop protection measures and post harvest technology, all aimed at increasing production, productivity and utilization of mushroom in the country. Major activities under the project are:

1. To conduct survey of naturally occurring wild mushrooms with a view to identify and catalogue the edible species as well as for exploring the possibilities of domistication of promising strains.
2. To evaluate the promising and high yielding strains received from NRCM stock for regional adaptability.
3. To carry multi-locational trials for finalization of standard production techniques for increasing yield of different edible mushrooms.
4. To explore possibility of selection of cheaper agro-waste available locally for substrate, compost and casing.
5. To supply good quality spawn to the mushroom growers.
6. Popularization of mushroom cultivation on large scale through training.

1.3. On-Going Experiments

I. CROP IMPROVEMENT

Experiment	Location
Imp. 1: Wild germplasm collection, identification and conservation	Pune, Pantnagar, Solan, Udaipur, Ludhiana, Faizabad, Coimbatore, Raipur, Vellayani, Ranchi, Barapani
Imp. 2: Testing of different strains of white button mushroom, *Agaricus bisporus*	Pune, Pantnagar, Solan (Pasteurized compost), Udaipur, Ludhiana, Faizabad (Long method compost)
Imp. 3: Strain evaluation of milky mushroom, *Calocybe indica*	Pune, Pantnagar, Solan, Udaipur, Ludhiana, Faizabad, Coimbatore, Raipur, Vellayani, Ranchi, Barapani
Imp.4: Strain evaluation of paddy straw mushroom, *Volvariella volvacea*	Ludhiana, Faizabad, Coimbatore, Raipur, Vellayani, Ranchi, Barapani
Imp. 5: Strain evaluation of oyster mushroom (*Pleurotus sajor-caju* and *Pleurotus florida*)	Faizabad, Udaipur, Raipur, Vellayani, Ranchi, Barapani
Imp. 6: Evaluation of the yield potential of *Pleurotus fossulatus*	Faizabad, Ludhiana, Udaipur, Raipur, Pantnagar, Ranchi, Barapani

II. CROP PRODUCTION

Experiment	Location
1. Button mushroom	
Prod. 7: Isolation and identification of thermophilic microorganisms from white button mushroom compost from different locations for their exploitation in rapid composting process	Pune, Pantnagar, Solan, Udaipur, Ludhiana, Faizabad
Prod. 8: To test different locally available agro-industrial waste for their feasibility as casing material	Pune, Solan, Udaipur, Ludhiana
2. Oyster mushroom	
Prod. 9: Effect of chemical sprays on yield of *Pleurotus* spp.	Pune, Pantnagar, Solan, Udaipur, Ludhiana, Faizabad, Coimbatore, Raipur, Vellayani, Ranchi, Barapani

Experiment	Location
Prod. 10: Evaluation of the yield potential of blue oyster mushroom (*Hypsizygus ulmarius*) on different substrates	Pune, Pantnagar, Solan, Udaipur, Ludhiana, Faizabad, Coimbatore, Raipur, Vellayani, Ranchi, Barapani
3. Paddy straw mushroom	
Prod. 11: Cultivation of paddy straw mushroom, *Volvariella volvacea*	Ludhiana, Faizabad, Coimbatore, Raipur, Vellayani, Solan, Barapani
4. Milky Mushroom	
Prod. 12: Cultivation of milky mushroom, *Calocybe indica*	Ludhiana, Faizabad, Pune, Raipur, Udaipur, Pantnagar, Vellayani, Ranchi
5. Shiitake Mushroom	
Prod. 13: Cultivation of shiitake mushroom, *Lentinula edodes*	Udaipur, Pantnagar, Coimbatore, Raipur, Pune, Ludhiana, Solan

III. POST HARVEST TECHNOLOGY

Experiment	Location
Pht. 14: Washing treatment for button mushroom, *Agaricus bisporus*	Pune, Pantnagar, Solan, Udaipur, Ludhiana, Faizabad
Pht. 15: Packaging for button mushroom, *A.bisporus*	Pune, Pantnagar, Solan, Udaipur, Ludhiana, Faizabad
Pht. 16: Drying of oyster mushroom, *Pleurotus* spp.	Ludhiana, Udaipur, Coimbatore, Raipur, Vellayani, Ranchi
Pht. 17: Drying of milky mushroom, *Calocybe indica*	Pune, Pantnagar, Udaipur, Ludhiana, Faizabad, Coimbatore, Raipur, Vellayani, Ranchi, Barapani

IV. CROP PROTECTION

Experiment	Location
Prot. 18: Survey and Surveillance of diseases and insect-pests in mushroom farms in different regions	Pune, Pantnagar, Udaipur, Ludhiana, Solan, Faizabad, Coimbatore, Raipur, Vellayani, Ranchi, Barapani

1.4. Man Power and Financial Details

The sanctioned financial outlays for different Centres during various plan periods are given in Table 2.

The sanctioned staff positions in various categories at different Centres under AICRP (Mushroom) during various plans are depicted in Table 3. Currently there are 16 scientific, 12 technical, 7 administrative and 9 supporting staff positions at various Centres.

1.5. Mechanism for Evaluation of Project Activities

Activities of the project are monitored through the visits of the Project Coordinator. Workshops/ Group meetings of AICRPM scientists are held regularly to discuss progress made under the project. During these meetings recommendations for release of varieties, cultivation technologies, and crop protection measures are brought out. Based on the previous results and keeping in view the

Table 2: Plan wise budget (lakhs) allocation for different Centres

Head	VI plan	Ad-hoc plan 1990-91	VII plan	VIII plan	IX Plan	X plan
Pay & allowances	3.58	9.86	25.90	89.75	200.00	318.93
Traveling allowance	0.15	0.26	1.50	2.54	4.55	6.32
Recurring contingencies	1.65	1.18	6.70	17.16	40.86	18.63
Equipments	5.87	0.80	4.95	6.65	21.19	6.12
Works	-	1.78	8.50	17.20	15.55	-
Total	11.25	13.88	47.55	133.30	282.15	350.00

Table 3: Centre-wise manpower at different Centres

Name of the Centre	Sanctioned positions in different categories			
	Scientific	Technical	Administrative	Supporting
Ludhiana	2	1	1	2
Pune	2	1	1	2
Coimbatore	2	2	1	1
Faizabad	2	2	1	1
Pantnagar	2	2	1	1
Raipur	2	1	1	1
Udaipur	2	2	1	1
Vellayani	2	1	-	-

emerging problems, new technical programmes are also worked out in these meetings. Since the inception of the project, 10 workshops/ Group meetings have been held in such a manner that venues are evenly distributed through out the country (Table 4).

Table 4: Workshops/ Group Meetings of AICRPM

Workshops/ Group Meetings of AICRPM	Date	Venue
Ist biennial Workshop of AICRP on Mushroom	September, 23-25, 1986	National Centre for Mushroom Research and Training, Chambaghat, Solan
IInd biennial Workshop of AICRP on Mushroom	February, 12-13, 1988	College of Agriculture, Pune
IIIrd biennial Workshop of AICRP on Mushroom	December, 18-19, 1989	National Centre for Mushroom Research and Training, Chambaghat, Solan
IVth biennial Workshop of AICRP on Mushroom	December, 27-28, 1991	Tamil Nadu Agricultural University, Coimbatore
Vth biennial Workshop of AICRP on Mushroom	April, 11-12, 1994	National Centre for Mushroom Research and Training, Chambaghat, Solan
VIth biennial Workshop of AICRP on Mushroom	December, 29-30, 1997	Rajasthan College of Agriculture, Udaipur
VIIth biennial Workshop of AICRP on Mushroom	May, 2000	National Research Centre for Mushroom, Chambaghat, Solan
VIIIth biennial Workshop of AICRP on Mushroom	March, 8-9, 2002	Tamil Nadu Agricultural University, Coimbatore
IXth biennial Workshop of AICRP on Mushroom	October, 25-26, 2004	National Research Centre for Mushroom, Chambaghat, Solan
Xth biennial Workshop of AICRP on Mushroom	October, 26-27, 2006	Indira Gandhi Krishi Vishwa Vidyalaya, Raipur

2. HISTORY OF AICRPM CENTRES

2.1. Ludhiana Centre

The work on mushroom research and development in the Department of Microbiology was initiated in early 1970's under an ICAR funded ad-hoc project which was further supported by a State funded "Research and Development project" in 1979. Subsequently w.e.f. 1.4.1983 the Department of Microbiology, Punjab Agricultural University, Ludhiana was selected as one of the Coordinating Centres (sanction no. ICAR NE19 (1) HSMC dated 29.10.1982) of the All India Coordinated Research Project on Mushroom with financial implication in the ratio of 75:25 (ICAR: Punjab State Government). Presently, the work carried out under AICRPM is being complemented by additional funding in the form of many ad-hoc projects funded by ICAR, UGC, DSR and self supporting. Mushroom production is the only state of the art economically viable solid state fermentation process to utilize the crop residues with an ability to provide high protein food, employment and improvement in the economic standards. Currently the mushroom production in the state is revolving around 68,000 tonnes per year.

2.2. Pune Centre

Maharashtra is the second largest state of the country with wide diversity in climatic conditions and soil types favouring the cultivation of various field crops. Research on different aspects of mushroom cultivation was initiated as early as in 1972 at College of Agriculture, Pune. In recognition of the pioneering research work on mushroom, the ICAR, New Delhi sanctioned 6th AICRPM Centre to College of Agriculture, Pune in 1983 (Fig.1). The Centre was sanctioned vide ICAR letter No.F-19(+) MC, dated 23rd Oct., 1982 and it actually started functioning on 22.08.1983. The funds for independent building and infrastructural facilities were received from VIIth five year plan. At present, few farms of button mushroom have come in operation in Pune, Nashik, Sangli, Thane and Akola districts of Maharashtra.

Oyster mushroom, locally known as "Dhingri" is now very popular among the common people mainly because of its simple cultivation technique and less investment. The popularity of the milky mushroom is also increasing among the growers and its major demand is in Mumbai and Pune cities. Many growers have successfully started growing of milky mushroom in the state.

Fig. 1. AICRPM Centre, Pune

A total of 72 research experiments have been conducted under AICRPM, since 1983 to till date. Of which, 29 experiments were on button mushroom; 24 experiments on oyster mushroom; 9 experiments on black ear, milky, paddy straw and shiitake mushrooms; 3 on germplasm collection and survey; 5 experiments on post harvest management and 2 experiments on survey an surveillance of insect-pests and diseases of mushrooms. The various equipments and infrastructure facilities developed at the Centre are listed below:

- The Mushroom Project Building in College of Agriculture, Pune Centre was completed in February, 1988 having total built up area of 1250 sq. ft., costing Rs. 2,72,558/-.
- A training hall cum dhingri house measuring around 400 sq.ft. was constructed in the year 1995-96 costing of Rs. 79,000/-.
- A bulk chamber for compost pasteurization was constructed during 2001-02 costing Rs. 2,15,000/- (Fig. 2).
- A mini boiler of 50 kg steam/h capacity with total cost of Rs.49,400/- was purchased in 1995-96 and water softner for the boiler costing Rs.17,000/- was purchased in 1996-97.
- Different equipments worth Rs. 3.99 lakhs were purchased during 1999-2004 (Fig. 2).

Fig. 2. Research Facilities at AICRPM Centre, Pune

2.3. Coimbatore Centre

With the sustained research, teaching and extension activities of the Department of Plant Pathology at TNAU, mushroom cultivation has become one of the promising agricultural enterprises in Tamil Nadu since 1983. A mushroom theme park was established during 2002 and a new building for Mushroom Research and Training has been established during 2006 with a total cost of Rs. 26 lakhs.

2.4. Ranchi Centre

The research and training in mushroom production at this Centre started in 2001 with a grant from Central Sector Scheme on Integrated Development of Horticulture by Ministry of Agriculture, Govt. of India. Consequently a spawn laboratory was established for supplying mushroom spawn to the mushroom growers. At a later stage regular Coordinated Centre of AICRPM was sanctioned with an aim to carry out location specific trials on mushroom cultivation in Jharkhand.

2.5. Pantnagar Centre

Mushroom research at G.B. Pant University of Agriculture & Technology, Pantnagar was initiated in mid-seventies in the Department of Plant Pathology with a state financed 'Mushroom Development Project'. Later, a regular Coordinated Centre of All India Coordinated Research Project on Mushroom was sanctioned in 1982 which started functioning from October, 1984. Creation of Centre laid foundation of systematic research on mushrooms at Pantnagar. Mushroom Research Laboratory

building constructed and equipped from the financial assistance of ICAR was formally inaugurated on 26th January 1989. It was further strengthened by the University and named as Mushroom Research and Production Centre in the year 1998. Later on with the addition of training unit, composting unit, a new research lab, class room, museum etc., it was renamed and recognized as Mushroom Research and Training Centre on April 05, 2003 by the Board of Management of the University. The Centre is designed to provide R & D support for mushroom development programmes of the Nation and the state in particular.

Presently, this Centre has a museum for display of different technologies, committee room to organize seminars and meetings, class room and demonstration rooms to impart trainings to students and mushroom growers, four experimental and one pilot scale technology testing cropping rooms, research laboratories, well equipped spawn and composting units for spawn and compost supply to the mushroom growers.

Museum: The Centre has a museum (Fig. 3), where all the activities of Centre are illustrated with the help of photographs, charts and nearly 200 dried and wet specimens of wild and cultivated mushrooms. Besides, the Centre provides video film, photographs, coloured slides and literature on cultivation technologies of different mushrooms on payment basis.

Fig. 3. Mushroom museum at Pantnagar

Culture and Spawn Unit: Pure cultures of cultivated mushrooms are made available to researchers and

Fig. 4. Spawn unit at Pantnagar

spawn producers on payment basis. The Centre's commercial spawn production unit (Fig. 4) sales master as well as commercial spawn of different strains of the cultivated mushrooms on advance booking.

Composting Unit: The Centre has a well equipped compost pasteurization unit (Fig. 5) for production of pasteurized compost. As per the requirement of researchers and mushroom growers, the supply of pasteurized compost is ensured on prior booking basis. Composting unit is comprised of a straw storage shed, pre-wetting platform, out door composting shed, two pasteurization tunnels each of 10 MT ready compost capacity, spawning room and boiler.

Cropping Rooms: Four experimental cropping rooms (Fig. 6), one pilot scale testing cropping room and two low cost mushroom production rooms (huts) are available for conducting trials under varied conditions.

Committee and Class Rooms: The Centre has adequate training facilities, which include a committee room with modern audio-visual gadgets. It also has a classroom of 40 seats capacity for the training courses (Fig. 7).

2.6. Faizabad Centre

Mushroom research and teaching was started at N.D. University of Agriculture & Technology, Faizabad during 1980-

Fig. 5. Composting unit at Pantnagar

Fig. 6. Cropping rooms at Pantnagar

Fig. 7. Committee room and classroom at AICRPM Centre, Pantnagar

81 as per state government plan. The Coordinated Centre of AICRP on mushroom (AICRPM) was sanctioned and implemented during 1993-94 and a well equipped spawn laboratory was established during 2003-04 (Fig. 8). Since then research, teaching and extension work has been carried out as per the AICRPM mandate.

2.7. Raipur Centre

The Coordinating Centre of All India Coordinated Research Project on Mushroom was established in the Department of Plant Pathology, College of Agriculture, Indira Gandhi Agricultural University, Raipur on 1st March, 1988 as the 8th Centre of AICRPM (Fig. 9). The

Fig. 8. Facilities at AICRPM Centre, Faizabad

entire Chhattisgarh region is comprised of three agroclimatic zones i) Chhattisgarh plains ii) Northern hill region iii) Bastar plateau which fall under the jurisduction of Indira Gandhi Agricultural University, Raipur.

Chhattisgarh is the third largest state of India having maximum forest area of 46 per cent. The forests are predominantly inhabited by tribles, whose livelihood depend on forest produce and mushroom being one of them. They collect the mushrooms from these forest areas for self consumption and sale in local village, town and cities. They mainly collect and consume the species of *Termitomyces, Boletus, Volvariella, Tuber, Cantharellus* etc. Survey conducted from 1988-1997 revealed that *Volvariella diplasia* grows in every village naturally in paddy straw stacks kept in the field. During favourable period of the year, about 5 quintals of fresh *Termitomyces* spp. per day is being sold in the Raipur market alone.

Chhattisgarh state also considered as "rice bowl", is mainly dominated by rice and 80 % of the area (4 m.ha.) is under rainfed rice system. As a result of which, about 50 lakh tons of paddy straw is produced every year. Mushroom cultivation in environment friendly low-cost mushroom huts can help to earn subsistence to a large population of the state during off season. A systematic work on mushroom cultivation (mainly Oyster mushroom) was taken up only after the establishment of Centre under All India Coordinated Research Project on Mushroom at Indira Gandhi Agricultural

Fig. 9. AICRPM Centre, Raipur

University, Raipur during 1988. During the last 20 years efforts have been made to spread awareness about mushrooms and for that mushroom cultivation has been demonstrated in villages with the help of Women and Child Welfare and Forest departments of Chhattisgarh state. Till date about 1000 rural women from Raipur district alone have been trained on mushroom production technology. Recently, a commercial unit for oyster mushroom production named as "Chhattisgarh Mushroom" with a capacity of 90 kg fresh mushroom per day has been established at Tendua 29 km from Raipur. Thus, mushroom production technology has started gaining momentum in this part of the country and has led to employment and subsidiary income generation mainly in rural areas of the state. About 15 mushroom spawn production units have been established in different parts of the state which are fulfilling the requirements of mushroom spawn.

2.8. Vellayani Centre

The Indian Council of Agricultural Research sanctioned the Coordinated Centre of AICRP on Mushroom at Vellayani in January, 2001. Since then regular trials chalked out by the Co-ordinator and team are being conducted at the Centre. Initailly Dr. B. Balakrishnan started the work as the Principal Investigator but later on it was taken over by Dr. Lulu Das in January 2006.

2.9. Barapani Centre

The Centre at Barapani, Meghalaya came in existence during ninth plan considering the availability of rich biodiversity in the area and great scope of mushroom cultivation. Being an ICAR institute no separate posts were kept for running of the Centre, however, funds were given in the form of contingency only to meet the day to day requirement.

2.10. Udaipur Centre

The Centre came in existence during the 8th five year plan with a full fledged man power and budget (Fig. 10). The Centre has developed good facilities with respect to training and experimentation on different mushrooms. The strategic location of the Centre has helped in developing cultivation technology of oyster and milky mushroom, and a large quantity of germplasm has been collected and preserved over the time.

Fig. 10. AICRPM Centre at Udaipur

2.11. Nauni Centre

The Centre at Nauni, Solan came in existence during ninth plan as a cooperating Centre. Manpower and budget was restricted to only the contingency support considering the availability of the infrastructure and the trained manpower at the Centre. The mushroom research at the Centre started in early 70's and over last 4 decades very high level of research outputs have come out from this Centre.

3. GENETIC RESOURCES

3.1. Ludhiana Centre

Surveys were conducted during different seasons at multiple locations in and around Punjab state and the fleshy mushroom fungi were collected. The various mushroom species collected were *Agaricus* (34), *Agrocybe* (3), *Arrhenia* (1), *Bolbitius* (4), *Calvatia* (2), *Clitocybe* (1), *Conocybe* (1), *Coprinus* (13), *Cyathus* (1), *Geaster* (1), *Lepiota* (1), *Leucocoprinus* (1), *Lycoperdon* (1), *Morchella* (2), *Mycena* (1), *Pleurotus* (4), *Psathyrella* (3), *Psilocybe* (1), *Sphaerobolus* (1), *Stropharia* (1), *Termitomyces* (3), *Tricholoma* (1), *Tulostoma* (9) and *Volvariella* (4). The mushroom germplasm collected at Ludhiana Centre is listed in Table 5.

Table 5: Germplasm collection at Ludhiana Centre

Genus	Species	Strain	Accession
Agaricus	*bisporus*	33	MTCC
	bitorquis	1	MTCC
Pleurotus	*sajor-caju*	14	ATCC/MTCC
	ostreatus	11	ATCC/MTCC
	florida	10	ATCC/MTCC
	flabellatus	7	ATCC/MTCC
	cystidiosus	3	MTCC
	citrinopileatus	3	MTCC
	sapidus	2	ATCC/MTCC
	eryngii	2	MTCC
	fossulatus	1	ATCC/MTCC
	pulmonarius	1	MTC
	platypus	1	-
	salmoneo stramineus	1	-
Volariella	*volvacea*	7	ATCC/MTCC
	diplasia	1	ATCC

Genus	Species	Strain	Accession
Calocybe	*indica*	10	-
Auricularia	*polytricha*	1	-
Morchella	*esculenta*	1	MTCC
Hypsizygus	*ulmarius*	1	-
Lentinula	*edodes*	2	-
Ganoderma	*lucidum*	4	-

Total number of 117 strains pertaining to 9 genera and 22 species were identified out of which 64 strains have already been accessioned. The cultures are maintained through regular subculturing and are being cryopreserved using glycerol/DMSO as the cryo protectant in liquid nitrogen.

3.2. Pune Centre

Mushroom species *viz., Pholiota, Lepiota, Chlorolepiota* and *Termitomyces* were collected from Lonawala, Igatpuri, Mahabaleshwar, Nashik and Goa (Fig. 11) and pure cultures were isolated. About 140 specimens of wild fleshy fungi were collected from different parts of western Maharashtra and identified upto generic levels.

Fig. 11. Survey and collection of wild fungi by Pune Scientists

The following mushroom cultures are being maintained at the Centre:

- *Agaricus bisporus*: P-1, U-3, S-11, CM-1 to CM-15, S-130, N-210, N-211 and N-560
- *Agaricus bitorquis*: NCB-6 and NCB-13
- *Pleurotus* spp.: *P. sajor-caju, P. florida, P. eous, P. citrinopileatus, P. ostreatus, P. eryngii, P. sapidus, P. membranaceous* and Blue oyster *(Hypsizygus ulmarius)*–CO-2

- Milky mushroom (*Calocybe indica*): CI-1 to CI-9 and APK-2
- Shiitake mushroom (*Lentinula edodes*): LS-5 and LE
- Paddy straw mushroom (*Volvariella volvacea*): PS-2
- Wild fleshy fungi cultures: 23 (FFP-1 to FFP – 23)

The following mushroom cultures were deposited at NRCM, Solan:

- FFP-1-OE-299-*Termitomyces* spp.
- FFP-2-OE-300- *Agaricus* spp.
- FFP-6-OE-301- *Tricholoma* spp.
- FFP-7-OE-302- *Agaricus* spp.
- FFP-15-OE-303-*Panaeolus* spp.
- FFP-23-OE-304-*Ganoderma* spp.

3.3. Coimbatore Centre

Tamil Nadu state has a great potential for collection of different newer species of wild mushrooms because of its proximity to the Western Ghats and Bay of Bengal, its subtropical/tropical agro climatic conditions and large forest covered area.

A total number of 120 fleshy fungi were collected during the survey. Among them one each of *Agaricus bisporus, Ganoderma lucidum, Schizophyllum* spp., *Lycoperdon* spp., *Auricularia polytricha, Tricholoma gigantea, Hypsizygus ulmarius, Pleurotus florida, P. ostreatus, P. cystidiosus, P. eous, P. platypus, P. djamor, P. flabelatus, Lentinula edodes, L. connatus, A. bitorquis, Termitomyces, Amanita* spp., *Fomes* spp., *Auricularia polytricha, Polyporus* spp., three isolates of *Calocybe indica* and three isolates of *Volvariella volvacea* were pure cultured and maintained in the germplasm bank of Mushroom Research and Training Centre, TNAU, Coimbatore.

The pure cultured mushroom cultures were tested for their bioefficiency and nutritional status and by continuous research, varieties were released for the benefit of the farmers from time to time. Among these cultures the *Volvariella volvacea* strain PS-1 and WC-19 strain of *Calocybe indica* are under multi location testing for their release as variety for commercial production.

3.4. Pantnagar Centre

Uttarakhand is gifted with rich flora of mushrooms. Under AICRP (Mushroom), surveys were conducted in the forest areas to collect the natural mushroom flora. Some of the fleshy fungi collected at Pantnagar Centre are listed in Table 6.

Of the collected mushroom species, five isolates of *Auricularia,* two species of *Pleurotus* and ten isolates of *Ganoderma lucidum* have been brought under cultivation. A total of 150 mushroom specimens from different locations of Uttarakhand have been collected and preserved.

Table 6: Fleshy fungi collected at Pantnagar Centre

Mushroom species	Mushroom species	Mushroom species
Agaricus silvaticus	*Daldinia concentrica*	*Auricularia* spp. (from silver oak)
Amanita phalloides	*Daedalea confragosa*	*Auricularia* spp. (from silver oak)
Amanita spp.	Earth Ball	*Auricularia* spp. (big size)
Auricularia spp.	*Ganoderma lucidum*	*Auricularia* spp. (small size)
Boletus edulis	*Ganoderma* spp.	*Auricularia* spp. (from mango tree)
Boletus spp. (brown)	*Geastrum* spp.	*Russula delica* (white colour)
Boletus spp. (light cream)	Puff Ball (big size)	*Geastrum triplex* (earth star)
C. lagopus	Puff Ball (small size)	*Grifola* spp. (mandarin colour)
Calocera viscose	*Grifola sulfurea*	*Pleurotus cystidiosus* (2 isolates)
Cantharellus spp.	*Grifola* spp. (white)	*Pleurotus djamor* (dark pink)
Clavulina spp.	*Grifola* spp. (orange white)	*Pleurotus djamor* (light pink)
Clitocybe spp.	*Hericium erinaceus*	*Pleurotus* spp. (creamy-white)
Clitopilus spp.	*Leptonia sericella*	*Pleurotus* spp. (off-white)
Collybia confluens	*Lycoperdon pyriforme*	*Pleurotus* spp. (funnel shaped)
Coltricia perennis	*Lycoperdon* spp. (white)	*Scleroderma* spp.
Coltricia spp.	*Melanoleuca* spp.	*Scleroderma* spp. (black spored)
Coprinus comatus	*Morchella esculenta*	*Scleroderma* spp. (dark grey spored)
Coral fungi	*Nyctalis parasittica*	*T. edista*

Mushroom species	Mushroom species	Mushroom species
Cordyceps sinensis	*P. smithii*	*Termitomyces* spp.
Coriolus spp.	*Russula* spp. (brown+ purple)	*Trametes confragosa*
Coriolus versicolor	*Russula* spp. (green colour)	*Tricholoma* spp.
Daedalea spp.	*Russula* spp. (grey colour)	*Tricholoma sulphureum*
Hericium spp.	*Schizophyllum commune*	*Tuber*
Hydnum spp.	*Ramaria cristata*	*Volvariella diplacia*
Hygrophorpsis spp.	*Russula atropurpurea*	*Volvariella volvacea*
Laccaria omethystea	*Russula foetens*	*Xylaria polymorpha* (dark grey and hard)
Lactarius blennis	*Russula lutea*	*X. polymorpha* (grey-white)
Lactarius deliciosus	*Russula nigricans*	*Xylaria* spp. (black colour)
Lactarius rufus	*Russula* spp. (red colour)	*Xylaria* spp. (grey coloured and thin)
Lactarius spp.	*Russula* spp. (white)	*Polyporus* spp.
Lactarius tabidus	*Phellinus ignarius*	*Polyporus squamosus*
Lepiota margaoni	*Pleurotus cervinus*	*Lepiota rhachodes*

3.5. Udaipur Centre

A total of 400 species of wild fleshy fungi were collected during 1996- 2007 form different areas of Sawai Madhopur, Kota, Bundi, Sirohi, Banswara, Chittorgarh, Barmer, Jodhpur, Rajsamand, Sirohi, Pali, Dungarpur and Udaipur districts in rainy season. The specimens of wild mushrooms were preserved in dry form; their cultures along with database were deposited to NRCM, Solan. Some common species are *Agaricus* spp., *Pleurotus* spp., *Phellorinia inguinans, Podaxis pistillaris, Auricularia polytricha, Schizophyllum communae, Daldinia concentrica, Ramaria* spp., *Coprinus pieaceus, Polypore sulphureus, Tricholoma* spp., *Hericium erinaceum, Auricularia* spp., *Auricula judae, Pleurotus salmoneo stramineus, Lepiota procera, Ganoderma lucidum, Xylaria polymorpha, Calocybe* spp.,

Lycoperdon spp., *Volvariella volvacea, Laitoporus* spp., *Inonotus hispidus, Hydnellum scrobiculatum, Polypore* spp., *Podaxis pistillaris, Phellinus igniarius, Piptoporus betulinus, Pluteus cervinus, Pleurotus ulmarius, Agaricus trisulphureus, Agaricus compestris, Tricholoma equestre, Sclaroderma citrinum, Leucocoprinus* spp., *Mycenia* spp., *Pisolithus* spp. and *Volvariella volvacea*.

3.6. Faizabad Centre

On this aspect work regarding maintenance of cultures of experimental use, and collection, culturing and supply of mushroom biodiversity has been done. A large number of naturally growing mushrooms were collected. The important among them were *Termitomyces* spp., *Volveriella volvacea, Pleurotus* spp., *Calocybe indica* and unidentified puffballs.

3.7. Raipur Centre

The climatic conditions prevailing in Chhattisgarh make it a natural habitat for a large number of mushroom flora. The detailed information pertaining to presence of natural agaric flora in different agroclimatic zones of Chhattisgarh started accumulating with the inception of All India Coordinated Research Project on Mushroom in 1988 at IGAU, Raipur. The various fleshy fungi collected till date at Raipur Centre are presented in Table 7.

Table 7: Fleshy fungi collected at Raipur Centre

Mushroom species	Habit and habitat	Season	Distribution	Type (edible/ non-edible)
Agrocybe erebia	Sporophore in groups on ground	Rainy season	Bilaspur	Non-edible
Agrocybe spp.	Sporophore in groups or scattered in soil	Rainy season	Bilaspur	Non-edible
Amanitopsis	Growing singly on leaf litter	Rainy season (August)	Barnavapara	Edible
Amanita citrina	Under shrubs	Rainy season	Bastar forest	Poisonous
Amanita spp.	Sporophore occurs on the soil under shrubs	Rainy season	Bastar forest	Not known

Mushroom species	**Habit and habitat**	**Season**	**Distribution**	**Type (edible/ non-edible)**
Armillaria mellea	Sporophore growing on deciduous stumps of dead trunk of tree	Rainy season	Raipur and Bilaspur	Non-edible
Astreatus hygrometricus (Boda)	Scattered on the soil, hypogeal mycorhizal association with root of sal tree	Rainy season (June - Oct.)	Forest area of Chhattisgarh	Excellent
Auricularia polytricha	Solitary or gregarious on dead wood and logs	Rainy season (June - Oct.)	Chhattisgarh	Edible
Auricularia spp.	On dead branches of mango, custard apple, subabool, gulmohar	Rainy season (June - Oct.)	Raipur	Edible
Boletus spp.	Sporophore solitary on sandy soil under dense shrubs	Rainy season	Uddanti and Barnawapara Wild life sanctuary of Raipur	Edible but not consumed by local people
Bovista appendicellata	Sporophore scattered on leaf litter under the shed of broad leaves trees	Rainy season (June - Oct.)	Bilaspur	Not known
Calocybe spp.	Sporophore solitary in soil under broad leaves trees	Rainy season (June - Oct.)	Ambikapur forest	Edible
Clavatia cyantiformis	Solitary or in groups on leaf litter of shrubs	Rainy season (June - Oct.)	Forest area of Korea District	Edible
Canthaerellus spp. (Bans phutu)	Sporophore in groups, mycorrhizal association with bamboo	Rainy season (August)	In all bamboo growing areas of Chhattisgarh	Edible
Clavaria fumosa	Sporophore grows in groups on the ground on fallen branches	Rainy season	Sitanadi Wild Life Sanctuary	Not Known

Mushroom species	**Habit and habitat**	**Season**	**Distribution**	**Type (edible/ non-edible)**
Clavaria spp.	On wood in scattered	Rainy season	Tirathgarh, Narayanpur	Non-edible
Clitocybe geostropa	Sporophore grows in groups on leaf litter under the shrubs	Rainy season	Tirathgarh, Chitrakut and other places of Bastar	Poisonous
Coprinus comatus (Shaggy cap)	Gregarious in grassland and road side	Rainy season	Chhattisgarh	Edible
Coprinus spp. (Ink cap)	Sporophore grows solitary or in groups on cow dung, damp soil, rotten paddy straw heaps	Rainy season	Chhattisgarh	Non-edible
Coriolus versicolor	On dead wood	Rainy season	Narayanpur	Medicinal or therapeutic value
Crepidotus spp.	Sporophore grows solitary or in groups on dead wood of broad leaves trees	Rainy season (August)	Teerathgarh	Not known
Cyathus limbatus	Sporophore grows solitary or in groups in open grass and same times in the soil	Rainy season	-	Not Known
Daldinia concentrica	Dead wood logs or live plants	Rainy season	Teerathgarh, Narayanpur forest area	Not Known
Flammulina spp.	On dead wood, mainly stumps	Rainy season	Teerathgarh, Barnawapara, Khajuri Nala and Uddanti Sanctuary	Edible

Mushroom species	Habit and habitat	Season	Distribution	Type (edible/ non-edible)
Ganoderma applanatum	Sporophore grows solitary or in groups on dead trunk of broad leaves tree	Rainy season	All forest areas of Chhattisgarh	Non-edible
Ganoderma lucidum	Sporophore grows solitary or in groups on dead trunk of broad leaves tree	Rainy season (July - Oct.)	All forest areas of Chhattisgarh	Non-edible
Ganoderma tsugae	Sporophore grows solitary or in groups	Rainy season	Ambikapur, Bastar and Bilaspur forest area	Non-edible
Geastrum fimbriatum (Earth stars)	Sporophore grows solitary or in groups in soil	Rainy season	Labhandi research farm	Non-edible
Hygrocybe marchee	Sporophore scattered on grass land	Rainy season	Churra, Gariabandh and Manpur area of Raipur	Not Known
Hypholoma udum	Sporophore grows in groups on the trunk of deciduous tree	Rainy season	Kevnchi, Lormi and Achanakmar forest	Not Known
Hypoxylon fragiforme	Normally gregarious on rooting beech, grow on wood, crust like stromata	Rainy season	Manpur, Sihava, Gariabandh forest	Non-edible
Laccaria laccata	From soil of mixed forest, sporophore in groups, singly or scattered	Rainy season	Chitrakut, Teeratgarh, Narayanpur	Edible
Lactarius acerrimus	Solitary or in groups under broad leaves trees	Rainy season	Narayanpur	Not known

Mushroom species	Habit and habitat	Season	Distribution	Type (edible/ non-edible)
Lactarius vellereus	Sporophore grows singly in scattered form under shrubs of broad leaves	Rainy season	Narayanpur	Not known
Lactarius spp.	Grows alone on leaf litter	Rainy season	Narayanpur	Not known
Lentinus spp.	Sporophore in bunches on dead wood logs	Rainy season	Korea	Edible
Lepista nuda	In humus rich ground under broad leaves shrubs	Rainy season	Achanakmar, Bilaspur	Good
Lycoperdon maximum	Sporophore solitary or scattered in grass land	Rainy season	Sandy loam soil	Edible
Marasmius oreades	Sporophore gregarious in grass land	Rainy season	Bastar forest	Edible
Melanoleuca alboflavida	Sporophore grows in soil or in leaf litter	Rainy season	Barnawa forest area	Non-edible
Microglossum viridae	On the ground in grass or woods	Rainy season	Narayanpur	Non-edible
Mutinus spp.	Sporophore in group under shade of old bamboo trees	Rainy season	Bamboo rhizomes near Bilaspur area	Poisonous
Panaiolima foenislcic	Gregarious in grassy areas	Rainy season	Achanakmar, Korea, Bilaspur	Non-edible
Phallorina spp.	Sporophore solitary or in groups on soil under the trees	Rainy season	Guru Ghasidas University, Bilaspur	Edible
Pleurotus florida (Pihri)	Sporophore grows solitary or in groups on mango logs	Rainy season	Narayanpur area	Edible
Pleurotus sajor-caju	Sporophore in groups on dead wood logs	Rainy season	Branches of mango trees	Edible

Mushroom species	**Habit and habitat**	**Season**	**Distribution**	**Type (edible/ non-edible)**
Pleurotus stramonius	Sporophore in groups on dead branches of mango	Rainy season	Raipur	Edible
Pleurotus spp.	Sporophore in groups on dry wood logs of trees	Rainy season	Bilaspur	Edible
Podbrella microcarpa	On soil in solitary or in groups	Rainy season	Nandghat, Bilaspur	Not Known
Podaxis spp.	Sporophore solitary and grows on sandy soil	Rainy season	Tarra village	Edible
Podoscypha mutzonata	Sandy loam in solitary	Rainy season	Nilanjee	Non-edible
Polyporus varius	Sporophore in groups on dead wood	Rainy season	All districts of Chhattisgarh	Not Known
Polyporus elegans	On dead wood	Rainy season	Bilaspur	Non-edible
Ramaria formosa	On wood logs of many trees	Rainy season	Narayanpur	Non-edible
Russula delica	Sporophore grows solitary or in groups under shade of forest shrubs	Rainy season	Chhattisgarh	Edible
Russula lepida	Under broad leaves trees in soil, scattered	Rainy season	Chhattisgarh	Edible
Russula aeruginea	In groups under sal forest	Rainy season	Chhattisgarh	Edible
Russula atropurpurea	Under broad leaves trees specialy in acidic soil	Rainy season	Bastar, Bilaspur	Edible
Russula mairei	Under shrubs or mixed forest	Rainy season	Achanakma, Barnawapara	Non-edible

Mushroom species	Habit and habitat	Season	Distribution	Type (edible/ non-edible)
Russula virginca	Under shrubs or mixed forest	Rainy season	Achanakma, Barnawapara	Edible
Rozites caperata	Under broad leaves trees on leaf litter	Rainy season	Korea, Manendragarh	Non-edible
Scleroderma verucosum (Dhela phutu)	Sporophore grows solitary or in groups in letrite soil	Rainy season	Labhandi farm	Edible
Scleroderma spp.	Sporophore grows singly or gregarious in the ground	Rainy season	Bastar	Edible
Stereum spp.	Sporophore on dead wood of broad leaves trees	Rainy season	Korea, Ambikapur, Pendra, Marvahi	Non-edible
Stropharia semiglobata	Sporophore grows on soil and either solitary or gregarious	Rainy season	Bilaspur, Ratanpur, Pali, Kathghora forest	Not known

3.8. Vellayani Centre

The cultures of strains of *Calocybe indica* were deposited in the National Mushroom Culture Bank at NRCM, Solan for which accession numbers were obtained. The other isolates of *Pleurotus eous*, *P. squarrosulus, Ganoderma, Schizophyllum, Termitomyces, Auricularia, Tricholoma* etc. are being preserved in the laboratory of the AICRP Centre, Vellayani (Fig. 12).

Fig. 12. Locally collected *Pleurotus* varieties at Vellayani

3.9. Ranchi Centre

The surveys were conducted during the monsoon season in Ranchi and Hazaribagh. The fleshy fungi listed in Table 8 were collected and wet preserved.

Table 8: Fleshy fungi collected at Ranchi Centre

Common Name	Scientific Name
Oyster mushroom	*Pleurotus* spp.
Bada Khukhri	*Macrolepiota* spp. *Termitomyces* spp.
Rugra	*Lycoperdon* spp.
Button mushroom	*Agaricus* spp.
Jamum Khukhri	*Boletus* spp.
Milky mushroom	*Calocybe* spp.
Medicinal mushroom	*Ganoderma* spp.
Namak Khukhri	*Termitomyces* spp.
Bansh Khukhri	*Lentinula* spp.
Pagla Khukhri	*Volvariella* spp.

4. REGION SPECIFIC MUSHROOM VARIETIES

4.1. Ludhiana Centre

At present, four mushroom varieties namely, *Agaricus bisporus, Calocybe indica, Pleurotus* spp. and *Volvariella* spp. have been recommended for round the year cultivation in the State . In addition, work on other mushrooms like, *Ganoderma lucidum*, *Hypsizygus ulmarius* and *Lentinula edodes* is also being undertaken.

4.2. Pune Centre

- *Pleurotus sajor- caju* followed by *P. florida* are the most suitable species of oyster mushroom for cultivation in Maharashtra during monsoon and winter season.
- *Agaricus bitorquis* strain NCB-6 could be successfully grown under natural conditions (22 to 26°C) during monsoon season under Pune conditions.
- Amongst different oyster mushroom species, *Pleurotus sajor- caju* has given the highest yield (84.6 kg/q dry substrate) followed by *P. florida*.
- In *Agaricus bisporus*, strains, P-1, NCS-12 (NCS-101), U-3, Pant-31, CM-9, CM-7 and CM-13 have shown higher yield potential in different evaluation trials. Till date strain, CM-9 with yield level of 18.63 kg/q compost has shown the highest potential followed by CM-7 (17.18 kg/q compost), P-1 (16.49 kg/q compost) and CM-13 (15.80 kg/q compost) (Fig. 13).

Fig. 13. Button mushroom crop raised at Pune Centre

- The temperature tolerant strains of *Agricus bitorquis,* NCB-6 and NCB-13 recorded the yield of 9.28

and 8.48 kg/q compost at ambient temperature conditions (22 to 26°C), respectively.

- Out of 9 strains of milky mushroom, only 5 strains fructify and of which strain, CI-1 recorded highest mushroom yield of 25.5 kg/q dry straw. Next best strain was CI-3 followed by CI-4 and CI-5.

4.3. Coimbatore Centre

The various mushroom varieties released by the Centre for the benefit of the mushroom growers of Tamil Nadu are listed in Table 9 and some of the oyster mushroom varieties released are shown in Figure 14.

Table 9: Varieties released by Coimbatore Centre

Mushroom	Colour	Strain	Year
Oyster mushroom, *Pleurotus citrinopileatus*	Pure white	CO-1	1986
P. eous	Pink	APK-1	1995
P. djamor	White	MDU-1	1996
P. flabellatus	White	MDU-2	2000
P. ostreatus	Ashy white	Ooty-1	1998
P. sajor-caju	Ash	M-2	1980
P. florida	White	PF	1989
Hypsizygus ulmarius	Bluish white	CO-2	2004
Milky mushroom, *Calocybe indica*	Milky white	APK-2	1998
Button mushroom, *Agaricus bisporus*	White	Ooty-1	2001

***Pleurotus florida*- PF**

***P. eous* - APK 1**

***Hypsizygus ulmarius* - CO2**

Fig. 14. Oyster mushroom varieties released by Coimbatore Centre

4.4. Pantnagar Centre

In Uttarakhand, three mushroom species are cultivated round the year by the growers . They are as under:

- Button mushroom (*Agaricus bisporus*) during the months of October-February.
- Oyster mushroom (*Pleurotus sajor-caju*) during the months of the February-April and August-October.
- Milky mushroom (*Calocybe indica*) during the months of April-June and July-September.

4.5. Faizabad Centre

Species and strains of different mushrooms performing better in eastern Uttar Pradesh conditions are mentioned below:

- *Agaricus bisporus* - CM-3, CM-13 and S-11 (Fig.15)
- *Pleurotus florida, P. sajor-caju, P. sajor-caju* hybrid strain-1 and *Hypsizygus ulmarius*
- *Calocybe indica* - strains CI-7, CI-6, CI-1 and APK-2 (Fig. 16)

Fig. 15. Button mushroom crop raised at Faizabad Centre

Fig. 16. Milky mushroom crop suiting to Faizabad conditions

- *Volvariella volvacea* - strains Vv-3, Vv-2, Vv-12 and Vv-8

4.6. Raipur Centre

Indira Gandhi Agricultural University, Raipur under All India Coordinated Research Project on Mushroom released a variety of

oyster mushroom (*Pleurotus florida*) NMS-7 strain as Indira Sweta (OM-1) in the year 2006 for commercial cultivation throughout the state of Chhattisgarh. The climatic conditions of Chhattisgarh state suit for the cultivation of oyster, milky and paddy straw mushrooms, as these mushroom varieties are easy to cultivate and need paddy straw substrate which is available in plenty. Button mushroom can also be grown but only for a limited period (winter) of the year. Collection of mushrooms from forest areas for their consumption is also very popular in the state.

4.7. Vellayani Centre

Ananthan, an interstock hybrid of *Pleurotus petaloides* developed at the AICRPM, Vellayani Centre was released by the Kerala State Government and is widely acclaimed by the mushroom growers of the state. A native strain of *Pleurotus florida* is giving excellent yield through out the year and is very popular among the growers (Fig. 17). Eight native sub species of *Pleurotus* have also been domesticated.

A tropical milky mushroom *Calocybe indica* has been identified to be well suited to Kerala and is

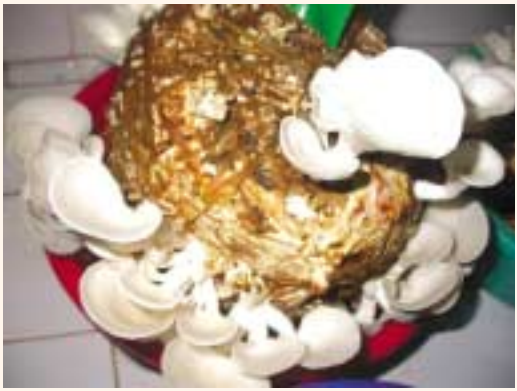

Fig. 17. *Pleurotus florida* crop at Vellayani Centre

rapidly gaining popularity. *Auricularia polytricha* can also be cultivated successfully using paddy straw and mango wood chips as the substrate. Paddy straw mushroom, *Volvariella volvacea* also carries excellent scope in Kerala, being having humid & tropical/sub-tropical climatic conditions.

4.8. Udaipur Centre

The subtropical and tropical varieties of mushrooms like oyster and milky mushroom are popular in the region. Button mushroom is also being grown but during very limited period of the year. There are some big farms that are growing button mushroom throughout the year by using environment controlled facilities. The region is rich in mushroom biodiversity and

collection and comsumption of wild mushroom is also common in the state.

4.9. Ranchi Centre

The area represented by the Ranchi Centre is rich in biodiversity and tropical and subtropical mushroom species are being grown in the area. The important mushroom species are *Pleurotus* spp., *Calocybe indica* and *Volvariella* spp. Button mushroom is not much popular in this region.

4.10. Barapani Centre

The area is again rich from biodiversity point of view and oyster, button and shiitake mushrooms are more popular. The area has great scope of mushroom cultivation considering varied type of agro-climatic conditions prevailing in the region.

4.11. Nauni Centre

The important mushrooms of the region are the button mushroom and oyster mushroom. Button mushroom is grown for 6 months under seasonal growing conditions and round the year under environment-controlled conditions. Oyster mushroom is grown from March to May and then October to December.

5. TECHNOLOGIES GENERATED

In order to enhance mushroom production in the country, continuous research efforts have been made on management practices through evolving newer formulations, supplementations, chemical sprays and the use of growth promoters. The mushroom productivity has also been increased through strain selection and their development using genetic techniques. As a result, different mushroom varieties are successfully cultivated round the year by the mushroom growers of different regions in India.

5.1. Button mushroom

- The highest yield of button mushroom (14.81 kg/q compost) was obtained from wheat straw based compost followed by soybean straw based compost (10.31 kg/q compost) at Pune.
- The use of coir pith alone as casing material gave highest button mushroom yield (13.62 kg/q compost) under Pune condition, followed by coir pith + FYM (1:1) (12.87 kg/q compost).
- The leaching of casing material for 16h gave higher button mushroom yield of 13.35 kg /q compost as compared to leaching of casing material for 8 h at Pune.
- At Pune, spraying of 0.2 % solution of calcium chloride on button mushroom beds gave higher button mushroom yield of 12.00 kg/q compost.
- Mixing of "Phosphotika" biofertilizer @ 0.5 & 1.0 % at the time of spawning in compost gave highest button mushroom yield of 12.51 kg/q compost in Maharashtra region. Strain U-3 showed better response with "Phosphotika" biofertilizer.
- The spray of 0.15% solution of Veradix-2 (rooting hormone, IBA) at pinning stage recorded higher button mushroom yield of 13.61 kg/q compost at Pune Centre.

- Strain, NCS-1 of *Agaricus bisporus* continued to be the best strain suitable to Coimbatore conditions (13.85 kg of fresh mushroom/q of compost).

- FYM + loam soil was found to be the best casing material in case of *A. bisporus* and *A. bitorquis* for Tamil Nadu region.

- Strain, S-11 of *Agaricus bisporus* yielded 10.17 to 10.84 kg of mushroom/q of paddy straw compost, prepared by LMC in Coimbatore region. It took 10 days for spawn run and 12 days for pinning.

- *A. bitorquis* (NCB-6) gave 10.6 kg of mushrooms/q of compost in paddy straw compost prepared by LMC under Coimbatore conditions.

- At Coimbatore, highest average fruiting body weight was recorded in strain, Pant-52 (12.74 g) followed by NCS-145 (12.69 g), U-3 (11.84 g), Pant-31 (11.50 g) and MS-30 (11.27 g).

- Compost prepared by using only wheat straw as base material was found better for Coimbatore conditions as compared to compost prepared with 1:2 combination of sugarcane bagasse and wheat straw. Highest number of fruiting bodies were also recorded in wheat straw compost, whereas average individual fruiting body weight was higher in sugarcane baggasse + wheat straw (1:2) based compost.

- Highest number of fruiting bodies were obtained in formalin + DDVP (15 ml + 0.5 g/10 kg compost) treated compost, followed by DDVP (15 ml + 0.5 g/10 kg compost) and bavistin alone (0.5 g/10 kg compost) over control at Coimbatore Centre.

- Highest button mushroom yield was obtained on casing the mycelial colonized substrate with the casing material prepared with FYM+spent compost+soil+ sand in the ratio 1:1:1:1, followed by FYM+burnt rice husk (1:10), vermi compost+ loam soil (1:1), spent compost and farm yard manure at Coimbatore Centre.

- Compost formulation with sugarcane baggase+wheat straw (2:1) resulted in reduced cost of cultivation of *Agaricus bisporus* under Pantnagar condition.

- Chemical treatment method of long method compost (Formalin 15 ml + Bavistin 0.5 g/10 kg compost) was developed by Pantnagar Centre to effectively control competitor/parasitic moulds in cultivation of *A. bisporus*.

- Siderophore producing *Pseudomonads* have been screened out by Pantnagar Centre for getting early fruiting and enhanced yield of *A. bisporus*.

- Button mushroom strain, CM-10 gave highest mushroom yield of 17.69 kg/q of compost followed by CM-5 (15.09 kg/q), U-3 (14.36 kg/q), and S-11 (14.35 kg/q) under Udaipur condition. Average individual fruiting body weight was obtained highest in strain CM-10 (19.76 g), followed by CM-3 (19.34 g), S-130 (16.46 g), U-3 (16.50 g) and least was in S-11 strain.

- In *Agaricus bitorquis* strains, NCB-6, NCB-1 and NCB-2 were found as high yielding strains with good quality characteristics and taste suitable for Udaipur region.

- *Agaricus bisporus* strains, NCS-11 and MS- 39 can be easily grown under natural climatic conditions from October to March in Udaipur region (Fig. 18). The strain MS- 39 yielded large size fruiting bodies (7-8 cm) with an average yield of 14.52 kg/q of compost. The strain NCS- 11 has small sized fruiting bodies (2-4 cm) and gave an average mushroom yield of 13.74 kg/q of compost, while the strain NCS-6 has medium size fruiting bodies (5-7 cm) with average yield of 13.72 kg/q of compost.

- In casing materials, 2 years old spent compost, FYM + spent compost (1:1, v/v) and FYM + soil + sand + spent compost (1:1:1:1, v/v) out yielded the other casing treatments under Udaipur condition.

- Highest number of fruiting bodies were harvested in casing material prepared with FYM (1041/ q of compost) and lowest in FYM + garden soil (1:1). The fruiting bodies harvested from FYM + garden soil (1:1) were of highest weight (29.25 g/fruit body).

Fig. 18. Button mushroom crop raised at Udaipur

- At Udaipur, the long method compost treated with DDVP + bavistin gave higher button mushroom yield.
- *Agaricus bisporus* strains, NCS-100 and NCH-102 were found to be the superior strains for Chhattisgarh state.
- Compost inoculated with mixed inoculum of *Gilmaniella humicola* + *Scytalidium thermophilum* + *Thermomyces lanuginosus* at the time of spawning enhanced the button mushroom yield by 21.30% over other treatments under Nauni condition.
- At Nauni, casing material prepared with mixture of farm yard manure + spent compost + vermicompost gave highest button mushroom yield of 25 kg/q compost and was followed by casing material prepared with FYM + spent compost (24.50 kg/q compost).
- Supplementation of compost with cotton seed cake and cotton seed meal at the time of spawning stimulated highest fungal population in compost and *Penicillium* spp. was the most predominant fungal species in the compost.
- Supplementation of compost with cotton seed meal, sesame meal and cotton seed cake enhanced the button mushroom yield in Nauni region.
- Supplementation of compost with peptone, glucose and malt extract led to maximum

contamination from *Penicillium chrysogenum*, *Penicillium coryophilum*, *Rhizopus nigricans*, *Sepedonium chrysospermum* and *Mucor racemosus* under Nauni condition.

- Strain, CM-14 of button mushroom (*Agaricus bisporus*) performed better than other strains and mushroom yield of 16.2 % was recorded at Barapani.

5.2. Oyster mushroom

- Wheat straw supplemented with soybean flour is recommended for getting higher yield of oyster mushroom for Maharashtra region.

- The hot water treatment of the substrate gave higher yield of oyster mushroom (72.0 kg/q dry substrate) than other two methods of substrate pasteurization (chemical and solar pasteurization) under Pune condition.

- At Pune, supplementation of substrate with 2% deoiled soybean meal (dry weight basis) gave highest oyster mushroom yield of 73.3 kg/q dry substrate as compared to other supplementation treatments in *Pleurotus sajor-caju* and *P. florida*. Supplementation of substrate with 4% rice bran also gave good yield of 71.5 kg/q dry substrate.

- In case of *Pleurotus sajor-caju*, significantly higher yield (48.9 kg/q dry straw) was obtained on spraying 0.1 M K_2HPO_4 on mushroom beds. In *P. florida* the effect of K_2HPO_4 and water spray were comparable. In both the species spray of urea gave lower mushroom yield.

- In case of *Pleurotus florida*, spraying of 0.1 M K_2HPO_4 at pinhead formation stage increased the mushroom yield by 40 g per bed compared to control under Coimbatore condition.

- The yield potential of Blue oyster mushroom, *Hypsizygus ulmarius* var. CO-2 (oyster mushroom) was compared with that of *P. florida*. The CO-2 (oyster mushroom) recorded significantly superior yield of 620 g / bed (BE-124 %) at Coimbatore Centre.

- All *Pleurotus* spp. *viz*., *Pleurotus citrinopileatus*, *P. sajor-caju*, *P. florida*, *P. platypus* and *P. solmoneostramineus* can be

cultivated through out the year under Tamil Nadu conditions. Among the different species tested, *P. solmoneo straminues* recorded highest mushroom yield with highest bioefficiency during the month of November.

- At Coimbatore, paddy straw or paddy straw + paper clippings was the most favoured substrate for *P. citrinopileatus*, *P. sajor-caju* and *P. platypus*, followed by either cotton waste or sorghum stalks. *P. platypus* recorded higher yield in all the substrates than the other two species.

- Supplementation of paddy straw substrate with powdered, steam sterilized neem cake @ 5 % increased the yield of *P. citrinopileatus* (26.2 %), *P. sajor-caju* (23.5 %) and *P. platypus* (15.5 %) at Coimbatore Centre (Fig. 19). In all the cases, time taken for spawn run (days) was also reduced considerably (2-6 days). Supplementation rate of 5% was found better than 2 per cent.

Fig. 19. *Pleurotus sajor-caju* crop at Coimbatore Centre

- Chemical sterilization of paddy straw substrate with 75 ppm carbendazim + 500 ppm formalin increased the yield of *P. citrinopileautus* by 38 per cent over control, while no significant difference between chemical sterilization and hot water treatment was recorded with *P. sajor-caju* under Coimbatore condition.

- Supplementation of substrate with mixture of neem cake+wheat straw+rice bran+ soybean meal @ 2% is recommended for *Pleurotus* species cultivation in Uttarakhand region.

- *Pleurotus sajor-caju* and *P. florida* have been recommended by Pantnagar Centre for commercial cultivation by using locally available soybean straw or paddy straw or wheat straw or mustard straw or mandua straw or jhnagora straw.

- Cultivation technology of *Hypsizygus ulmarius* has been standardized by using wheat straw supplemented with wheat bran substrate.

- Four per cent rice bran supplementation gave highest yield of *Pleurotus sajor-caju* and *Pleurotus citrinopileatus* under Udaipur condition.

- *Pleurotus fossulatus* and *Pleurotus florida* were successfully grown on wheat straw substrate and *P. florida* gave highest mushroom yield (96.67 kg/ q dry substrate) with 96.66 % biological efficiency, followed by *P. fossulatus* with the yield of 88.60 kg/q dry substrate (88.60% biological efficiency). Regarding average number and average weight of fruiting bodies; *P. fossulatus* produced lowest number (56.40), where as highest number of fruiting bodies were produced (65.53) by *P. florida*. Average fruiting body weight was higher (15.69 g) in *P. fossulatus* as compared to *P. florida* (4.75 g) at Udaipur Centre.

- Blue oyster mushroom (*Hypsizygus ulmarius*) was successfully grown on wheat straw in Rajasthan with 57.80% biological efficiency as compared to 45.60 % with *Pleurotus florida* and 53.87% with *Pleurotus sajor-caju*. Regarding the average number of mushroom fruiting bodies, highest number was recorded in *Hypsizygus ulmarius* (185) followed by *Pleurotus florida* (129.5) and least in *Pleurotus sajor-caju* (93.05).

- Dipping of oyster mushroom beds in 0.4 and 0.6 % solutions of effective microorganisms significantly enhanced the mushroom yield by 50 % or even more in several experiments under Raipur condition.

- Out of several locally available substrates tried for oyster mushroom cultivation under Chhattisgarh conditions, paddy straw, wheat straw, soybean and mustard straw performed exceedingly well in almost all the trials conducted.

- Of several species of *Pleurotus* tried, the performance of *P. florida* and *P. flabellatus* was excellent both under experimental as well as farmers growing conditions at Raipur. Among strains of *P. florida*, local strain spp. 26 was better than *P. florida* spp. 29.

- Of three methods of substrate treatment evaluated, hot water treatment followed by chemical treatment of straw were effective in suppressing the contaminants and increasing the yield of *Pleurotus* spp. under Raipur condition.

- Spawning of oyster mushroom substrate @ 5% was better than 3% in several trials laid out by Raipur Centre, while layer spawning method was found to be more effective than thorough mixing and spot methods.

- At Raipur, hollow beds resulted in substantial increase in yield of different species of *Pleurotus* probably due to increase in aeration and proper wetting of the inner surface of the substrate. Chopping of straw in the length of 6-9" was extremely helpful in yield enhancement of *Pleurotus* spp. than straw length of 3", may be due to increased air space, surface area and effective penetration of water.

- In Kerala, locally available alternative substrates were identified and their processing technology was also standardised for bringing down the cost of cultivation of oyster mushroom. Red banana pseudostem, mango wood chips and *Eleocharis plantagenia,* a wet land weed were recorded as the promising ones.

- An improvised air cooling system was developed by Vellayani Centre for speedy sporocarp induction in dormant beds of oyster mushroom during the cropping phase.

- Low cost technology for spawn production using cheap substrates like match work waste, potato blended gravel *etc*. was developed at Vellayani Centre.

- Techniques were standardised for blending coconut endosperm milk in culture media for enhanced growth and biomass

Fig. 20. *Pleurotus sajor-caju* crop at Vellayani Centre

production of *Pleurotus* under Vellayani condition (Fig. 20).

- Coir pith could be conveniently converted into an organic manure using three different mushroom species namely *Pleurotus eous, Schizophyllus commune* for retted and non retted coir pith and *Pleurotus sajor-caju* for non retted coir pith alone. Conversion of this waste material into an organic manure is a boon to the farmers of Kerala and spawn of these varieties exclusively meant for coir pith decomposition is available at the Centre.

- Supplementation @ 2 % with wheat bran significantly enhanced the yield in *P. florida* (48.3 %), *P. sajor-caju* (44.9 %) and in *P. ostreatus* (48.1 %) over control. Hence, wheat bran supplementation @ 2 % (w/w) is recommended for higher mushroom yield for Ranchi region.

- Spray of mushroom beds with 0.1 M solution of K_2HPO_4 significantly increased the yield of *P. sajor-caju* at Ranchi Centre.

- Among different oyster myshroom species, highest yield per q dry straw was recorded in *Hypsizygus ulmarius* (223.2 kg), *Pleurotus florida* (181.4 kg) and *Pleurotus sajor-caju* (172.5 kg). Thus only two species *viz*., *Hypsizygus ulmarius* and *Pleurotus florida* (Fig. 21) can be successfully cultivated during winter season in Ranchi.

- Supplementation of substrate @ 5% with wheat bran or rice bran gave higher mushroom yield over

Fig. 21. High yielding oyster mushroom suiting Ranchi condition

control under Barapani condition.

- In Barapani, spraying treatment with 0.1 % urea gave significantly higher yield in oyster mushroom, *Pleurotus florida*.

- Average yield of 67 % was recorded in Blue oyster mushroom (*Hypsizygus ulmarius*) at Barapani Centre.

Fig. 22. Paddy straw mushroom crop at Coimbatore Centre

5.3. Paddy straw mushroom

- Supplementation of paddy straw with cotton waste and neem leaves @ 5 % enhanced the mushroom yield and the technique is suitable under Coimbatore conditions.

- At Coimbatore, paddy straw soaked for 18 h in cold water recorded highest mushroom yield compared to 48 h and 24 h of soaking. Soaking of paddy straw beyond 24 h was not favourable for cultivation of *V. volvacea*.

- Circular compact beds gave significantly higher mushroom yield of 1020 g / bed (22.5 per cent bio-efficiency) of *V. volvacea* at Coimbatore Centre (Fig. 22).

- Bed size measuring 45 cm diameter and 30 cm height recorded the highest mushroom yield of 982 g / bed (19.64 percent bioefficiency) with more number of harvestable buttons (55.4) compared to other bed dimensions in Coimbatore region.

- Among different strains of *V. volvacea*, strain PS-1 recorded highest mushroom yield of 1263 g / bed (bio-efficiency of 25.3 %) followed by Vv-7 and PS-2 (23.8 % and 23.7 % bio efficiency, respectively) in Tamil Nadu condition.

- Amendment of the substrate with cotton waste followed by

neem cake and chicken manure increased the yield of *Volvariella volvacea* by 46, 33 and 30 per cent, respectively over control at Coimbatore.

- Paddy straw bundles put in a spiral fashion on a wooden pillar or cemented pillar were found to enhance the yield to a great extent in paddy straw mushroom at Raipur. Frame method of paddy straw mushroom cultivation also performed better than standard bed method of cultivation.

- At Raipur, partially composted cotton waste substrate was found to be the most suitable substrate for cultivation of paddy straw mushroom, followed by paddy straw substrate.

- Strains, Vv-7, Vv-9 and Vv-11 of paddy straw mushroom (*Volvariella volvacea*) performed better than other strains and mushroom yield of 13.88 %, 15.8 % and 12.66 % were recorded, respectively in Ranchi condition.

- Strain, Vv-6 of paddy straw mushroom (*Volvariella volvacea*) performed better than other strains and mushroom yield of 10.8 % biological efficiency (BE) was obtained at Barapani Centre. The Centre followed bed system of growing for cultivating paddy straw mushroom (Fig. 23).

Fig. 23. Bed system of growing paddy straw mushroom at Barapani

5.4. Milky mushroom

- Among 16 different wild strains of *C. indica* evaluated for their yield potential at Coimbatore, strain WC-19 gave significantly superior yield compared to all other strains.

- Among different strains obtained from NRCM, Solan (CI-1 to CI-9), the strain CI-1, CI-7 and CI-8 gave higher yield of 520 g, 505 g and 490 g per bed, respectively under Coimbatore condition.

- The superior mushroom yield of above 172% biological efficiency was recorded in all strains of milky mushroom (Fig. 24).

Fig. 24. Milky mushroom crop at Coimbatore Centre

- Cultivation of *Calocybe indica* was standardized at Pantnagar by using wheat straw as the substrate and casing with FYM+spent compost+sand (2:1:1) based casing material.
- Udaipur Centre also developed a simple cultivation technology of *Calocybe indica* and highest mushroom yield was recorded in strain, CI-6 on wheat straw substrate.
- At Raipur, wheat straw substrate alone and in combination with paddy straw in the ratio of 1:1 gave good yield of milky mushroom.
- The highest biological efficiency was recorded in strain, CI-6 (107 %) followed by CI-7 (88.9 %), CI-1 (80.2 %), CI-3 (73.8 %) and APK-2 (72.8 %). However, the strains, CI-6 and CI-7 were at par with each other but significantly different from other strains. Thus strains, CI-6, CI-7 and APK-2 were better-suited strains in respect to fruiting body quality and yield in Jharkhand.

5.5. Black ear mushroom

- Supplementation of wheat straw substrate with 2% wheat bran + 2% rice bran was found effective in increasing yield of black ear mushroom at Pune.
- Supplementation with 4% rice bran, followed by 2% rice bran and 2% wheat bran favoured the good yield of black ear mushroom at Coimbatore.
- Five local isolates of *Auricularia* were examined and characterized at Pantnagar.
- Cultivation of *Auricularia polytricha* was standardized at Pantnagar using sterilized wheat straw supplemented with 5% wheat bran substrate (Fig. 25).
- At Pantnagar, the wheat decoction agar medium, pH 6.5 and temperature 25±2°C favoured the optimum growth of *Auricularia.*

Fig. 25. Black ear mushroom grown at Pantnagar

- Paddy straw, followed by rapeseed straw were found to be the most suitable substrate for higher yield of *Auricularia* in Uttarakhand region.
- The cultivation technology for Jelly mushroom (*Auricularia polytricha*) has been standardized at Udaipur Centre with highest yield (51.73 kg/q dry substrate) on wheat straw supplemented with 10% wheat bran substrate.
- Wheat bran supplementation @ 4 % on dry weight basis was found to be suitable substrate for good growth and higher yield of *Auricularia polytricha* in Raipur condition.
- Black ear Mushroom was successfully grown in Ranchi with mushroom yield of 156.7 kg/q dry straw.
- Silver oak saw dust supplemented with 8% wheat bran was found to be the best substrate for the cultivation of *Auricularia polytricha* with an average yield of 81.17 kg/q of substrate under Tamil Nadu condition.

5.6. Shiitake mushroom

- The Potato Dextrose Agar (PDA) medium, pH 5.0 and temperature 25°C favoured optimum growth of *Lentinula edodes* at Pantnagar.
- Cultivation of *Lentinula edodes* was standardized at Pantnagar

Fig. 26. Shiitake mushroom grown at Pantnagar

on wheat straw and popular sawdust substrates with 20% supplementation of wheat bran (Fig. 26).

- Two isolates of *L. edodes* were examined and characterized biochemically at Pantnagar Centre.

- Cultivation technology of shiitake mushroom (*Lentinula edodes*) was also developed with good biological efficiency under Udaipur condition.

- Silver oak saw dust+wheat bran (20 %) was found to be the best substrate for cultivation of *Lentinula edodes* under Coimbatore condition. An average yield of 231 g/bed and an average number of 10.7 fruiting bodies/bed were obtained, each fruiting body weighed approximately 21.7 g.

- At Coimbatore, silver oak saw dust+wheat bran (8 %) and tapioca thippi+wheat bran (4 %) gave the highest yield of 78.5 kg and 73.05 kg/q of substrate, respectively. The average weight of the fruiting body in these substrates ranged from 3.8 to 4.2 g.

5.7. Medicinal mushroom

- Of ten isolates of *Ganoderma* collected at Pantnagar, three were examined, and biochemically and molecularly characterized.

- Cultivation technology of *Ganoderma lucidum* was standardized at Pantnagar by using sterilized wheat straw substrate supplemented with 5% wheat bran (Fig. 27). The Malt Extract Agar (MEA) medium, pH 5-6 and temperature range of 26±2°C recorded highest growth of *Ganoderma lucidum*.

Fig. 27. Commercial cultivation of *Ganoderma* at Pantnagar

- The presence of polysaccharides and Ganoderic acids A, C2 and H was examined and extracted from the fruiting bodies of *G. lucidum*.

Antioxidative properties were also examined among different isolates of *G. lucidum* at Pantnagar Centre.

- At Raipur, saw dust and wheat straw substrates took 30-35 days for spawn run of *G. lucidum* and fruiting body initiation was observed after 8-10 days of spawn run completion.

- *Ganoderma lucidum* local strains, Chinese strains and Udaipur strains were successfully evaluated at Raipur Centre.

5.8. Keera ghas/ Yarsha gumboo (*Cordyceps sinensis*)

- Cultural growth of *Cordyceps* was found to be initially white to light cream and it changed into orange or pink to light purple and reverse purplish red or dark tan or blood red colour on different media (Fig. 28).

- The SDYA medium and pH 6.0 favoured the highest growth of *Cordyceps*.

- Antioxidative properties were determined from the fruiting bodies of *Cordyceps sinensis*.

Fig. 28. Growth of *Cordyceps* at Pantnagar Centre

5.9. Post harvest technology

- Acceptable white colour of button mushroom was retained in dipping treatment of 200 ppm and 75 ppm EDTA and by storing under ambient and refrigerated conditions, respectively at Pune Centre.

- On storage under refrigerated conditions, dipping treatment of 100 ppm EDTA and 100 ppm EDTA + 0.02% KMS helped in retention of good milky white colour of button mushroom upto 48 h. However, at ambient temperature in Pune, desired colour was retained only in 100

ppm EDTA + 0.02% KMS treatment upto 48 h.

- The acceptable white colour of button mushroom was retained upto 48 h on packaging mushrooms in 100 gauge PP bags without holes followed by storage at both refrigerated and ambient temperature at Pune. However, the acceptable white colour was retained upto 48 h only on packaging mushrooms in 100 gauge PP bags with hole followed by storage at refrigerated condition. However, performance of 100 gauge PP and 100 gauge PE bags were more or less comparable.

- Dipping treatment of button mushroom fruiting bodies (strain S-11) in 125 ppm EDTA solution increased the shelf life and maintained good colour and texture on storage both under refrigerated and ambient temperature up to 72h. The gill opening in stored mushrooms ranged from 16 to 40 % and it increased with increase in storage time in Coimbatore condition.

- Packaging of button mushroom strain S-11 in either PP or PE bags of 100 to 125 gauge thickness (with 10 pinholes) helped in retaining good quality upto 48 h of storage. Not much difference was noticed between PP and PE bags with respect to change in colour and weight loss. However, storage under refrigerated condition reduced percent veil opening compared to storage at ambient condition at Coimbatore.

- The whiteness of button mushroom strain, MS-39 (S-11) could be retained up to 11 days by giving a dipping treatment of 75, 125 and 200 ppm EDTA and 0.05 % potassium meta bisulphite (KMS) and on storage at refrigerated temperature (10°C), while at ambient temperature, whiteness was retained only for a day under Udaipur condition. Veil-opening did not occur up to 9 days of storage in refrigerated temperature (10°C), while it increased upto 15 days of storage in refrigerator along with dipping treatment of 75, 125 and 200 ppm EDTA and 0.05 % potassium meta bisulphite (KMS). At ambient temperature, veils opened after first day in case of 75, 125 and 200 ppm EDTA washed mushrooms, while in 0.05 % KMS washed mushrooms

veils did not open upto second day of storage.

- The whiteness of button mushroom could be increased with dipping treatment in 100 ppm, 150 ppm, 200 ppm and 500 ppm EDTA and 100 ppm EDTA + 0.02% KMS over unwashed mushroom. At ambient temperature storage in Udaipur, whiteness was less as compared to storage at 5°C in 150, 200, 500 ppm EDTA and 100 ppm EDTA + 0.02 % KMS washed mushrooms.

- Button mushroom fruiting bodies could be well preserved up to 3 days under ambient temperature at Raipur and 11-16 days under refrigerated conditions after giving a dipping treatment in 200 ppm and 500 ppm solutions of EDTA and KMS, respectively.

- Blanching of oyster mushroom (*Pleurotus florida*) for 2 min in 0.2 % salt+0.1 % citric acid solution before drying and storage (for 3 months) slightly improved the whiteness. Direct sun drying or cabinet drying with out chemical treatment or blanching kept superior brittleness after 3 months of storage.

- Sun drying method was found best for drying of *Pleurotus sajor-caju* in comparison to cabinet drying, unblanched and blanched methods (Fig. 29).

Fig. 29. Oyster mushroom dried by two different methods

6. CROPPING SYSTEM RESEARCH

6.1. Ludhiana Centre

A round the year cultivation cycle recommended by the Punjab Agricultural University (Fig. 30) is being followed by the mushroom growers in Punjab for cultivation of mushrooms under natural indoor environmental conditions.

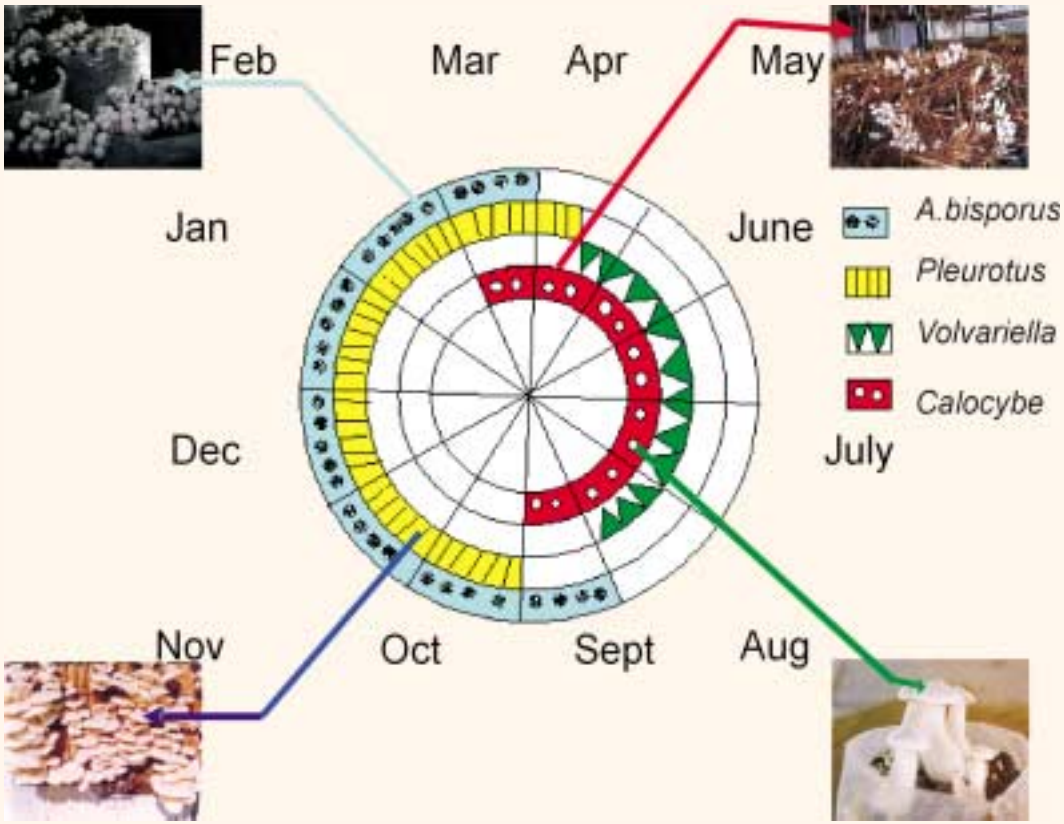

Fig. 30. Round the year cultivation of mushrooms

6.2. Pune Centre

- Wheat straw compost was found better than paddy straw compost for growing *Agaricus bisporus*.
- Intial N level of 1.5 % in the compost was proved to be optimum for getting higher yield of *A. bisporus* (S-11).
- Different agrowastes like wheat straw, paddy straw, soybean straw and soybean straw + wheat straw (1:1) were evaluated as base materials for button mushroom compost preparation. The 1:1 combination of soybean + wheat straw recorded significantly higher yield of *Agaricus bisporus* (15.43 kg/q compost) than other base materials.
- Addition of 100 g grain spawn / m^2 of casing material at the time of casing significantly enhanced the *Agaricus bisporus* yield. It recorded 30 per cent yield enhancement over control.
- Monsoon and rainy seasons were recorded as most suitable seasons for cultivation of all the species of *Pleurotus*. *P. sajor-caju* was found to be higher yielding than other species.
- Cotton stalks and leaves recorded significantly higher yield of oyster mushroom (82.4 kg /q dry substrate), followed by paddy and wheat straw yielding (72.1 & 71.7 kg/q of substrate), respectively.
- Among different oyster mushroom species evaluated for yield, significantly higher yield was obtained with *Pleurotus sajor-caju* (55.1 kg/q dry substrate), followed by *P. florida* (54.5 kg/q dry substrate). The blue oyster mushroom recorded lowest yield of 50.2 kg/q dry substrate.
- Supplementation of wheat straw with 2% wheat bran and 2% rice bran is beneficial for getting higher yield of black ear mushroom, *Auricularia polytricha*.
- The highest fresh mushroom yield of *Calocybe indica* was obtained in mix substrate of wheat + paddy straw (1:1) *i.e.* 61.6 kg/q dry substrate.

- The sawdust substrate supplemented with 20% wheat bran was found better for shiitake mushroom and it recorded on an average 5 fruit bodies / bed with an average fruiting body weight of 20 g.

- The climatic conditions are more suitable for oyster mushroom cultivation (12 months) followed by milky and paddy straw mushrooms (9-10 months), and button mushroom (3 months).

6.3. Coimbatore Centre

- A suitable out-door cultivation system of Paddy straw mushroom *(Volvariella volvacea)* was established along with banana, maize and sugarcane crops.

- Paddy straw mushroom could be successfully cultivated in the inter row spaces of maize (30 days after sowing), sugarcane (8 months after planting) and banana (5 months after planting).

- Among different substrates tried, paddy straw constantly gave higher mushroom yield with bioefficiency ranging from 9-16 % from 25 kg of substrate with in a total crop cycle of 28- 30 days.

- The Cost Benefit ratio worked out during the intercropping in maize, sugarcane and banana fields was 1:1.37, 1:1.94 and 1:1.44, respectively.

- Inter cropping of paddy straw mushroom followed by 60 days *in situ* biodegradation of mushroom spent substrate led to addition of 13.2-16.9% N level, 9.5-16.67% P level and 5.90-11.82% K level in the field.

- Inter cropping of paddy straw mushroom led to overall reduction in the weed population /m^2, their group and dry weight (9 g /m^2).

- Nearly 10 months of the year are suitable for cultivating milky mushroom, while all 12 months for oyster mushroom and 9 months for paddy straw mushroom.

6.4. Pantnagar Centre

A relay cropping schedule developed for Tarai region of Uttarakhand consisted of two crops of *Agaricus bisporus* from September-March, four crops of *Pleurotus* spp. from September-November and February-April and three crops of *Calocybe indica* from

March-October. Five crops of paddy straw mushroom can also be harvested from April to September depending upon its popularity. Cropping schedule for different zones of Uttarakhand state is presented in Table 10.

6.5. Faizabad Centre

As per the climatic conditions of eastern Uttar Pradesh and the requirements of different species of mushrooms, research work was carried out and a yearly calendar of

Table 10: Mushrooms suitable for different zones of Uttarakhand state as per climatic conditions

Zone (height from sea level)	Region	District	Mushroom species & Number of crops
Zone-'A1' (100-600 m)	Tarai, Bhawar	U.S. Nagar, Haridwar, Nainital, Pauri Garhwal, Champawat, Dehradun	Button - 2 crops (October-March) Oyster - 2+2 crops (August-October & February-April) Milky - 2 crops (April-September) Shiitake - 1 crop (November-February) Black ear - 2 crops (July-October)
Zone-'A2' (600-1000 m)	Lower hill	Champawat, Nainital, Pauri Garhwal, Dehradun, Almora	Button - 2 crops (October-April) Oyster - 2 crops (April-November) Milky - 1 crop (May-July) Shiitake - 1 crop (November-February) Black ear - 2 crops (April-October)
Zone-'B' (1000-1500 m)	Medium hill	Champawat, Nainital, Almora, Dehradun, Tehri Garhwal, Bageshwar, Pauri Garhwal, Chamoli, Pithoragarh	Button - 2 crops (October-March) Oyster - 2 crops (August-March) Milky - 2 crops (April-September) Shiitake - 1 crop (November-February) Black ear - 2 crops (July-October)
Zone-'C' (1500-2400 m)	High hill	Pithoragarh, Chamoli, Bageshwer, Uttar Kashi, Dehradun, Tehri Garhwal, Rudra Prayag	Button - 3 crops (February-November) Oyster - 2 crops (May-August) Shiitake - 2 crops (March-October)
Zone-'D' (>2400 m)	Higher hill	Pithoragarh, Chamoli, Uttarkashi	Button - 3 crops (February-October) Oyster - 2 crops (June-July) Shiitake - 2 crops (March-October)

cropping system was prepared. Four crops of oyster mushroom can be raised from November to April, while one crop of button mushroom from Nov. to Feb., 3 crops of milky mushroom from May to October and 5 crops of paddy straw mushroom from April to Sept. can be harvested.

6.6. Raipur Centre

- Seven mushroom species *viz*., oyster mushroom, paddy straw mushroom, milky mushroom, white button mushroom, shiitake mushroom, black ear mushroom and reishi mushroom were evaluated according to their suitability under prevailing climatic conditions of Chhattisgarh. A crop calendar has been developed to grow different mushrooms and their species after conducting a series of experiments for several years. Among oyster mushroom species, *Pleurotus florida* and *P. flabellatus* were found to grow well almost round the year. *Pleurotus florida, P. eous, P. membranaceus* were found to grow well during monsoon season in Chhattisgarh Plains, Bastar Plataeu and Northern Hilly regions, while *P. sajor-caju, P. columbinus,* and *P. ostreatus* were found to perform well during winter season in Bastar Plataeu and Northern Hilly regions. *Pleurotus eous, P. salmoneo stramineus* were found to be good during spring season in Chhattisgarh plains.

- *Calocybe indica, Volvariella volvacea, V. diplasia* and *Auricularia polytricha* were found to grow well during monsoon season under natural growing conditions, while button mushroom can be very well cultivated during winter season. Two crops of button mushroom can be grown during winter season under Northern Hilly regions and Bastar Plateau conditions, while only one crop can be grown in Chhattisgarh Plains. In Spring/Pre-monsoon season, *Volvariella volvacea* and *Calocybe indica* are nicely grown. Thus, the above mushrooms can be suitably grown almost the round year depending upon the prevailing climatic conditions one after the other.

6.7. Vellayani Centre

- The traditional system of growing *Volvariella* has been discarded and polybag method of cultivation

is followed. Polybag method is also followed for oyster mushroom.

- The *Calocybe* beds are split into halves before casing and the mushroom is grown exclusively in blue silpaulin sheds to get best results.
- Paddy straw and milky mushroom can be grown at least for 9-10 months of the year (Feb. to Oct.), while oyster mushroom cultivation can be taken up for rest 3 months (Nov. to Feb.).

7. STRATEGIES FOR PEST AND DISEASE MANAGEMENT

7.1. Ludhiana Centre

The commonly encountered mushroom pests and diseases in Punjab are listed in Table 11. Most of the pathogens and pests of white button mushroom can be managed by sound hygiene and sanitary measures which at the moment is the only best available defense with a grower. The use of chemicals should be the last resort under extremely unavoidable circumstances.

A grower can get a reasonably disease free crop at his farm if the following undermentioned tips are routinely followed during various stages of mushroom cultivation:

- Reduce the dust load at mushroom farms by using maximum concrete on the open area as dust is the primary source of many mushroom pathogens.
- The location of the farm should not be accessible to toxic fumes and gases.
- Bulk ingredients used for compost preparation should either be purchased fresh or stored properly. These should not be already wet, muddy or too broken down.
- Compost ingredients should be properly formulated, correctly supplemented if required and processed. Incorrect C/N ratio

Table 11: Mushroom pests and diseases encountered in Punjab

Fungi	*Aspergillus, Chaetomium, Coprinus, Dactylium dendroides, Diehliomyces microsporus, Mycogone perniciosa, Penicillium, Populaspora byssina, Trichoderma, Verticillium fungicola*
Bacteria	*Pseudomonas tolaasii*
Insects/Pest	*Lycoriella, Megaselia*, Mites & Springtails
Nematodes	*Aphelenchoides composticola, Ditylenchus myceliophagus, Caenorhabditis* spp.

attracts unwanted weed/indicator molds.

- Choice of spawn and supplements should be well thought of. Try to procure and use spawn from a genuine source and it should be free from contaminants.

- Casing soil should be properly prepared, stored and disinfected/ pasteurized correctly. Any mixture suspected to be containing fungal spores should be avoided. Avoid over pasteurization of casing soil for longer duration. The casing soil preparation and casing operation should be carried out under strict hygienic conditions.

- The surface of the beds should be dressed properly before casing and preferably spot treatment with 2 % formaldehyde be given if any weed or cosmetic moulds growth is visible . Some indicator moulds like ink cap need to be weeded out before it autolyse and open to liberate spores.

- On occasions chlorinated water (150 ppm chlorine) should be sprayed on mushroom beds to reduce bacteria population level on the mushroom caps. Condensation of water droplets and water splashes should be avoided.

- Special attention should be paid to maintain optimum air velocity. CO_2 level should be between 5000-15000 ppm during spawn run and the first few days following casing and between 1000-1500 ppm thereafter.

- Prophylactic spray of Indofil M 45 (0.25-0.50 %) at casing, at pin head appearance and between 2nd and 3rd mushroom breaks help in restricting the growth and spread of a few fungal pathogens. Use of carbendazim (0.02-0.05 %) under certain conditions is also recommended.

- Picking of mushrooms should preferably be done once during the day and before the opening of the caps.

- At the end of the crop cycle, the cropping rooms should be properly pasteurized (cook out), cleaned out and prepared for another filling. The "Cook out" is essentially required in the event of nematodes infestation. Emptying or dumping off of the spent substrate should be done at a far off site from the mushroom producing area.

- As an aid to good sanitation and hygiene, use the recommended fungicides and pesticides as

Table 12: Treatment recommended by Ludhiana Centre for mushroom pests and diseases

Fungi	Formaldehyde 2 %, Indophil M-45 0.2-0.5 %, Carbendazim 0.02-0.05 %, Manual removal of infected patches and weed fungi
Bacteria	Chlorinated water 75 ppm
Insect-Pests	Malathion 0.05 %, Dichlorovos 0.5 %, Lindane (g BHC) in compost
Nematodes	Furadon 3G (50 g/q) in compost / casing, pasteurization / cooking out where facility is available

mentioned above in the event of appearance of diseases and insect pests.

The various treatments suggested and recommended by Ludhiana Centre for mushroom pests and diseases management are given in Table 12.

7.2. Pune Centre

- Chemical sterilization of wheat straw using 75 ppm bavistin with 500 ppm formalin observed to be equally good to hot water treatment.
- The chemical treatment of long method compost with DDVP (3 ml) + Bavistin (0.5 g) per 10 kg compost recorded highest button mushroom yield of 10.64 kg/q compost.

7.3. Coimbatore Centre

Integrated Pest Management (IPM) programme is generally followed in mushroom growing farms, which involves acquiring knowledge of the biology and behavior of the pests and diseases, monitoring the farm environment, assessment of the damage, making appropriate management decisions and use of IPM tools and techniques

The various components of IPM are:

- Farm hygiene is given utmost priority
- Providing doors, windows and ventilators with 35 mesh nylon net to prevent entry of the flies in the cropping room
- Use of TNAU light traps and yellow sticky trap for monitoring and killing of mushroom flies

- At the end of each crop, cooking out at 70-80^{0}C for 2 hours before removing the beds to kill all stages of pests and diseases is strongly recommended.

- The spent compost and casing materials should be safely disposed off in isolated manure pits to check the spread of diseases and breeding of flies.

7.4. Pantnagar Centre

The major mushroom pathogens observed were *Verticillium, Sepedonium, Trichoderma, Fusarium, Mycogone perniciosa* and *Hypomyces rosellus*. These can be managed by using the following below listed techniques.

- *Pseudomonas fluorescence* proved effective in controlling mushroom diseases caused by *Verticillium, Sepedonium, Trichoderma* and *Fusarium.*

- Botanicals, *Aegle mormelos* (0.5 %) and *Cleome viscosa* (1.0 %) were found effective in controlling of *Mycogone perniciosa* and *Trichoderma viride*, respectively.

- Chemical control of pathogens, *Mycogone perniciosa* and *Verticillium fungicola* by sporgon (0.075 %) and *Hypomyces rosellus*, *Fusarium moniliformae* and *Sepedonium chryosporium* by Bavistin (0.025 %) + Formalin (0.2 %) have been worked out.

7.5. Udaipur Centre

- In survey and surveillance studies, several oyster mushroom farms were surveyed and in few farms infection of green mould, inky caps and *Aspergillus* spp. was recorded. Among insects, Dipterien flies and spring tails were common.

- However, in button mushroom infection from brown plaster mould, *Coprinus* spp. and green mould was recorded. Infection from nematodes and Dipterien flies was also recorded in few farms.

- In tribal areas, no disease and insect pests were found. Further, only at 2-3 farms in Dhimadi village infection of *Coprinus* spp. and green mould was observed in traces.

7.6. Faizabad Centre

- Treatment and drying of straw in jute bags, use of light traps for

insect management, re-casing of mushroom beds against plaster moulds and strict hygiene were used.

7.7. Raipur Centre

- Bavistin and Subeej at 50 ppm were most effective in inhibiting the growth of most of the weed fungi, whereas antracol was less effective.
- 75 ppm Bavistin + 500 ppm Formalin was most effective treatment in inhibiting the growth of most of the weed fungi compared to other treatments.
- Lowest fungal count was recorded in substrate treated with riolon +formalin (75+500 ppm), followed by bavistin +formalin. However, highest biological efficiency (71.25) was obtained with Topsin–M, followed by Sultaf+formalin treatment.
- Under *in vivo* conditions, riolon + formalin (75+500 ppm) recorded significantly higher yield (80.2 % BE), followed by 78.8 % BE with Subeej + formalin (75+500 ppm) in comparision to only 29 % BE in control.
- Treatment with neemazole @ 0.1 % was found to enhance the yield of *P. florida* (57.40%) in comparision to control (16 %).

7.8. Vellayani Centre

- Blue and yellow light traps installed in mushroom houses, reduce the flies infestation in mushrooms. Hanging of gingelly oil rubbed X-ray films near the mushroom beds help in trapping of flies.
- Garlic paste put around the mushroom house was found to reduce the insect attack.
- Boiling is the most effective method of substrate treatment as it results in very low incidence of diseases in mushroom beds.
- Keeping the surroundings of the growing houses clean helps to tackle the pest problem.

8. TECHNOLOGIES TRANSFERRED AND EXTENSION SERVICES RENDERED

8.1. Ludhiana Centre

A complete package of technologies has been transferred for the growers of the state and adjoining areas through University 'Package of Practices'.

Technologies transferred

- Round the year cultivation technology for 4 mushrooms varieties namely button, oyster, paddy straw and milky mushroom.
- Low cost compost and casing soil formulations
- New composting schedule of 24 days for long method of composting
- High yielding cultivars – PAU-S-11 (*Agaricus bisporus*), PAU-2 (*Pleurotus ostreatus*), PAU-3 (*P. sajor-caju*), PAU-5 (*P. florida*) (Fig. 31), *Volvariella diplasia* selection and Mm-3 (*Calocybe indica*) (Fig. 32)

Fig. 31. High yielding cultivar PAU-5 (*P. florida*) developed at Ludhiana Centre

Fig. 32. High yielding cultivar Mm-3 (*Calocybe indica*) developed at Ludhiana Centre

- Comprehensive disease control package for control of mycopathogens

Extension services rendered

- Short duration training courses on mushroom production technology at PAU, Ludhiana, KVKs and Regional Research Stations on regular basis as per the mushroom cultivation season
- Visits to/by the growers and high dignitaries
- Button mushroom compost sample analysis for pH, moisture, Carbon to Nitrogen ratio, nematodes etc.
- Lectures/ demonstrations in training programmes and Kisan Melas

Extension material prepared

- Bulletins – Punjabi and English
- Bilingual-CD's
- Compendiums
- Audio cassettes, Video CD
- Pamphlets/handouts

Mitigation techniques

The challenges/problems encountered by the mushroom growers are addressed on personal contact basis and on-site visit/melas/ demonstrations and through:

- Spawn supply
- Use of electronic and print media
- Audio/Visual demonstrations
- Demonstration of popular techniques
- Rendering advisory services
- Preparation of project reports
- On-line services

8.2. Pune Centre

The Centre has organized 705 training programmes so far and a good number of trainees (15883) have been trained in mushroom cultivation. The Centre has also supplied 41 tons of mushroom spawn. The Centre has published 15 popular articles on mushroom along with delivering of talks on All India Radio (20) and T.V. (20). Five front line demonstrations were conducted at the Centre and more than 95000 visitors have visited the Centre (Fig. 33). The Centre also participated in 50 melas / exhibitions.

Fig. 33. Delegates from Canada visiting AICRPM Centre at Pune

A training programme for self employment has been launched by the Govt. of Maharashtra and two batches of 20 participants each have been imparted training of four month duration in all aspects of mushroom production (Fig. 34).

Fig. 34. Hands on training to tribal people at Pune Centre

Academics

Ph.D. and M.Sc. students have conducted research on various aspects of mushroom technology in the Department of Plant Pathology and Agricultural Microbiology, Mahatma Phule Krishi Vidyapeeth, Rahuri and Department of Plant Pathology and Agricultural Microbiology, College of Agriculture, Pune. The details are given in Table 13.

8.3. Coimbatore Centre

The technologies on cultivation of different mushrooms and pest/ disease management were transferred through conducting regular one day training programme on 5th of every month by this Centre. Every month on an average 50 participants attended the programme from different places of the state and other adjoining states. So far 295 such programmes have been conducted and more than 20,000 trainees have participated in these programmes for the past 20 years. The Centre also participated in various national and state level exhibitions (Fig. 35).

Table 13: M.Sc and Ph.D thesis work conducted at Pune Centre

Sr. No.	Title	Name of student	Name of guide	Year	Degree
1	Studies on efficacy of wheat straw and sugarcane trash on yield and nutrient status of *A.bitorquis*	D. Venkata Reddy	Dr. D.M. Sawant	2000	M.Sc. (Ag.)
2	Studies on competitive moulds in straw substrate for *Pleurotus sajor-caju* and their management	V.D. Surya-wanshi	Dr. D.M. Sawant	2000	M.Sc. (Ag.)
3	Effects of supplementation of wheat straw on performance of *Pleurotus eous* (Berk.) Sacc.	S.S. Dangat	Dr. P.V. Wani	2002	M.Sc. (Ag.)
4	Effect of different casing materials on the yield of button mushroom (*A. bisporus*)	Ms. V.M. Jadhav	Prof. S.K. Jadhav	2002	M.Sc. (Ag.)
5	Applied aspects of cultivation of *Pleurotus eous* (Berk) Sacc.	C.T. Kumbhar	Dr. P.V. Wani	2003	Ph.D. (Ag.)
6	Studies on competitive molds in *Pleurotus eous* (Berk) Sacc.	K.V. Harphale	Dr. P.V. Wani	2003	M.Sc. (Ag.)
7	Effect of size and shape of bed on growth and yield of *Pleurotus sajor-caju*	P.S. Ilhe	Dr. S.W. Jadhav	2003	M.Sc. (Ag.)
8	Hybridization studies in *Pleurotus* spp.	S.G. Sawashe	Dr. D.M. Sawant	2003	Ph.D. (Ag.)
9	Hybridization studies in *Agaricus bisporus*	S.W. Jadhav	Dr.D.M. Sawant	2003	Ph.D (Ag.)
10	Effect of biofertilizers on yield of mushroom *Pleurotus sajor-caju*	A.B. Gaikwad	Dr. S.S. Wange	2004	M.Sc. (Ag.)
11	Effect of microbial inoculants on white button mushroom (*Agricus bisporus*)	Ms. A.S. Gitay	Dr. S.S. Wange	2005	M.Sc. (Ag.)
12	Studies on *Hypsizygus ulmarius*- A new edible mushroom	R.N. Patil	Dr. S.S. Wange	2006	M.Sc. (Ag.)

Fig. 35. AICRPM Centre Coimbatore exhibiting their stall

Recently 30 advanced training programmes of 5 days and 10 days duration on mushroom cultivation were organized and about 105 trainees were benefited out of the trainings. For the first time in India, distance learning on mushroom cultivation has been organized at TNAU, Coimbatore from 2005 onwards. The Centre has supplied mushroom spawn of 98 tons. The Centre has also published 6 books on mushroom. Two ODL trainings were conducted at the Centre and more than 2000 visitors visited the Centre (Fig. 36).

Fig. 36. Ministers from Sri Lanka and Gujarat visiting AICRPM Centre, Coimbatore

8.4. Ranchi Centre

Various training programmes were conducted to popularize mushroom cultivation in the Jharkhand State (Fig. 37). A large number of farmers (5200) have been trained by the Centre and other organizations in the Jharkhand state. A mushroom Divas was organized by HARP on 24th Oct., 2003 to popularize mushroom cultivation in Jharkhand in which a good number of mushroom growers participated. Mushroom training-cum-mela was organized on 3-4 November, 2007 in which 97 persons were trained on oyster and button mushroom cultivation (Fig. 38). During past six years (2002 to 2007), a total of 166.7 q spawn of oyster mushroom was made available to the interested mushroom growers of Jharkhand and other adjacent states.

Fig. 37. Hands on training programme organized at Ranchi Centre

Fig. 38. Mushroom training-cum-mela organized at Ranchi Centre

8.5. Pantnagar Centre

For dissemination of the research findings to the growers, the Centre carried out a variety of extension programmes:

- Demonstrations and on-farm trials in adopted villages
- Training courses for entrepreneurs, small growers, BPLs and extension workers
- Organization and participation in exhibitions and farmers fairs
- Consultancy services to entrepreneurs and advisory help to farmers
- Supply of quality spawn to mushroom growers and cultures of improved strains to industry / spawn producers
- Supply of pasteurized compost to mushroom growers

The Centre has maintained linkages with different Departments like Microbiology, Plant Pathology, Food Science and Technology, Biotechnology, Post Harvest Technology, Chemistry, Biochemistry etc. of the University, and 30 M.Sc. and 14 Ph.D. degrees have been awarded on thesis work on different aspects of nutra and nutriceutical aspects of mushrooms.

Impact

Mushroom production during 1999-2006 period had started showing upward trend. The mushroom production in the state reached to 5340 MT in 2005-06 from 2203 MT in 1999-2000.

It is evident from the Figure 39 that there was 3100 MT mushroom production during the year 2001 when Uttarakhand state was established. The production has increased substantially from 3100 MT in 2001 to 5340 MT in 2005. The increase in quantity of spawn / compost supplied to growers and number of growers in 2006 indicate higher mushroom production in the State.

Fig. 39. Mushroom production in Uttarakhand state

Total number of mushroom production units in the State reached to 903 in the year 2005 from 485 units during the year 2002. The various marginal, small and industrial scale units established in different parts of Uttarakhand state are given in Table 14.

8.6. Udaipur Centre

A total number of 118 training programmes were conducted on mushroom cultivation and 1277 farmers, farm women, entrepreneurs and students were trained in mushroom cultivation (Fig. 40). Total of 180 letters pertaining to cultivation of button mushroom, oyster mushroom, milky mushroom, spawn production and marketing of mushrooms were replied. In addition to this, technical and spot guidance was provided to 320 farmers on various aspects of mushroom cultivation. Twenty radio talks and four TV programmes on mushroom production technology were also delivered. About 12.5 quintals of mushroom spawn was supplied to mushroom growers.

Table 14: Mushroom production units in Uttarakhand state

District	Level	Units (2002)	Units (2003)	Units (2004)	Units (2005)
Dehradun	Marginal	101	131	151	167
	Small	02	03	06	07
	Industrial	01	01	01	01
Haridwar	Marginal	03	09	11	31
Pauri Garhwal & Uttar Kashi	Marginal	04	06	09	15
Nainital	Marginal	135	200	217	224
	Small	02	03	06	06
Almora	Marginal	30	105	130	148
U.S. Nagar	Marginal	203	283	288	297
	Small	04	06	06	07
Total		485	741	825	903

Fig. 40. Training programme organised at Udaipur Centre

8.7. Faizabad Centre

Besides assigned technical programme of AICRPM, research work has been carried out on the basis of farmer's feedback to sort out their problems. Some of them are:

- Casing technology of *Calocybe indica* in comparison and contrast with *A. bisporus*
- Utilization of spent substrate in mushroom cultivation
- Timing for removing polythene cover of oyster beds
- In all in all the complete package of practices for the cultivation of *Agaricus bisporus, Pleurotus* spp. and *Calocybe indica* were standardized and transferred for their adoption in eastern Uttar Pradesh.

8.8. Raipur Centre

Training programmes organized

a) National Training Programmes

With a view to promote mushroom production and marketing, a self-employment generation scheme on payment basis was launched on 1st January, 1997. It attracted the entrepreneurs from Madhya Pradesh, Orissa, West Bengal, Bihar, Rajasthan and Maharashtra. These entrepreneurs after being exposed to 7 days training were able to establish either their own spawn lab or mushroom production units. Many of the entrepreneurs trained at the Centre are now engaged in mushroom spawn production, mushroom

production and marketing. The Centre has organized 5 such national training programmes sofar at Raipur.

b) State Level/sponsored/other training programmes

More than 35 on and off campus training programmes on mushroom spawn production, cultivation of different mushrooms and mushroom preservation / processing were organised for the farm women / men / rural youths under different programmes which have benefited 2294 farmers in variety of ways (Fig. 41).

Fig. 41. Training programme at Raipur for farm women

Adoption of villages

Tarra and Dondekhurd villages were adopted under Institutional Village Linkage Programme through Technology Assessment and Refinement under DBT Ad hoc project on "Transfer of mushroom production and processing technologies for the upliftment of rural farmers of Chhattisgarh". The technical persons visited these villages on regular basis for imparting training on different aspects of mushrooms *viz*., mushroom cultivation, spawn production, processing, marketing etc. The technology generated under AICRPM at IGAU, Raipur was also evaluated under farmers growing conditions in these two villages and further refinement in the technology was done based on the concrete feedback of the farmers. The interested farmers frequently visited the mushroom laboratory and sought the necessary advice on implementation of mushroom technology in their villages.

Participation in Kisan mela/ Kisan Diwas

To create awareness among common mass, mushroom stall with live demonstration of mushroom technology, technology demonstration through coloured posters, flexy boards, mushroom recipes and processed mushroom products were depicted by the Centre during the 22 Kisan mela/

Krishak Diwas/ Kisan Gosthi/ Rajyotsava/Krishi Pradarshini/NSS Camp/NSS Day etc.

Organization of State Level Exhibition

An exhibition on "Production and Processing Technology of Mushroom" was organized at mushroom research lab, Department of Plant Pathology, IGAU, Raipur from 20-22 January, 2002. During this exhibition thirty six recipes of mushrooms were displayed. Some of the important recipes were mushroom ice-cream, mushroom paneer, whey based mushroom chilli, mushroom kheer, etc., which were appreciated by the visitors. The exhibition was attended by more than 1500 participants. The exhibition was visited by Dr. Prem Sai Singh, Hon'ble Agril. Minister, Shri B.K.S. Ray, Principal Secretary and Agril. Production Commissioner, Govt. of Chhattisgarh and Shri J.P. Negi, Managing Director, NHB, Gurgaon (Fig. 42). A bulletin entitled "Mushroom ke Vyanjan" written by Ms. Ratna Naseene was released during inaugural session of the exhibition.

Fig. 42. Deligates visiting AICMIP Centre at Raipur

Organization of National Seminar / Workshop

- A National Seminar on "Role of Antimicrobials for Sustainable Horticulture" was jointly organized by the Department of Plant Pathology and Indian Society of Mycology and Plant Pathology, Udaipur on 20th January, 2002 to commemorate the 16th foundation day of IGKV.

- A 2 days National Workshop on "Awareness Creation on Biodiversity and Conservation of Mushrooms" was organized from 1-2 December, 2005 at Department of Plant Pathology, Indira Gandhi Agricultural University, Raipur in collaboration with National Biodiversity Authority of India, Chennai.

Extension publication

a) Bulletin / Compendium / Folder

Publication of bulletins, compendiam and folders in Hindi on nutritional and medicinal values of mushrooms, production technologies of different mushrooms, mushroom recipes and processed products created lot of awareness among the readers. The literature costing Rs. 49,145/- was sold from Mushroom Research Lab. So far the Centre has published 10 technical bulletins, 13 compendium of lectures, 13 leaf folders, 30 popular articles and about 150 news items in various news papers.

b) Preparation of Video CD on mushroom cultivation

A documentary film of 10 min duration on cultivation of white button mushroom was prepared in the year 2004-2005. Similarly a documentary film of 12 minutes duration on oyster mushroom kee vyavsayik kheti was also produced in the year 2005-06. These video films are available for sale as VCD's at the Centre.

Radio/ TV Talks

Twenty-five radio talks on various aspects of mushrooms were delivered/broadcasted at All India Radio, Raipur. Thrity five TV Talks and news coverage on channels like E TV (M.P.), Sahara TV, Raipur Doordarshan Kendra and local channels on different topics under "Annadata" programme had imparted the technical know how of different mushrooms. Mushroom research lab in Department of Plant Pathology, IGAU, Raipur has generated a revenue of Rs. 3,22,151/- by selling culture tubes, mother spawn, commercial spawn, fresh mushroom, pickles, mushroom literature and consultancy since inception of the project in 1988.

Promotion of spawn makers

A list of spawn makers promoted by the Centre and quantity of spawn sold by spawn makers in Chhattisgarh are given in Table 15.

Promotion of different organizations

Mushroom Hitgrahi Sangh (MHS): It is a registered NGO working throughout the State of

Chhattisgarh absolutely for the cause of mushroom development in the State. It has organized about 35 training programmes on 'Mushroom Production Technology' and 'Mushroom Processing Technology' for the rural women. Various agencies like Department of Horticulture, Department of Forest, Department of Women and Child Development, IFFCO etc. had sponsored these training programmes. About 1050 rural women have been benefited by the activities of MHS.

Prerna Swawlamban Samiti (PSS): It is also a registered NGO working in Chhattisgarh especially for the upliftment of tribal people belonging to below poverty line. It has trained about 1150-1200 tribal women / men in almost all districts of Chhattisgarh through organizing 25 training programmes on oyster mushroom cultivation.

Saheb Agrovet: It is a registered firm for the sale of mushroom spawn. It purchases spawn from various sources and makes it available to the mushroom growers, through its sale counter in Raipur.

Sradha Suman Samuh: It is a self-help group of 6 women of Tarra village (Dharsewa block of Raipur District) promoted by the Centre for mushroom spawn production. This group started working in August, 2005 and has sold about 3500 bags (250 g/ bag) of spawn. The group has also been trained in mushroom processing and have sold about one quintal of mushroom papad mainly for mid day meal scheme. These women are also acting as resource person for imparting training in mushroom programmes organized by the Department of Women and Child, Govt. of Chhattisgarh.

Swa Shakti Samuh: It is a self-help group of 10 women of Dondekhurd (Dharsewa block of Raipur District) promoted by the Raipur Centre and this group is actively involved in mushroom cultivation and transfer of mushroom production technology. The women belong to this group also act as resource persons for imparting training on mushroom cultivation for village women.

Chhattisgarh Mushroom Swayatt Sahkari Samiti: It is a registered NGO and has trained about 700-800 mushroom growers in Kanker and Jagdalpur areas. It is involved in mushroom spawn preparation and mushroom production. It had sold about 2000 spawn bags to different states of India.

Table 15: Mushroom spawn production in Chhattisgarh

Sr. No.	Name of the firm	District	Quantity (quintal per annum)
1.	Mushroom spawn lab, IGAU, Raipur	Raipur	8-10
2.	Chhattisgarh mushroom, Tendua, Abhanpur	Raipur	18-20
3.	Vanved Network Pvt., Ltd., Sadar Bazar, Raipur	Raipur	20-25
4.	Chhattisgarh Mushroom Swayatt Sahkarita Maryadit, Gudihari	Raipur	25-30
5.	Shri Satguru Mushroom Centre	Raipur	8-10
6.	Bose Mushroom Lab.	Raipur	8-10
7.	Roverent Mushroom	Durg	8-10
8.	Chhattisgarh Resource Organization	Durg	20-25
9.	Querishi Mushroom Farm	Durg	8-10
10.	Deshmukh Spawn Lab.	Durg	8-10
11.	Om Mushroom Farm	Rajnandgaon	12-15
12.	Biotech. Lab., Govt. of Chhattisgarh	Ambikapur	5-7
13.	Pradeep Shah Mushroom Lab.	Ambikapur	10-12
14.	Basant Gupta Mushroom Lab.	Bilaspur	12-15
15.	Raghav Mushroom Lab.	Bilaspur	15-20
16.	Precious Mushroom Spawn Lab.	Bilaspur	22-25
17.	Rupak Mushroom Lab.	Korba	40-50
18.	Annapurna Mushroom Farm	Korba	8-10
19.	Chakrabarty Mushroom Lab.	Durg	8-10
20.	Tamrakar Mushroom Lab.	Durg	5-7
	Total		**300-325**

Establishment of commercial units: With concerted efforts of the Centre on transfer of mushroom technology *viz*., training, live demonstrations, contributing articles, participation in kisan mela/

Table 16: Mushroom units promoted by Raipur Centre

Sr. No.	Name of Firm	Place	Proprietors	Targets
1.	Chhattisgarh Mushroom	Tendua (Abhanpur), Raipur	Ms. Namrata Ghai	95 kg / day
2.	Chhattisgarh Mushroom Processing Unit	Tendua (Abhanpur), Raipur	Ms. Namrata Ghai	-
3.	Om Mushroom	Dongargarh, Rajnandgaon	Sh. D. K. Shukla	90 kg / day
4.	Annapurna Mushroom	Korba	Sh. Ajay Vishwa-karma	70 kg / day
5.	Mushroom Corner	Raipur	Ms. Namrata Ghai	Sale of fresh mushroom, dry mushroom and processed product
6.	Roverent Mushroom	Durg	Sh. Rahul Gupta	Sale of fresh mushroom, dry mushroom and processed product

kisan diwas/ Rajyotsav etc., a lot of awareness has been created among common mass. Many entrepreneurs have established commercial units on oyster mushroom production, while some entrepreneurs have involved themselves in mushroom marketing. The details of the mushroom units promoted by Raipur Centre are listed in Table 16.

8.9. Vellayani Centre

A simple technique namely stapler method – a modified spawn production technique has been perfected at the Centre and is being practiced by the farmers. A simple cultivation technique for cultivation of *Calocybe indica* using spent compost of oyster mushroom was evolved for the first time in Kerala

Fig. 43. Training programme at Vellayani Centre

and the technology has been transferred to farmers of the State. Regular training programmes on cultivation of different varieties of mushrooms were conducted for unemployed youth, members of kudumbasree units, VHSE students, senior citizens and members of residents association (Fig. 43). Advanced training on production of milky mushroom was imparted to more than 3000 growers from different parts of State. TV programmes were recorded and telecasted on production of oyster and other important mushrooms. Regular advisory services were extended from the Centre to the mushroom growers of the state. Self-help programmes were also conducted with technical expertise of the staff of the university.

9. BENEFIT REAPED BY THE FARMERS

9.1. Punjab

The availability of production technology for growing different varieties of mushrooms round the year has enabled the growers in not only improving their dietary level but also their economic standards. This has also helped to recycle the abundantly available agricultural residues particularly paddy straw, into protein rich food, feed and fertilizer, thereby has solved the environmental pollution problem resulting from their *in situ* burning. The increased production in the State, which accounts for nearly 60 % of the total national produce also reflects the increased level of domestic consumption.

By the continuous efforts of the Ludhiana Centre, about 400 mushroom growers have adopted this venture for their livelihood. The mushroom growers can be classified into three categories namely i) small or domestic scale ii) medium scale and iii) commercial or large scale or industrial scale growers depending upon their straw processing capacity (Table 17).

A village, Dehriwal in Amritsar has more than 150 mushroom growers who are successfully cultivating white button mushroom. Large scale growers are concentrated in and around Amritsar, Patiala, Jalandhar, Ludhiana, Kapurthala, Hoshiarpur and Gurdaspur districts.

Table 17: Mushroom growers in Punjab

Type of Grower	Approx. no. of growers	Straw processing capacity (q)	Mushroom production (MT)/Annum
Small			
Domestic	200	<50	
Medium			5, 000
Cottage	125	<100	
Commercial			
Seasonal	70	>100	65, 000
Industrial	4	>500	

Few cold storage chambers have been converted to suit the mushroom cultivation in some of these districts.

9.2. Maharashtra

Commercial production of button mushroom in Maharashtra was started in 1972. Initially it was done in potato cold storage with some alterations in the structural designs. The total mushroom production in the Maharashtra was 300 MT during 1992-93 and it has increased to 2500 MT in 2005-06. More than hundred and fifty growers are engaged in the oyster mushroom cultivation, marketing, spawn production and processing. The popularity of milky mushroom is also increasing among the growers and the demand for milky mushroom is more in Mumbai, Pune and coastal Konkan region. Few growers have successfully started growing milky mushroom in the state.

The Pune Centre is catering the needs of mushroom growers by imparting practical training in cultivation of oyster and button mushroom. By the concerted efforts of the Centre, 20 spawn production units have been established to produce button, oyster and milky mushroom spawn with a production capacity of 3500 kg/year. There are more than 160 mushroom farms in the State with a production capacity of 2665 MT/year. There are 5 units engaged in production of value-added mushroom products *viz*., mushroom soup powder, mushroom biscuits, mushroom pickles, mushroom papad and mushroom powder capsule.

9.3. Tamil Nadu

Among different kinds of mushrooms, the farmers of Tamil Nadu prefer to grow oyster and milky mushrooms because of their simple cultivation techniques. Total production of mushrooms in the state is about 18,000 MT/ annum. In oyster mushroom, *Pleurotus florida, P. eous,* and *Hypsizygus ulmarius* are commercially grown in all parts of Tamil Nadu. About 400 spawn production units and more than 680 mushroom growers are distributed through out the State.

The sustained efforts made through AICRPM for the production and timely supply of quality spawn, mother cultures and stock cultures of various kinds of mushrooms has created a strong impact on mushroom production in the state. Many satellite mushroom growing units, self-help groups and spawn production centres have been

established through out the State due to the efforts made by Coimbatore Centre.

9.4. Faizabad

Over 5000 small and marginal farmers of the state have improved their economic status by adopting mushroom cultivation. Every year about 400 to 500 new mushroom growers are starting mushroom cultivation and presently the spawn requirement of the area is over 100 tons per annum.

10. MILESTONES AND LAMP POSTS OF THE PROJECT

10.1. Ludhiana Centre

The project had several milestones and lamp-posts during the last many years and they are listed below

- Infrastructure for short method of composting (pasteurization tunnel) created.
- A mushroom compost turner has been locally designed and fabricated as prototype. The same has been used as a model and a second one was fabricated at NRCM, Solan.
- Spawn production unit has been developed at the main campus and four additional spawn producing labs have been created in different districts (Patiala, Sangrur, Jalandhar and Hoshiarpur) by the State Department of Horticulture.
- Two test-cum-demonstration facilities in the form of walk-in growth chambers (climatically controlled) have been created (Fig. 44).
- Specialized mushroom training courses (four nos.) are a regular feature in the University training schedule for every year.

Fig. 44. Controlled growth chamber at Ludhiana Centre

10.2. Pune Centre

Since its establishment, the Pune Centre has played a key role in the development and dessimination of mushroom production technologies, and in imparting trainings to develop skilled man power. However, there are some key issues, which are listed below:

- Little awareness about nutritional, medicinal values and taboos, and superstition about mushrooms.
- Illegal and unrecognized mushroom training Centres.
- Low domestic consumption of mushrooms.
- Less number of recognised mushroom labs in the State.
- Low and inconsistent mushroom yield due to non-availability of high yielding and good quality strains.
- High input cost due to non-availability of abundant indigenous technologies.
- Lack of marketing channels and proper pricing.
- Lack of coordination and collaborations among growers and researchers.

Keeping in view, the mandates and objectives assigned, the Centre has the following future lamp posts

- Survey, collection, isolation and conservation of wild fleshy fungi.
- Genetic improvement / hybridization studies in cultivated edible mushrooms.
- Improvement and refinement in production technologies of new edible and medicinal mushrooms.
- Research on accelerated and improved composting by using microbes.
- Testing and utilization of newer waste materials for mushroom cultivation and as casing material.
- Recycling of spent compost and straw using useful microbes.
- Improvement and development of spawn production technology to increase shelf life and suitability for bulk transport.

- Integrated pests and diseases management for important pests and diseases encountered in mushroom production.
- Research on post harvest technology of mushrooms, to improve shelf life, packaging, drying and value addition.
- Effective transfer of technology through publications and distribution of literature, electronic media, holding of mushroom melas, demonstrations, exhibitions and training programmes.
- Transfer of technology through village adoption, collaboration with NGOs' and SHGs'.

10.3. Coimbatore Centre

The several milestones and lamp-posts of the Centre are listed below

- Evolving high yielding varieties of *Calocybe indica* and *Volvariella volvacea*.
- Exploring the possibility for the molecules of biopesticidal and pharmaceutical importance from macro Basidiomycetes.
- Creating new entrepreneurs for increasing the mushroom production.

10.4. Faizabad Centre

In 1980, mushroom production was almost nil in Uttar Pradesh and presently it is around 4000 tons. However, the several milestones and lamp-posts identified for the Centre are listed below

- Number of farmers involved in regular mushroom growing is over 5000 in eastern Uttar Pradesh and mushroom demand is more than supply.
- Over 100 % biological efficiency of *Calocybe indica* in a duration of 90-100 days harvesting.
- Over 35 % yield of button mushroom in a duration of 90-95 days harvesting.
- Day-by-day increasing demand of mushroom spawn.

10.5. Raipur Centre

- Release of Indira Sweta, a variety of oyster mushroom, *Pleurotus florida* for commercial cultivation in the entire state of Chhattisgarh.
- Development of spiral method of paddy straw mushroom cultivation around wooden / cemented poles which has almost

doubled the mushroom yield and enhanced the period of growing.

- Development of mushroom crop calendar for round the year cultivation of different mushrooms and their species under prevailing agroclimatic conditions of the Chhattisgarh State.
- Collection, identification & characterization of 102 wild mushroom flora from 16 districts of Chhattisgarh.
- Isolation, preservation & maintenance of about 28-30 species of Mushroom flora from Chhattisgarh.
- Identification of *Pleurotus florida, Pleurotus flabellatus, Pleurotus sajor–caju* as most promising species for cultivation in the entire state of Chhattisgarh.
- Identification of paddy straw/ wheat straw as substrate for oyster mushroom, white button mushroom, milky mushroom and paddy straw mushroom, while cotton waste for paddy straw mushroom cultivation.
- Collection, identification & characterization of eight local species of *Ganoderma lucidum* (Reishi Mushroom).
- In strain evaluation study, CI-10 strain of *Calocybe indica*, Vv-11 of *Volvariella volvacea*, NCS-100 (CM-3) and NCH-102 of *Agaricus bisporus* were found to be the most promising strains in several years of testing trials under prevailing climatic conditions of Chhattisgarh.
- Three Ph.D., 15 M.Sc. (Ag.) thesis and 35 undergraduate project works on different aspects of mushrooms.
- Organization of three National Seminars/Workshops and One ICAR sponsored Short Course on Mushroom.
- Publication of 35 research papers and presentation of about 65 research papers in International /National Conferences.
- Technical support to 20 mushroom spawn production units in the state of Chhattisgarh.
- Technical support to six commercial oyster mushroom production units in the state of Chhattisgarh.

- Publication of Literature in simple Hindi language (11 bulletins, 10 compendiams, 13 leaf folders, 2 CD's) for the rural people, illiterate women/men etc.

- Training of about 4000 entrepreneurs from seven States *viz*., Rajasthan, West Bengal, Bihar, Maharastra, Madhya Pradesh, Orissa and Chhattisgarh.

- Organization of five National Level and 79 sponsored training programmes on different aspects of mushrooms.

- Contribution of 75 popular articles in different magazines of national repute.

- Delivering of about 150 talks in different training programmes/ Kisan Melas/Kisan Gosthies/ Kisan Sammelan organized by different agencies.

- Delivering of 35 talks on television telecasted at Doordarshan Kendra Raipur, ETV and Local Channels on different aspects of mushrooms and plants diseases management.

- Delivering of 25 talks on All India Radio on different aspects of mushrooms and plants diseases management.

- Organisation of three days State level exhibition on mushroom production, mushroom recipes and mushroom processing technologies.

10.6. Vellayani Centre

A mobile mushroom unit is to be setup with all amenities in order to facilitate the faculty members to visit and conduct on the spot training, supply of spawn and inspect the work progress at the grower's farm. Each individual dwelling must be able to produce atleast one kilogram mushroom per day to meet his family nutritional requirement. Ready-made mushroom beds are to be supplied to the mushroom growers. People prefer ready-made beds since they lack time and patience to make their own mushroom beds.

Meetings of the mushroom growers are to be conducted once in three months for sharing of their experiences and shortcomings if any and transferring of any new technology devised at the Centre. Processing zones are to be set up in the rural areas by engaging rural women so that value added products

of mushroom can be prepared as part of cottage industry.

Establishment of a depository herbarium for tropical species of mushrooms and publication of a series of monographs on tropical species of mushrooms should be given attention.

Leaflets and brochures have to be prepared regularly with up to date details of technologies to popularize mushroom cultivation in Kerala State. Popular articles in magazines and media coverage are very essential to popularize mushroom cultivation. Ready to cook series of mushroom recipes have to be marketized to cope up with the high-speed life style.

11. INFORMATION GATEWAYS

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12. ATTRIBUTES OF MUSHROOM VARIETIES/STRAINS/ TECHNOLOGIES RELEASED

Important attributes of recommended mushroom strains and technologies released by AICRP (mushroom)

Variety / Strain / Technology	Compost / casing requirements	Salient features and response to biotic & abiotic stresses
NCS-100 of *Agaricus bisporus*	Pasteurized compost	❖ High yielding single spore isolate ❖ Peak yield in the first flush ❖ Fruiting bodies tough with short stipe, average weight 7.2
NCS-101 of *A.bisporus*	Pasteurized/unpasteurized compost	❖ Small stipe; pileus stipe ratio 2.28 as compared to 2.17 in strain S-11 ❖ Medium size fruiting bodies; average fruiting body weight 8.2g as compared to 9.5g in strain S-11 ❖ Peak yield in second flush ❖ Suitable for cultivation in plains in winter under natural /partially controlled conditions ❖ Fruiting bodies are tough with good post harvest quality
NCH-102 of *A.bisporus*	Pasteurized compost	❖ High yielding hybrid variety ❖ Suitable for cultivation on compost prepared by short method especially suitable for the hilly regions of the country ❖ Fruiting bodies tough with short stipe
P-1 of *A.bisporus*	Pasteurized/unpasteurized compost	❖ Long stipe, fruiting bodies open quickly, dark brown gills

Variety / Strain / Technology	Compost / casing requirements	Salient features and response to biotic & abiotic stresses
MS – 39 of *A. bisporus*	Pasteurized/unpasteurized compost	❖ Medium sized fruiting bodies, light brown gills, average toughness
NCB – 6 of *A. bitorquis*	Pasteurized compost	❖ Grows at a temperature of 22-26°C ❖ High yielding strain ❖ Mushroom with superior shelf–life ❖ Produces large size excellent quality smooth fruiting bodies ❖ Fruiting bodies about 3-5 cm in dia ❖ Resistant to known mushroom viruses and comparatively resistant to false truffle ❖ Yields 15kg mushrooms from 100 kg compost in 6 weeks of cropping, with 80 % yield in first 2-3 flushes under optimum growing conditions
NCB – 13 of *A. bitorquis*	Pasteurized compost	❖ Grows at a temperature of 22-26°C ❖ Prolific yielding strain ❖ Produces large size excellent quality smooth fruiting bodies suitable for fresh market ❖ Fruiting bodies with superior shelf life ❖ Fruiting bodies about 3-5.5cm in dia ❖ Resistant to known mushroom viruses ❖ Yields 15 kg mushrooms from 100 kg compost in 6 weeks of cropping
Pleurotus florida	Chemical treated or steam pasteurized substrate	❖ Suitable for cultivation under winter conditions between a temperature range of 10 – 20°C ❖ Fruiting bodies of light brown to pallid yellow in colour and 6 – 12 cm in size, grows in clusters ❖ Gives very high mushroom yield under favourable temperature conditions

Variety / Strain / Technology	Compost / casing requirements	Salient features and response to biotic & abiotic stresses
Pleurotus sajor-caju	Chemical treated or steam pasteurized substrate	❖ Suitable for warmer regions of the country and requires 22 – 28°C temperature for optimum mushroom yield ❖ Popular for its attractive shape, size and flavour ❖ Fruiting bodies with 4-12 cm dia pileus and 2 – 5 cm long stalk and greyish brown in colour, grows single or in clusters
Chemical treatment of substrate for oyster mushroom cultivation	Chemical treatment with 25 ppm concentration of carbendazim and 500 ppm of formalin for 12 – 14 hours	❖ Assured crop of oyster mushroom ❖ No infection from weed fungi like *Trichoderma*, *Penicillium*, *Sclerotium* etc.
Cultivation technology of Black ear mushroom (*Auricularia polytricha*)	Overnight soaking of saw dust, Draining of excess water, Mixing of wheat or rice bran @5.0% on dry weight basis, Filling in 2 – 3 kg capacity in polypropylene bags of 30 x 20 cm size, plugging followed by autoclaving at 22 p.s.i. for 2 hours, Mixing of wheat grain or saw dust based spawn @ 5.0% and incubation for 15 – 20 days for spawn run at 22-28°C, Making of longitudinal slits of 10 cm x 2 cm size and hanging of the bags in cropping rooms, Maintaining of 80 – 85 % RH, temperature 25-32°C, fresh air (2 – 3 times) each for 10 min/ day and 4 – 5 hours of diffused light	❖ Suitable under tropical and sub-tropical climates ❖ Popular for stomach and gastric disorders ❖ 15-20 days for spawn run ❖ Fruiting starts after 20-25 days of spawning

Variety / Strain / Technology	Compost / casing requirements	Salient features and response to biotic & abiotic stresses
Supplementation of oyster mushroom substrate with nitrogen rich supplements	Neem cake @ 4 % on dry weight basis during summer conditions or wheat or rice bran @ 4 % on dry weight basis during winter conditions	❖ Higher mushroom yield and better quality fruiting bodies ❖ Strict watch on bed temperature is needed as supplements tend to increase the temperature by 6 – 7°C
Spray treatment of 0.1% rooting hormone (Veradix–2 containing indole butyric acid) on button mushroom beds	Spraying of beds at the time of pin head initiation of 1st, 2nd and 3rd flushes with 0.1% solution of Veradix - 2	❖ Higher mushroom yield by 20 – 35% ❖ Higher mushroom yield during first 15 days of cropping ❖ Early first harvest by 1 – 2 days and has no effect in spawn run and case run ❖ Better quality fruiting bodies
Mixing of 'Phosphotika' biofertilizer @ 0.5% in compost at the time of spawning	Mixing of 'Phosphotika' biofertilizer containing phosphate solubilizing bacteria @ 0.5 – 1.0% in ready to spawn compost at the time of spawn mixing.	❖ Higher mushroom yield by 15 – 20% ❖ Early spawn run and early first harvest of mushrooms ❖ Lower incidence of competitor moulds in compost ❖ Heavier and whiter fruiting bodies ❖ Early first harvest by 2 – 3 days (post-spawning) ❖ Early spawn run by 2-3 days and no effect on case run
1.5% initial Nitrogen level in compost	Nitrogen level between 1.5 to 1.75% at the beginning of composting and C:N ratio in 25-30:1	❖ Congenial for button mushroom growth ❖ Minimum growth of competitor moulds ❖ Higher mushroom yield
Wheat straw/paddy straw as the substrate for button mushroom compost preparation	Can be used alone and in combination with each other	❖ Cheap and easily available ❖ Give good growth of button mushroom ❖ Higher mushroom yield

Variety / Strain / Technology	Compost / casing requirements	Salient features and response to biotic & abiotic stresses
Shortening of the composting period for button mushroom cultivation	Maintaining of initial Nitrogen level of 1.5% in compost and turning schedule at 0,2,4,6,8,10,12,14,16 days and spawning	❖ Saving of time and labour ❖ Higher compost from unit weight of the basal ingredients
CACing: Spawned casing or mixing of spawn run compost in casing material	The contaminants free spawn run compost is mixed in casing material at the time of casing	❖ Reduction in time taken for case run ❖ Controlled and synchronized flushes ❖ Enhanced mushroom yield
Chemical sterilization of long method compost	Mixing of Formalin and Bavistin @ 1.5 liter and 50 gm/ton compost, respectively 48 hours before spawning.	❖ Checking of competitor moulds and yellow mould disease ❖ Higher mushroom yield