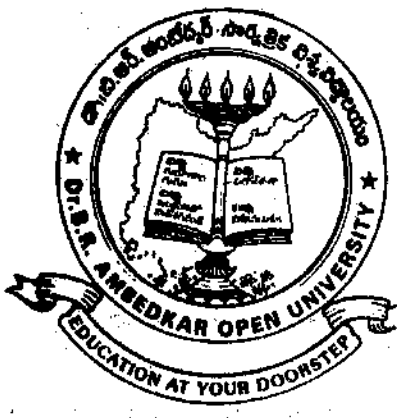
CERTIFICATE PROGRAMME IN MUSHROOM CULTIVATION

COURSE 2
CULTIVATION OF MUSHROOMS

Block 1	:	Introduction to Mushroom Cultivation
Block 2	:	Button Mushroom
Block 3	:	Oyster Mushroom
Block 4	:	Paddy Straw and Other Mushrooms
Block 5	:	Pests, Diseases & Economics



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PREFACE

This book deals with the Cultivation of Mushrooms included in the syllabus of six months duration certificate programme in Mushroom Cultivation offered by Dr. B.R. Ambedkar Open University. The topics generally cover the core area of the subject. The syllabus for the sake of convenience is divided into Blocks, each of which comprises a number of units. Each block generally covers a specific area of the subject. The units are prepared by the specialists in accordance with the format so designed as to enable the student to read and understand them without much difficulty. Each unit begins with a statement of its contents followed by objectives. In order to check the student's understanding ability, some questions are introduced here and there in the unit. The students can write the answers in the space given below every question and compare their answers with those given at the end of the unit. At the end of each unit summary and model examination questions are given for quick reading and to acquaint the student with the type of questions that appear in the examinations.

This paper on Cultivation of Mushrooms is included mainly to acquaint the students with the names of different mushrooms which are cultivated, the morphology and commercial production of button mushroom, oyster mushroom, paddy straw mushroom, shiitake mushroom, black ear mushroom, milky white mushroom etc. The preparation of spawn for these mushrooms, different methods of cultivation, harvesting, processing, preservation techniques and marketing are also dealt with. In addition to these, various problems caused due to competitor moulds and diseases caused due to fungi, bacteria and viruses and also the damage caused due to various pests and nematodes are also clearly given along with control measures. To acquaint the students with various recipes of mushrooms, the ingredients and method of preparation of the Western and Indian recipes of several kinds are included in this volume. There are three assignments at the end of the book and the students are expected to answer any two of them and submit to the coordinator/Asst. Director/Dy. Director of the concerned study centre.

The University hopes that this material will help the students to understand the methods of cultivation of mushrooms. Critical suggestions for improving the text are most welcome and they will be incorporated in the future edition.

C O N T E N T S

BLOCK - 1
INTRODUCTION TO MUSHROOM CULTIVATION

UNIT - 1 : CULTIVATED MUSHROOMS

Contents

1.1. OBJECTIVES

After going through this unit you will be able to :

- give the historical account of mushrooms,
- list out the commonly cultivated mushrooms all over the world,
- describe the distribution of cultivated mushrooms in the world,
- describe the production of mushrooms in various countries.

1.2. INTRODUCTION

Mushrooms are the fleshy spore bearing organs of some fungi. Fungi are non-chlorophyllous organisms living mostly as saprophytes. The majority of the mushrooms belong to the class Basidiomycotina and a few to Ascomycotina under kingdom Fungi. The fruit bodies of basidiomycetous fungi are commonly called basidiocarps or basidiomata. The basidiocarp has a fleshy stipe or stalk, a membranous veil or annulus and the cap or pileus. The basidiospore bearing layer known as hymenium is present in the gills situated on the underside of the pileus starting from the apex of the stalk and radiate out towards the margin. e.g., *Agaricus*. Numerous pores may be present in the fruit body e.g., *Boletus*. Fruit body may be covered with teeth like structures e.g., *Hydnum*. Fruit bodies which are angiocarpous (closed) and open by an apical pore at maturity are produced in Gasteromycetes e.g., *Lycoperdon*. Other fleshy fungi like *Morchella* belong to Discomycetes of Ascomycotina produce ascospores in a sponge like fruit body. Around 2000 species are edible throughout the world and all of them are not cultivated.

1.3. HISTORICAL ACCOUNT

For the first time in the world in China about 1000 years ago, a species of *Auricularia* (Black ear mushroom) was cultivated. Later on, about 900 years ago, *Lentinus edodes* (Shiitake-mushroom) was produced in China only. In the year 1650 *Agaricus bisporus* (Button mushroom) was cultivated in France. About 300 years ago *Volvariella volvacea* (Paddy straw mushroom) was cultivated in Kwangtung Province in China. Tournefort in the year 1707 at Royal Academy of Science demonstrated the compost preparation and mushroom cultivation. Miller (1731) introduced the French method of *Agaricus* cultivation in England. In the year 1779 Abercrombie described a method of composting stable manure in stacks. Chambry, a French gardener (1810) grew button mushrooms in underground quarries in Paris. In the year 1831, Callow cultivated button mushrooms in cropping houses. He warmed the cropping rooms by fire heat and got good yield of 1.5 lbs/sq ft. In the year 1893, Costanin emphasized the need of changing of growing area due to the danger of disease incidence. In 1902, Ferguson in America published his work on spore germination and growth of mycelium. Duggar (1905) was successful in preparing mycelium cultures from the tissue of button mushroom caps, a significant breakthrough for the establishment of many spawn laboratories in America.

In 1915, Mushroom growers in U.S.A introduced the second phase of composting called sweating out. Flack (1917) described the cultivation of *Pleurotus ostreatus* on logs and tree stumps. Lambert (1929) discovered that spawn could also be prepared from single spore cultures of *Agaricus*. This led to the further development in improving the cultures. Above ground cultivation has originated in Sweden. Lundberg (1754) described the method of growing mushrooms in green houses. Sinden (1932) patented grain spawn process. Sinden and Tschierpe have done useful work on composting and environmental control. In the last 30 years much has been done in the field of mechanisation. France, Taiwan, U.S.A., U.K., Holland, China, Japan, Korea, Italy, Malaysia and other countries are making significant contributions in the production of mushrooms in the world.

Sinden (1937) observed that about 1/3 of monospore cultures of *A.bisporus* were not producing fruit bodies. Sinden and Hauser (1950) introduced "short method" of composting. In 1951, *Pleurotus* was grown on saw dust mixtures by Lohwag. Hau, Block and Tsao cultivated large number of *Pleurotus* fruit bodies on sterile saw dust and oat meal mixtures. In 1962, Bano and Srivastava used many straw based substrates for the cultivation of *Pleurotus*. In 1961, Bano etal observed that *Pleurotus* yields are more on paddy straw. Hybridization method of *A. bisporus* was developed by Robert Miller (1971). In 1973, Somycel, a French firm introduced *A. bitorquis* strain (strain no.2017) commercially. In 1974, Purkayastha and Chandra reported a wild edible fungus, *Calocybe indica* for the first time in India from the forests of West Bengal. Due to its colour it is popularly known as milky white mushroom.

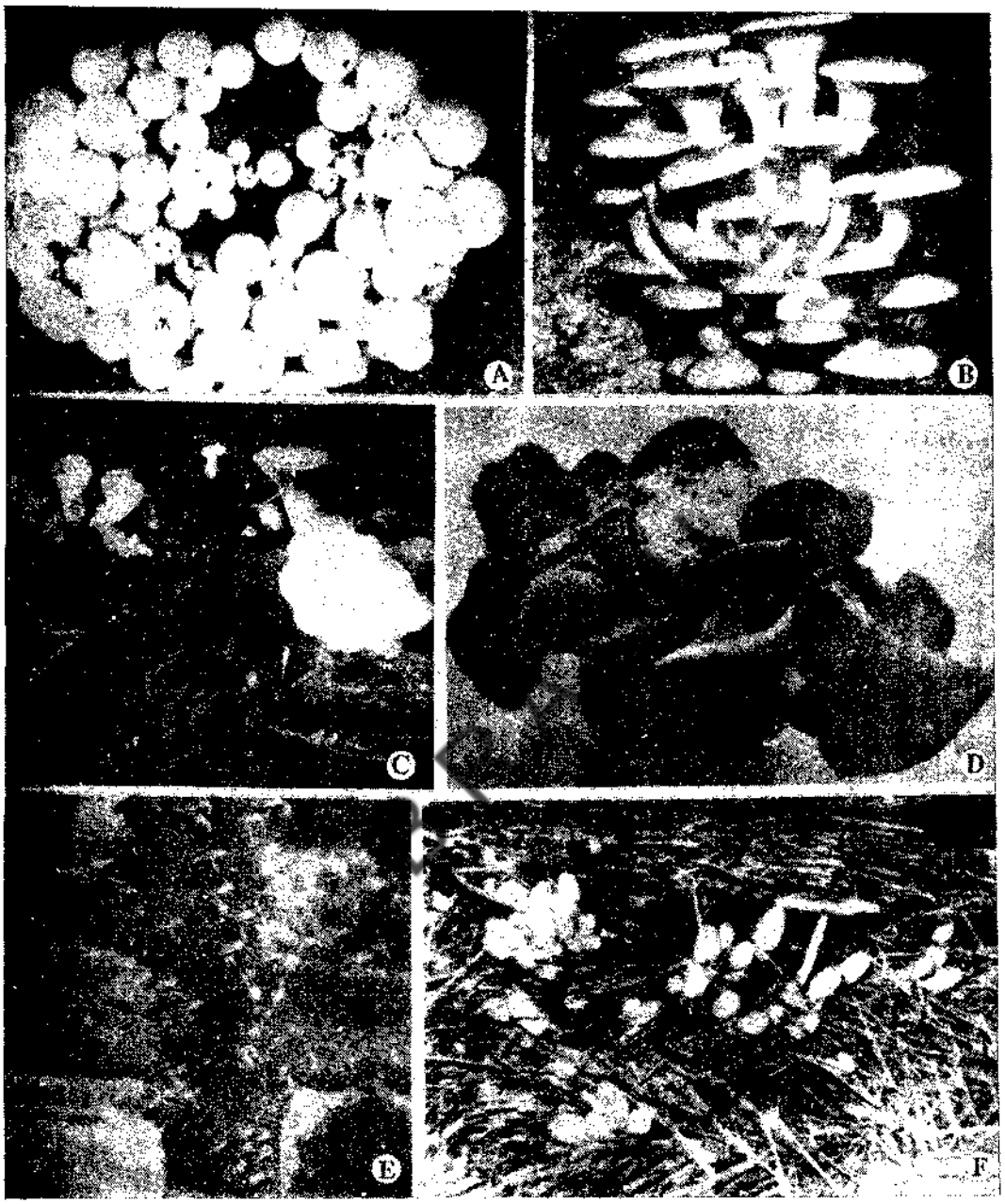

Fig.1.1. Commonly cultivated mushrooms. A. *Agaricus bisporus*. B. *Pleurotus florida* C. *Calocybe indica*. D. *Auricularia polytricha*. E. *Lentinus edodes*. F. *Volvariella volvacea* (Courtesy of NCMRT and Chang and Miles)

In India, though methods of cultivation were known for many years, cultivation of mushrooms is of recent origin. In the year 1886, N.W. Newton exhibited some mushrooms at the annual show of Agriculture, Horticulture society of India. Dr B.C.Roy (1896-97) of Calcutta Medical College conducted the chemical analysis of the mushrooms occurring in local caves and mines. Sir David Pain (1908) conducted the survey of edible mushrooms. Bose, in the year 1921 cultured two agarics on sterile dung media. During 1939-45 *Volvariella* was cultivated by the Department of Agriculture, Madras, on experimental basis. Asthana (1947) carried out the chemical analysis of Paddy straw mushroom. He also suggested that April-June is the most suitable period for growing this mushroom. In 1961, Himachal Pradesh state government in collaboration with ICAR (Indian Council of Agricultural Research) started a scheme at Solan on Mushroom cultivation where serious attempts were made for button mushroom growing. In 1964, button mushroom was grown by CSIR (Council for Scientific and Industrial Research) and state government at Srinagar in Jammu and Kashmir. From 1965-72 Mushroom expert, Dr. E.F.K. Mantel, F.A.O (Food and Agricultural Organisation) guided and assisted the Department of Agriculture for construction of a well equipped spawn laboratory and a fully air conditioned mushroom farm house. In 1974, Mushroom expert, W.A. Hayes, F.A.O., assisted in imporving the method of compost preparation, pasteurization and management of important parameters in the farm. Department of Horticulture, Himachal Pradesh in the year 1977, launched 1.27 crore Mushroom Development Project under U.N.D.P. (United Nations Development Programme). From 1983, NCMRT (National Centre for Mushroom Research and Training) started functioning. AICMIP (All India Coordinated Mushroom Improvement Project) was sanctioned by ICAR (Indian council of Agricultural Research) during VI plan in April 1983 at a total cost of Rs.16.72,800/- with head quarters at NCMRT, Solan. The six centres sanctioned initially are G.B.Pant University of Agriculture and Technology, Pantnagar (Uttar Pradesh), Punjab Agricultural University, Ludhiana (Punjab), Tamil Nadu Agricultural University (Coimbatore), Bidhan Chandra Krishi Viswa Vidyala, Kalyani (West Bengal), M.P.A.U. College of Agriculture, Pune (Maharashtra), and C.S. Azad University of Agriculture & Technology, Kanpur (Uttar Pradesh). Since then significant research work on cultivated mushrooms has been carried out at other centres also like NCMRT (ICAR), Solan, Division of Mycology and plant pathology, IARI (Indian Agricultural Research Institute), New Delhi, Indian Institute of Horticulture Research, Hessaragutta, Bangalore, ICAR Research complex, North Eastern Hills, Shillong, Regional Research Laboratory (CSIR), Srinagar, Indira Gandhi Krishi Vidyalaya, Raipur (Madhya Pradesh) etc.

Man has been interested in mushroom cultivation since ancient times. Bose (1921) was successful in culturing two agarics. Sue and Seth (1940) outlined the procedure of the spawn production of *Volvariella*. Munjal (1982) has discussed the prospects of mushroom cultivation in India. Indian Council of Agricultural Research and Government of Himachal Pradesh started the experimental cultivation of mushrooms at Solan in 1961. This was strengthened by Dr. E.F.K. Mantel, the

FAO expert. The conversion of Mushroom Research Project, Solan into an ICAR Coordination Research Scheme with main centre at Solan and three subcentres at Ludhiana, New Delhi and Bangalore gave a further fillip to mushroom production in India. Commercial production of mushrooms was first started in New Delhi and Solan, Later it has spread to Jammu and Kashmir, Nilgiris, Punjab, Haryana, Chandigarh, Uttar Pradesh, Maharashtra, Madhya Pradesh, Gujarat, Bangalore, Madras and Andhra Pradesh

Check Your Progress - 1 & 2

1. What are mushrooms ?

2. Name the first cultivated mushroom in the world ?

Note : (i) Write your answers in the space provided below.
(ii) Compare your answers with those given at the end of this unit.

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1.4. COMMONLY CULTIVATED MUSHROOMS IN THE WORLD

There are more than 2000 edible fungi throughout the world. However, there is no sufficient technology available for cultivating all mushrooms. Four types of mushrooms are cultivated in different countries for centuries. They are white button mushroom (*Agaricus bisporus* or *A. bitorquis*), paddy straw mushroom (*Volvariella* spp.), oyster mushroom (*Pleurotus* spp.) and shiitake mushroom (*Lentinus edodes*).

Recently some other mushrooms are also grown in different parts of the world. They are black ear mushroom (*Auricularia polytricha*), nameko mushroom (*Pholiota nameko*), enokitake mushroom (*Flammulina velutipes*), giant fungus (*Stropharia rugoso-annulata*), truffles (*Tuber melanosporum*), jelly fungus (*Tremella fusiformis*) and milky white mushroom (*Calocybe indica*). Commonly cultivated mushrooms and their taxonomic position are given in Table - 1.1.

Table - 1.1 : Commonly cultivated mushrooms.

Genus	Family	Order	Sub class	Class
Agaricus	Agaricaceae	Agaricales	Holobasidiomycetidae	Basidio mycetes
Auricularia	Auriculariaceae	Auriculariales	Phragmobasidiomycetidae	"
Tremella	Tremellaceae	Tremellales	"	"
Coprinus	Coprinaceae	Agaricales	Holobasidio-mycetidae	"

Genus	Family	Order	Sub class	Class
Flammulina	Tricholomataceae	"	"	"
Lentinus	"	"	"	"
Pleurotus	"	"	"	"
Tricholoma	"	"	"	"
Dictyophora	Phallaceae	Phallales	"	"
Hericium	Hericiaceae	Aphyllophorales	"	"
Hypholoma	Hypholomataceae	Agaricales	"	"
Kuehneromyces	Strophariaceae	"	"	"
Pholiota	"	"	"	"
Stropharia	"	"	"	"
Volvariella	Pluteaceae	"	"	"
Tuber	Tuberaceae	Tuberales	Hymenoascomycetidae	Ascomycetes

Check Your Progress - 3

Name the four commonly cultivated mushrooms in the world ?

Note : (i) Write your answer in the space given below.

(ii) Check your answer with the one given at the end of this unit.

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1.5. DISTRIBUTION OF CULTIVATED MUSHROOMS

The cultivated mushrooms are distributed world wide. *Agaricus* spp have been cultivated in U.S.A., China, France, Holland, Italy, England, India and others. China, South Korea, Taiwan, Italy, India etc are mostly cultivating oyster mushrooms. Paddy straw mushroom has been distributed in China, Taiwan and Thailand. Japan, China, Taiwan and more recently Europe, America, and Australia have been cultivating shiitake mushroom (*Lentinus edodes*). More recently other types of mushrooms like black ear mushrooms, jelly fungi, truffles, enokitake, nameko etc., have been cultivated in different parts of the world.

1.6. PRODUCTION OF MUSHROOMS IN VARIOUS COUNTRIES

Since world war II the production of mushrooms has been increasing steadily. The table - 1.2 shows the percentage production of various mushrooms throughout the world.

Table - 1.2 : World production of cultivated edible mushrooms (%) (Source : Chang and Miles).

Name of the Mushroom	1975(%)	1986(%)	1989-90(%)
1. White button	73	56	38
2. Oyster	1.3	7.7	24
3. Paddy straw	5	8	5.5
4. Shiitake	14	14	10.4
5. Black ear	0.6	5.5	11
6. Jelly fungus	0.2	1.8	2.8
7. Nameko	1.6	1.1	1.4
8. Enokitake	4.2	4.6	3.8
9. Others	0.16	0.5	3.5

Agaricus bisporus, the white button mushroom is being cultivated commercially in many countries like U.S.A. (23%), China (15%), France (13%), Holland (9%), United Kingdom (7.7%), Italy (65%) and other countries (25%). The major oyster mushroom producing countries are : China (59%), S.Korea (21%), Italy (6%), Taiwan (5%) and others (9%). Major countries producing paddy straw mushroom are : China (56%), Thailand (34%), Taiwan (3.7%) and others (3%). Shiitake Mushroom is being produced in countries like Japan (51%), China (38%), Taiwan (10%) and others (25%). Approximate mushroom production in India is around 15,000 tonnes per year.

Check Your Progress - 4

Name the leading country in the production of paddy straw mushrooms?

Note : (i) Write your answer in the space given below.
(ii) Compare your answer with the one given at the end of this unit.

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1.7. FOOD VALUE OF EDIBLE MUSHROOMS

Sufficient food supply is the need of the hour for growing population. It is essential that search must be made for alternate sources of energy and food. Mushrooms contain all essential aminoacids, elements, proteins, vitamins and others. They contain more water and lesser values of fat, starch and cholesterol. It forms healthy diet for people suffering from diabetics and cardiac problems. To solve protein hunger and malnutrition cultivated mushrooms become a great source besides being a good source of energy. Mushrooms form a low calorie diet. The following table gives an insight into different nutrients present in edible mushrooms.

Table - 1.3 : Composition of common edible mushrooms (g/100g of fresh weight).

S.No.	Mushroom	Moisture	Protein	Fat	Carbo-hydrate	Fibre	Ash	Calories
1.	*Agaricus-bisporus*	90.1	2.9	0.3	5.0	0.9	0.8	36
2.	*Volvariella-volvacea*	90.1	2.1	1.0	4.7	1.1	1.0	36
3.	*Pleurotus sajor-caju*	90.2	2.5	0.2	5.2	1.3	0.6	35

* Source : Gopalan etal. (1971). "Nutritive Value of Indian Foods". N.I.N. Hyderabad.

1.8. SUMMARY

Mushrooms are the fleshy, macroscopic spore bearing structures of some fungi belonging to Basidiomycotina and Ascomycotina. Fungi do not contain chlorophyll in them and thus depend upon others for food either as saprophytes or parasites. There are nearly 2000 types of edible mushrooms available throughout the country. Cultivation of mushrooms started around 1000 years ago. In India, N.W. Newton was the first to exhibit mushrooms in an horticultural show. In 1961 ICAR in collaboration with the state government of Himachal Pradesh started a scheme on "Mushroom cultivation" at Solan. Slowly mushroom cultivation has become popular among various Universities and Horticultural Institutes in India. White button (*Agaricus bisporus*), oyster mushroom (*Pleurotus* spp), paddy straw mushroom (*Volvariella* spp) and shiitake mushroom (*Lentinus edodes*) are the most commonly cultivated mushrooms in the world. Other mushrooms like black ear, nameko, enokitake, jelly fungus, truffle, giant fungus also have been cultivated to some extent. The cultivated mushrooms have been distributed throughout the world. U.S.A., China, Taiwan, France, England, Italy, Korea, Japan have been engaged in the production of mushrooms and mushroom production has become a technology.

1.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Mushrooms are the fleshy spore bearing organs of some fungi.
2. *Auricularia* (Black ear mushroom) is the first cultivated mushroom in the world.
3. White button, oyster, shiitake and paddy straw mushrooms are the commonly cultivated mushrooms in the world.
4. China is the leading country in the production of paddy straw mushrooms.

1.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines.

1. Write briefly the historical account of cultivated mushrooms.
2. Write a brief account on the cultivated mushrooms in the world and add a note on their distribution.

II. Answer the following questions in about 10 lines each.

1. Write a note on commonly cultivated mushrooms.
2. Write briefly about the production of mushrooms in various countries.

Ms. K. Prasunamma

BLOCK - 2
BUTTON MUSHROOM

UNIT-2 : MORPHOLOGY AND COMMERCIAL PRODUCTION OF BUTTON MUSHROOM

Contents

2.1. OBJECTIVES

After going through this unit you will be able to :

- describe the morphology, occurrence and distribution of button mushroom,
- estimate the commercial production of button mushroom in developed countries,
- estimate the commercial production of button mushroom in developing countries particularly in India,
- describe the environmental conditions required for the cultivation of button mushroom.

2.2. INTRODUCTION

Button mushroom which is also known as white button mushroom or European mushroom is being cultivated all over the world. Forty percent of the total world production of mushrooms come from the white button mushroom only. In the year 1650, this mushroom was first cultivated in Paris (France). The mushroom derives its name due to its closed, button like fruiting body during young stage. The fruit body is divided into various parts viz., stipe (stem), pileus (cap), lamellae (gills) and veil.

Button mushroom is grown on small to large scale all over the world. Since last two to three decades many Asian countries started its commercial cultivation. Developed countries like U.S.A., France, Netherlands, U.K., Italy etc., started using bulk pasteurization system and computer controlled environmental operations. In India, button mushroom production was started by Maharaja of Patiala

at Chail, Himachal Pradesh in the year 1965. India, being an agriculture country is having the excellent opportunities for growing button mushroom commercially.

While designing the farm house for growing button mushrooms one should be careful in choosing the site, while constructing the composting yard, bulk chamber, growing rooms etc.

2.3. MORPHOLOGY

The mushroom is a fruiting body connected to the root like structure known as mycelium made up of filaments called hyphae. It is made of a cap (the pileus) and a stalk (the stipe). Underneath the cap is spore bearing tissue called hymenium made of gills. In early stage gills are covered by veil which breaks when mushrooms are mature and remains of this can be seen as a ring around the stalk. The basidiocarp of button mushroom can be divided into pileus, gills, veil, and stipe. Each one of them is described below.

a) Pileus : This part is thick, fleshy, smooth, cap like, round structure. It is also called cap.

b) Gills : Gills or lamellae are situated underneath the cap starting from the apex of the stalk to margin of the cap and bear brown, short, ellipsoid and smooth spores. Lamellae whitish initially then turn to pink and finally to the colour of spores.

c) Veil : This covers the gills extending from the margin of cap to the stalk. With the development and maturity veil breaks away resulting some portion attached to the cap's margin and appearance of a ring on the stipe. This is called annulus.

d) Stipe : This is also known as stalk centrally attached to the pileus. It is solid and cylindrical connected to root like mycelium spread in soil/compost.

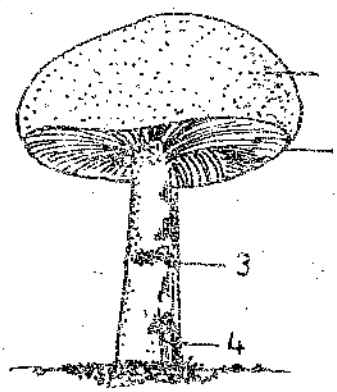

Fig: 2.1. Basidiocarp of *Agaricus bisporus* 1. Pileus or cap. 2. Gills or Lamellae. 3. Annulus. 4. Stalk or stipe.

2.4. PRODUCTION

Button Mushroom is the most popular throughout the world and grown on small to large scale in many countries. Initially its cultivation started in France

and later on spread to U.K., U.S.A. and other European countries. During the last two to three decades its cultivation on commercial scale started in Asian countries viz., China, India, Japan, Taiwan, South Korea, Hongkong, Singapore and Australia. Its cultivation is also being done in some African countries. At present the button mushroom production is estimated to be around 1.5 million tonnes per annum.

2.4.1. Production in Developed Countries

The major mushroom producing countries are developed ones viz , U.S.A., France, Netherlands, U.K., Italy etc., (Table: 2.1.). The technology being used in these countries are based on bulk pasteurization system and environmental factors are controlled by the computer. There are minor variations where some farms do phase 1 (outdoor) and phase 2 in bulk chambers and even spawn running is done in these chambers. Growing is done in shelves using beds or polythene bags.

The button mushroom cultivation started about 1630 in France. Chambry's year round production in protected area represent the beginning of mushroom industry. There is very little information about early stages in evolution of cultivation methods adopted. Basically the process of cultivation is almost same with more precision in compost and spawn production and environmental control system whether it is grown in racks, trays, polythene bags or on shelves. However the biology of cultivation is same irrespective of method adopted.

The total annual production of white button mushroom in major countries is given below.

Table-2.1. Annual Production of white button mushroom in major countries (Tonnes X 100)

Country	1980	1981	1982
France	131.7	131.2	143.2
Holland	60.0	68.0	71.0
U.K.	61.8	63.8	66.6
Italy	44.0	44.0	43.2
West Germany	35.0	37.8	30.0
Belgium/Luxemburg	13.0	13.0	13.5
Ireland	6.7	6.5	9.5
Denmark	6.6	5.9	6.2
U.S.A	213.3	224.0	229.0
China (Estimated)	66.8	80.0	87.0
Taiwan	64.4	55.5	52.5
Spain	35.0	32.5	32.0
Canada	29.1	32.6	32.0
South Korea	25.6	18.9	15.0
Australia	8.3	8.3	9.4
Japan	5.5	4.5	4.5
Switzerland	3.3	2.9	3.2
Sweden	2.1	2.3	2.3
Total	812.2	831.7	850.1

(Source: The Biology and Technology of cultivated mushroom)

2.4.2. Production in Developing Countries

In India button mushroom production is being done in Himachal Pradesh (H.P.), Jammu and Kashmir, Haryana, Punjab, Uttar Pradesh, Karnataka, Andhra Pradesh, Kerala, Maharashtra, Madhya Pradesh and West Bengal. This mushroom was introduced in H.P. during 1965 by Maharaja of Patiala at Chail. Initially its production in the country was quite low however in recent years it has picked up particularly due to big units coming up for export market. There are large number of small and medium growers mostly during seasonal cropping as in Northern states.

2.5. PROSPECTS OF CULTIVATION IN INDIA

In India more than 85 per cent population live in villages and their main occupation is agriculture. The food grain production has increased after the green revolution in mid sixties. Thus there is little possibility for further increase in crop production. With the raise in agricultural production, the farmers have been facing problem of utilisation of these wastes. These agricultural wastes on burning lead to pollution and also waste of organic material.

In India, the population is mostly vegetarian and as the Indian diet is cereal based protein deficiency is more prevalent in certain areas. Mushrooms require less land and can utilize the agricultural wastes effectively yielding valuable protein. Thus mushroom growing can fill the protein gap to a large extent in our country.

They earn foreign exchange to the country. Besides there has been lot of awareness about mushrooms in our country. Thus mushrooms have both domestic and international demand. APEDA (Agricultural and Processed Food Products Export Development Authority) suggested the following points regarding the prospect of mushroom production in India.

1. Due to the high nutritive and medicinal values mushroom consumption is increasing day by day in the world.
2. Mushroom cultivation is labour intensive. There is decline in production of mushrooms in Taiwan and South Korea due to high labour cost. Thus India enjoys its advantage.
3. Due to the fall of production in developed countries the world trade is declining.

Thus India has excellent opportunities in button mushroom production.

Check Your Progress - 1

Write the future prospects of button mushroom production in India?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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2.6. FARM DESIGN

Button mushroom cultivation is horticultural activity where hygiene is most important. Hence farm should not be constructed near the other mushroom farms or business which would affect it. Since button mushroom cultivation is indoor activity, it does not take much land area.

1. **Building plot :** While selecting plot one must keep provision for future expansion. Plot should be approachable by road for the delivery of raw materials and removing materials, spent compost etc. There should be proper water, electricity and sewage facilities. Farm layout should be prepared after drawing the plan of the farm. However, farm should be constructed in phased manner, for example, if farm is of 12 rooms only first 3 or 4 rooms should be constructed initially. In India there are small, medium and big farms. Generally small and medium farms have conventional steam pasteurization rooms along with spawn running and cropping rooms using wooden trays for both pasteurization and cropping or only for pasteurization. Cropping is done either in shelves or in polythene bags. However, some medium and large farms are having bulk pasteurization chambers for compost pasteurization and cropping is done either in shelves or bags. Some big farms are using cold storage as one zone system i.e., all the operations (pasteurization to cropping) are carried out in shelves in same room.

2. **Design of farm :** There are different types of mushroom farm designs in different parts of the world suiting local conditions. However, the Dutch farm design is becoming more popular with modifications to suit local requirements. In the Netherlands cropping rooms with 200 m^2 cultivation surface are used in which there are two rows of shelves each having 5 beds one above the other. The room size is: breadth 6.00 m x length 17.75m x height 3.80m. In front of the room 4 m wide passage is provided where as in backside cemented area is provided to facilitate compost filling. With the introduction of bulk chamber big farms are adopting it and such farms go for 12 rooms (200 m^2 each and 20 tons of compost in bags) with one composting platform (100' x 45') with

provision for further expansion. Two bulk chambers (20 tons capacity) are provided.

i) **Composting platform** : It is advisable to have spacious platform with 2 parts, one at lower level with slope and medium size tank to collect seepage water and another about 3′ above ground level with small tank for collection of seepage water and it should be provided with shed. Platform should have road approach for delivery of raw materials. For 10 tons compost 50′ x 25′ size farm can be utilized and big platform should be used for big projects.

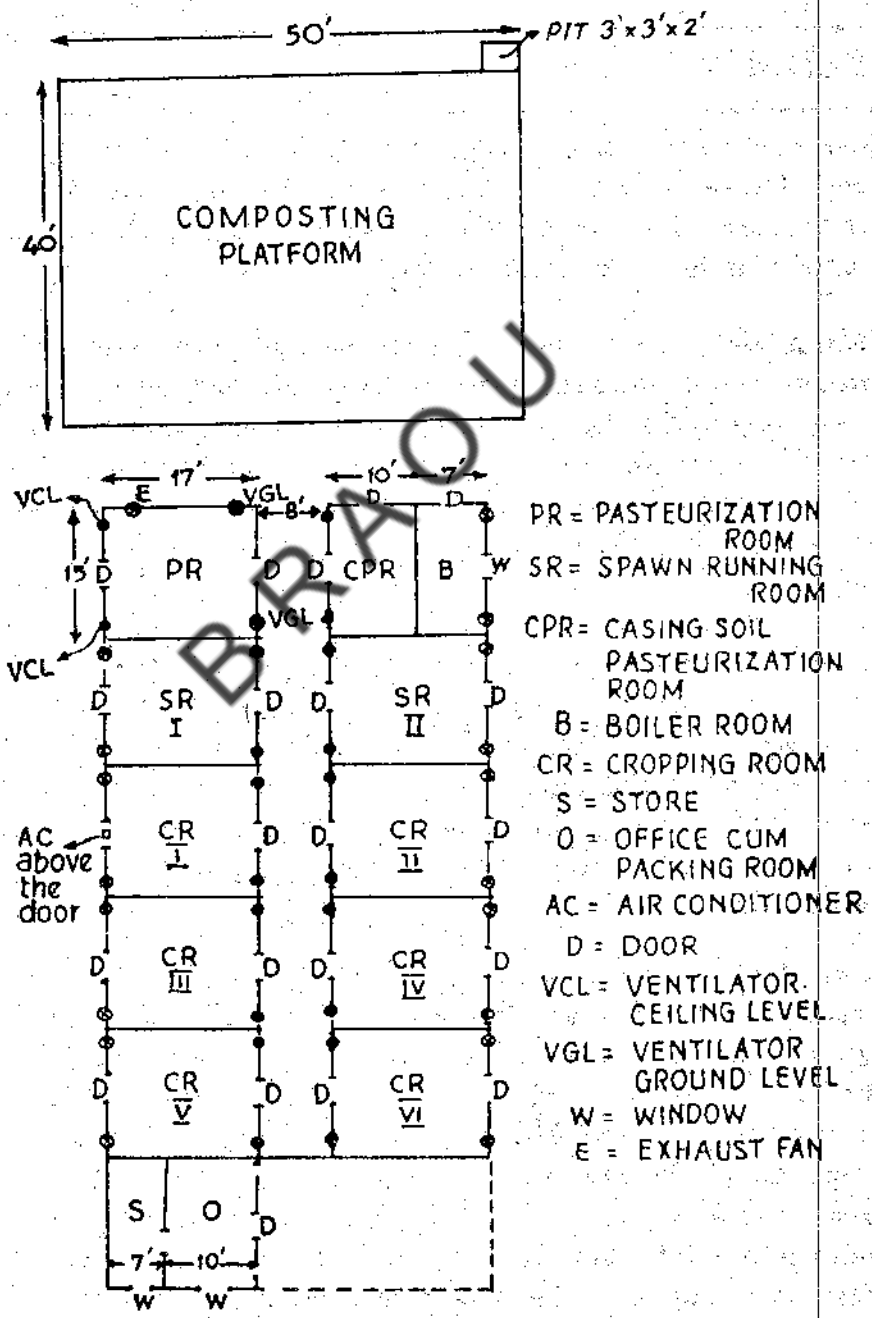

Fig. 2.2. Farm layout of white button mushroom.

ii) **Bulk chamber :** The size of chamber depends on the compost to be loaded. For 20 tons capacity bulk chamber with 36′ x 9′ x 12′ (length x breadth x height) dimension is used; wall should be well insulated. The plenum should be 3′ deep on the side of fan and other end 6" deep; this helps in uniform distribution of air. Grated floor is provided with either wooden or iron with 25-30 % of the total area left in the form of gap for movement of steam and air. Walls are provided with 5cm thick insulating material between brick wall (9"wide) and inside plaster. Roof is also insulated and surface is sprayed with bituminous paint to serve as a vapour barrier. The chamber will have two exhaust vents, one for recirculation exit and the other for exhaust of gases on introduction of fresh air via filters. Doors (provided at both ends) should also be insulated and air tight.

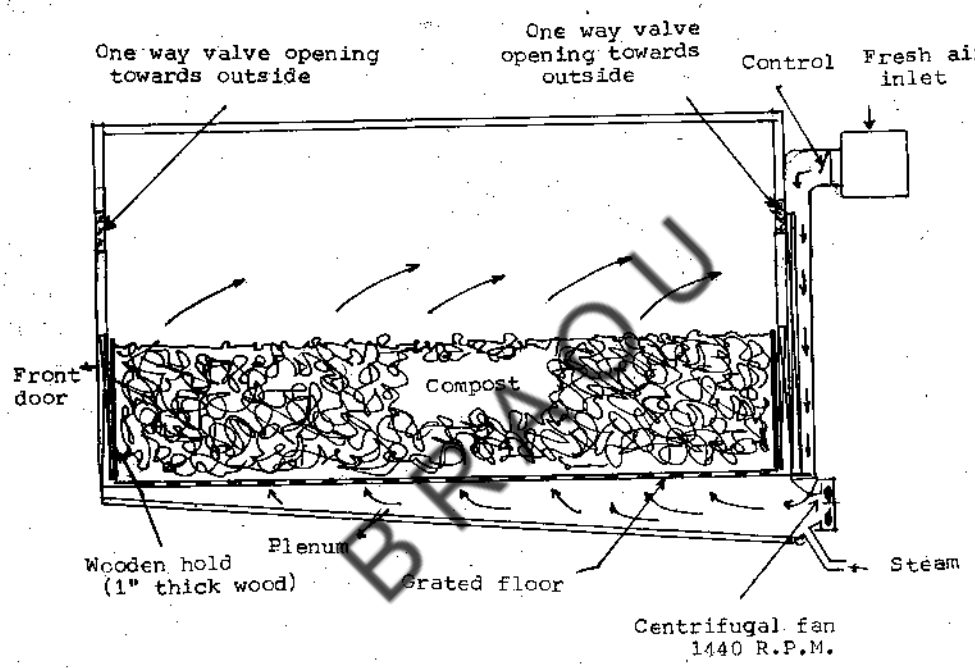

Fig. 2.3. Cross section of bulk chamber

During pasteurization an airflow of 150-200 m^3/hour per ton of fresh compost is required. Compost filling should be 900-1000kg/m^2 floor area with depth of 2-2.2m. There will be a loss of about 25-30% dry matter. Filling in tunnel should be always loose and uniform. There may be loss of about 10% moisture content.

In India small chamber 22′ length x 8′ width x 10′ height with iron door (6′ x 4′) has been used after providing proper insulation. The boiler with a capacity of 300 p.s.i and coal/wood/oil fired will be enough. The blower is used to introduce and recirculate hot air. The blower has 24" fan with an opening for fresh air from one side with provision to control air by adjusting shutter. The blower is run by 1440 rpm motor and pulling 6" x 3" is used to run blower (6" fitted with blower and 3" with motor).

In India many farms have conventional pasteurization rooms where compost is filled in trays and stacked in centre of the room. On one side steam pipe (perforated) is provided at about 4′ ht. from ground; on this side only, fan is provided at about 75 cm away from the vent at ceiling level. Trays are stacked in centre leaving 3′ gap from ceiling to provide free movement of air from the duct. At 1-2′ above ground level on other end of duct ventilator with wire mesh is provided for the escape of gases. The size of pasteurization room should be same as spawn running and cropping or a little smaller. It should be insulated or made of hollow cement brick wall.

Growing rooms : Growing rooms should be insulated. Bricks or cement hollow bricks are used for construction. Generally ground is not insulated. There should be provision for forced air circulation system installed centrally on top of the entry door. There should be provision for humidity control. Vents with fine wiremesh are also provided at about 3′ above ground level on both sides of door and backside. Though in Europe cropping rooms are quite big in size, in India we use different sizes viz 15′x17′x10- 12′/25′x15′10-12′/35′x20′x12′ and 35′x25′x12′ (particularly for shelves holding 18-20 tonnes compost). The depth of compost should be low i.e., 5"-7" in places where out door temperature is higher and moderate and 7"-9" where outside temperature is low. This helps to control bed temperature. When polythene bags are used generally 10-12" deep compost is filled. The gap between 2 shelves is 26-28" in case of bag cultivation whereas in shelved beds it is 18-24". Many growers are still using wooden trays 3′x2′x6"-8" (depth) and 6"-8" legs. For such system trays are used for compost pasteurization, spawn running and cropping. Trolley should be used to shift trays from one place to other. Manually operated trolley is available costing around Rs.10,000/-.

Check Your Progress - 2 & 3

2. What is a bulk chamber ? Write the parameters for construction of bulk chamber ?

3. What are growing rooms?

Note : (a) Write your answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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2.7. SUMMARY

Button mushroom is a fruiting body which is connected to the root like structure known as mycelium. The fruiting body is divided into the pileus (cap) and the stipe (stalk). Pileus is the fleshy, smooth, cap like structure which bears gills underneath the cap. Stipe is the stalk which is centrally attached to the pileus. In nature, button mushroom (*Agaricus bisporus*) grows on nitrogen rich soils, heap of organic manures etc and distributed in the Northern hemisphere, Arctic region, European countries, Siberia, North Africa and also in other tropics. Button mushroom cultivation was started initially in France and spread to U.K., U.S.A. and other European countries. Asian countries started cultivating this mushroom on commercial scale since the last three decades. In India, the button mushroom is being produced in Himachal Pradesh, Jammu and Kashmir, Haryana, Punjab, U.K, Karnataka, Tamil Nadu and Andhra Pradesh. In Northern states, large number of small and medium growers are doing seasonal cultivation. Button mushroom growing is labour intensive, needs agricultural wastes as raw materials. Hence, India suits well for button mushroom production.

Button mushroom cultivation is an indoor activity and needs technical expertise. Hence precautions are to be taken while selecting the area and designing the farm. The building plot is to be approachable by road for raw material delivery and disposal of spent compost. Though, there are different types of farm designs, Dutch farm design with few modifications suits local requirements. A spacious composting platform with slope and a collecting tank are to be constructed for compost preparation. Bulk chamber should be constructed for pasteurization of the compost. Insulated growing rooms are essential for monitoring the inside environment.

2.8. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Due to the availability of labourers at cheap cost, plenty of agricultural wastes, decrease in mushroom production in developed countries, India has excellent opportunities in future for button mushroom production.

2. Bulk chamber is a pasteurization chamber designed to pasteurize the compost. For 20 tons capacity 36'x9'x12' (length x breadth x height) dimension is used. The plenum is 3' deep on the side of the fan and 6" deep on the other end. Grated floor made up of either wooden or iron with 25-30% of the total area left in the form of gap for free movement of steam and air should be provided. Walls should be provided with 5cm thick insulating material between brick wall (9" wide) and inside plaster. Roof is also to be insulated and surface is sprayed with bituminous paint. Two vents one to recirculating duct and the other to outside are to be provided. Doors should be insulated and air tight.

3. The rooms where the button mushroom is grown are called growing rooms or crop rooms. They should be insulated and have provision for forced air circulation system and humidity control.

2.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write an essay on button mushroom production in developed and developing countries. Add note on its future prospects in India.
2. Describe in detail the farm designing of button mushroom

II. Answer the following questions in about 10 lines each.

1. Write a note on the morphology of the fruiting body (basidiocarp) of button mushroom
2. Write a short note on bulk chamber.

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Ms. K. Prasunamma

UNIT-3 : RAISING OF PURE CULTURE AND SPAWN PREPARATION OF BUTTON MUSHROOM

Contents

3.1. OBJECTIVES

After going through this unit you will be able to:

- describe the method of preparation of culture media,
- list out and describe the isolation methods of pure culture,
- describe the method of preparation of spawn substrate,
- describe the preparation of spawn,
- explain the storage methods, transportation and quality control of spawn.

3.2. INTRODUCTION

The pure cultures of button mushroom can be prepared either by germinating the spores or by growing pieces of inner tissue of mushroom on a suitable and sterilized culture medium.

Duggar in 1905 made the significant discovery that a piece of the inner growing tissue of mushroom is capable of producing mycelium. Since then, the potential of this method for isolating pure cultures has been utilized. Ferguson (1902) first discovered the use of germinating basidiospores of *Agaricus* for making spawn. Although the use of basidiospores is a better and more safe method of making

spawn, tissue culture due to easy handling had laid the foundation for spawn making industry.

Sinden's (1932, 1936) use of cereal grain as the substrate for mushroom spawn was an advance in making commercial spawn. Duggar (1915), Ware and Glasscook (1946) and Davis (1946) provided description of basic methods and equipment used to make spawn. Stellar analysed a number of practical problems in modern spawn making.

In the Western Countries highly specialised and sophisticated batch system for making spawn was developed. The system however, incorporated bulk- blending and precooking of grain. Plastic bags (fitted with a "breathing strip filter) filled with pre-cooked grain are sterilized. When cooked each bag of grain is inoculated with mushroom mycelium.

Recently Maul etal (1980) described a system that can be used to make spawn entirely by a bulk operation. A cooled, sterilized substrate mixture is inoculated with mushroom culture and semiautomatically transferred from a large rotary blender to sterile polythene bags aseptically in which the mycelial colonisation of the substrate occurs.

3.3. PREPARATION OF PURE CULTURE

Pure culture of a desired mushroom species can be grown on a suitable medium. Mushroom culture should be pure and without contamination. The whole process should therefore be carried out under strictly aseptic conditions. The culture is prepared either by germinating the spores or by growing pieces of inner tissue of mushroom in a suitable and sterilized culture medium.

3.3.1. Culture Media

The medium on which the pure mushroom mycelium is grown is called culture medium. These media vary widely in form and composition depending on the organism to be cultivated. Some of the common media used are:

1. **Potato Dextrose Agar (PDA) Medium** : Wash, peel and cut into small pieces about 250 gm of potatoes. Boil them in 1000 ml distilled water till they are soft but not over cooked. Filter through a cheese cloth, collect the liquid in a graduated cylinder. Restore the volume of the decoction to 1000 ml by adding fresh distilled water and heat it. Then add 20g of Dextrose and 20g of Agar powder and boil with occasional stirring until agar and dextrose dissolve. Transfer the medium in 10 ml. test tubes and plug with non absorbent cotton.
2. **Malt Extract Agar (MEA) Medium** : Dissolve 50 gm of commercially available Malt extract Agar in 1000 ml. of distilled water. Boil it and pour it in test tubes and plug with non-absorbent cotton.

3. **Complete medium (CM) :** This medium is constantly used for *Volvariella* culture. The chemical components are:

$MgSO_4$ $7H_2O$	...	0.50g
KH_2PO_4	...	0.46g
K_2HPO_4	...	1.00g
Bacteriological Peptone	...	2.00g
Dextrose	....	20.00g
Agar (Sigma type IV)	...	20.0g
Thiamin-Hcl	...	0.50g
Distilled water	...	1.0 litre.

Mix all the ingredients in distilled water, boil and fill in the test tubes and sterilize.

It should be noted that most mushrooms prefer a neutral to slightly acidic range of medium. Hence the pH of these media should be between 6.5 to 7.0. For *Volvariella* pH between 6.8 to 7.8 is preferred. All media should be sterilized immediately after their preparation. Sterilization is done by steam. Sterilization can be done in autoclaves at 15 lb pressure, which gives a temperature of 121°C. This temperature is maintained for 15-20 min. After sterilization the tubes are immediately taken out and kept in an inclined position for one day to get the slants. If sterilization is being done in pressure cooker, it should be sterilized for 1 hour.

The following precautions are to be taken while preparing culture media.

1. All the glasswares being used should be washed thoroughly and rinsed with distilled water before use.
2. Weigh the ingredients correctly.
3. Only distilled water should be used for media preparation.
4. Care should be taken that all the ingredients are dissolved.
5. pH of the medium should be tested by pH paper before sterilization.
6. The medium should be poured in tubes while it is still hot. Care should be taken to fill only 1/3 vol. of the tube.
7. The tubes should be properly plugged with nonabsorbent cotton. The plugs should not be loose. As an extra precaution aluminium foils can be used to cover over the cotton plugs to prevent any moisture or steam entering in the tubes.
8. Sterilization should be properly done.

9. The tubes should be slanted while still hot and kept in that position for one day.

10. If any bacterial or fungal growth is seen in the tubes, such tubes should be immediately discarded.

3.3.2. Isolation of Pure Culture

Initial mushroom culture can be obtained by any of the following four ways:

i) Sub-culture

ii) Single spore culture

iii) Multispore culture

iv) Tissue culture

i) Sub-Culture : A small piece of pure culture obtained form other laboratories can be inoculated on fresh medium to get fresh culture.

ii) Single Spore Culture : A mass of mushroom spores are to be collected by taking a spore print. For taking a spore print the stalk (stipe) of the basidiocarp is cut and the cap is placed on a sterile paper. After sometime the spore mass is collected and spore suspension is prepared in serile distilled water. Further, it is diluted to obtain a concentration of 20-25 spores and one ml is poured in sterile petriplates containing medium. The plates are incubated at 25^{0}C and observed under microscope. After germination, mycelium developed from single spores is picked and transfered to the slants.

iii) Multispore Culture : Spores obtained by spore print are picked with a needle and added directly in the sterilized slants or petriplates containing medium under aseptic conditions.

iv) Tissue Culture : The slants are inoculated with pieces of tissue from a fresh mushroom. The mushroom selected should be healthy and of desirable size.

Hands, working area and the mushroom itself should be disinfected with rectified spirit to get rid of the surface contaminants. The mushroom fruit body should be cut out longitudinally into two halves and small piece of internal tissue should be taken. In case of oyster and paddy straw mushroom, small pieces from the upper part of the stipe should be taken (Fig. 3.1).

Care should be taken to do everything in aseptic conditions. All the work should be performed near flame.

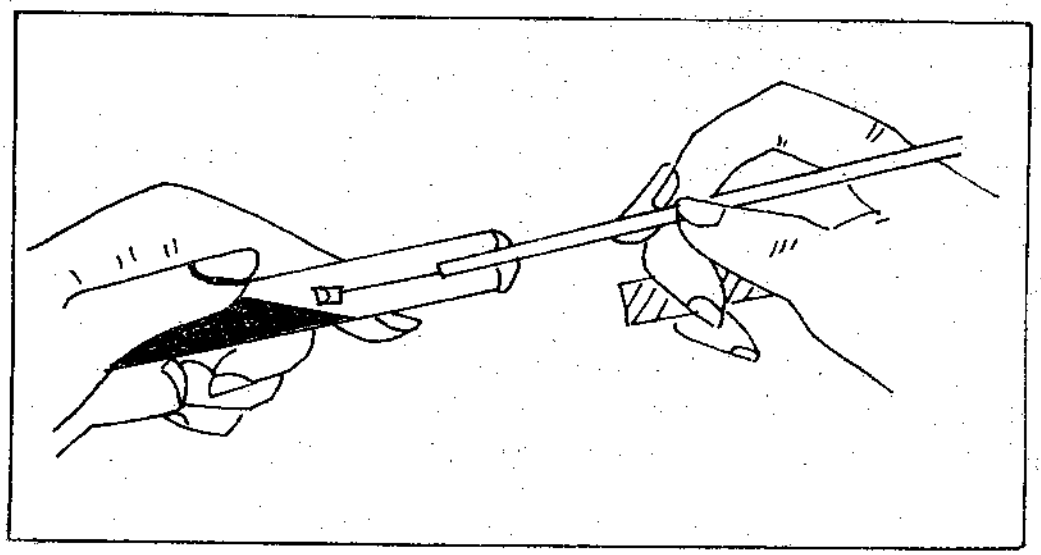

Fig. 3.1. Transferring the tissue onto medium.

After inoculation the tubes should be incubated at 25-30^{0}C for growth. When the mycelium has fully covered the medium, it can be used to inoculate spawn substrate or if not in use can be stored in refrigerator for further use.

Check Your Progress - 1 & 2

1. What are the common media used for raising pure culture of button mushroom?

2. What is subculture?

Note : (a) Write your answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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3.4. PREPARATION OF SPAWN SUBSTRATE

The word spawn in the mushroom industry means the planting material, which consists of the vegetative body (mycelium) and its substrate. In other words spawn could be regarded as analogous to the seeds of the higher plants.

Spawning was the essential and first step in the early development of mushroom cultivation. Initially small masses of infected manure from naturally infected beds was used. Subsequently, more reliable forms of spawn e.g., French flake and English brick spawn were developed. Brick spawn consists of compressed bricks of horse or cow manure and loam or leaves colonized by mushroom mycelium. Flake spawn is dried mycelium-filled compost. Like natural spawn, however, flake and brick spawn were not pure cultures. Neither the identity of the mushroom species nor the absence of pests was assured.

A number of materials alone and in different combinations are used as spawn substrates. The materials vary from place to place and on economic grounds. In Hong Kong the following types of substrates are being used.

1. **Used tea leaves** : Used tea leaves are washed, drained and 2% calcium carbonate is added to adjust the pH. The substrate is mixed thoroughly and put in bottles, plugged and sterilized.

2. **Cotton waste** : The cardfly grade of cotton waste is usually chosen. It is washed and 2% calcium carbonate is added to adjust the pH.

3. **Straw spawn** : Paddy straw is soaked for two to four hours, cleaned and cut out to pieces of 3 to 5 cm long, mixed with 1% calcium carbonate and 1- 2% rice bran, then put into bottles, plugged and sterilized.

In Thailand spawn substrate is made by mixing fresh horse manure and lotus husks in equal amounts after they have been steeped in water until they have swelled or absorbed enough moisture to prevent their drying out.

In Philippines the following types of substrates are used.

i) **Coffee pulp** : Fresh Coffee pulp gives uniform mycelial growth on both outer and inner surfaces of the pulp.

ii) **Ipil-ipil leaves spawn** : Dried ipil ipil (*Seucaura glauca*) leaflets with coir dust or saw dust is soaked in water and fermented for three to four days. The fermented mixture will be washed with three changes of water. 15% rice bran is added and then the mixture is bottled.

3.5. SPAWN PREPARATION

Grain as the substrate for spawn production is the more popular and most widely used method. The details for the preparation of grain spawn is given below.

Facilities Required : The facilities required for spawn preparation are :

1. Preparation and autoclave room.
2. Inoculation chamber (5′ x 6′ x 7′) fitted with ultraviolet tube (3′ in length), one table and double door entrance.
3. Chamber for spawn growth.
4. Autoclave.
5. Facility to boil grain like hot plate or gas stove
6. Container for boiling
7. Milk or glucose bottles
8. Non-absorbent cotton
9. Spirit lamp
10. Rectified spirit
11. Inoculation needle
12. Jowar or wheat grains
13. Chalk powder
14. Gypsum.

Method of Preparation

Jowar or wheat grains are washed in water and boiled. Care should be taken that the grains are not over boiled and broken. Excess of water is drained off and boiled grains are spread on fine wire mesh for about one hour. This helps to break lumps and reduces moisture. Chalk powder (6%) and Gypsum (2%) are mixed in boiled grains which are then filled in the bottle or pp. bags. Mouth of bottles are cleaned and plugged with non- absorbent cotton. Plugs are wrapped with paper and bottles are sterilized at 22 lb. pressure in autoclave for 2 hours.

Sterilized bottles are transferred to inoculation chamber and 2% formaldehyde is sprayed inside the chamber. Next day ultra violet tube is put on for half an hour to 1 hour prior to inoculation. U.V. light should be switched off while entering the chamber for inoculation.

For inoculation, a bit of culture, about 1 cm is taken out from a culture tube having pure culture. This piece of culture is inoculated in the bottles with the help of inoculation needle. The culture should be preferably, transferred in the middle towards wall side so that the growth can be noticed. Inoculation should be done over the burning spirit lamp to avoid contamination.

After inoculation, bottles are transferred to spawn growing chamber where temperature should be 25 $\pm$ 2°C. Once a week all bottles should be checked and contaminated bottles should be removed.

Fig. 3.2. Pure mushroom spawn in glucose bottle.

The spawn prepared from the culture can be further used to multiply spawn @ 1 bottle for 20-25 bottles, by transferring few grains (2 teaspoons of spawn/bottle, over spirit lamp. This helps in faster multiplication of the spawn. However, pure culture of high yielding strains should be used for spawn production.

The following figure shows various steps in raising pure culture and spawn preparation (Fig.3.3.).

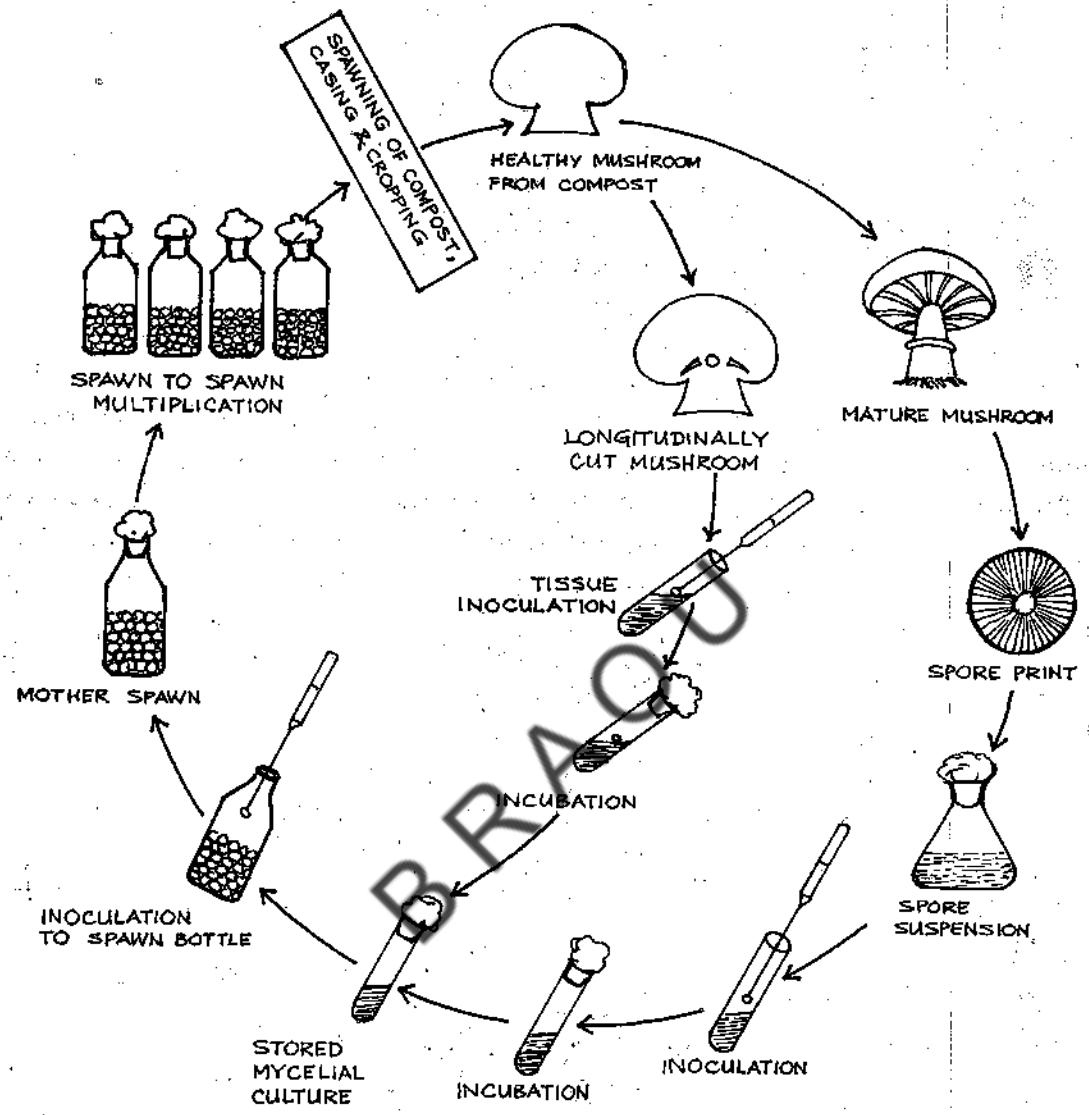

Fig.3.3. Raising of pure culture and spawn preparation of white button mushroom.

3.6. STORAGE AND TRANSPORTATION OF SPAWN

It is always advisable to use fresh spawn. When the spawn needs to be stored, it should be stored at 0-4^{0}C for 4 to 6 months. Spawn should not be stored at room temperature. When the spawn is stored at low temperatures, it should be allowed to attain room temperature and should be used for spawning.

Spawn should not be transported at high temperature. It should be transported either in refrigerated vans or during night time when temperature is low. Such spawn should be used immediately or stored in cold storage rooms until further use.

3.7. QUALITY CONTROL IN SPAWN MAKING

A major source of contamination of growing mushroom mycelium in a spawn making plant is the grain used to prepare the substrate. Modern equipments and facilities for sterilization and maintenance of sterile conditions are capable of reducing fungal and bacterial contamination to 0.1% of the spawn units.

Quality control in spawn making consists essentially of inspections to eliminate spawn units visibly contaminated or exhibiting unacceptable differences in appearance, growth, colour or odour. In addition, study of possible role of spawn cultures and sources of spawn cultures as carriers of bacterial disease is needed in view of the reported attachement of bacteria on spores and hyphae of the mushrooms.

Care should also be taken that spawn is free from virus. For this purpose stock cultures should be raised from virus free mushrooms and this can be tested with the help of electron microscope. Some other things to be borne in mind are :

1. Use of unbroken and half cooked grains only for spawn production.
2. Boiled grain mixed with lime and gypsum should not be kept unsterilized for more than 10 hours.
3. Bottle should be plugged and sterilized properly.
4. Sterilized bottles should be inoculated after 2 days of sterilization.
5. The bottles should be kept under UV rays for 30-60 min. before inoculation.
6. The whole process should be carried out in a double chambered, closed air tight inoculation room.
7. Inoculation should always be done facing the burner.
8. Give minimum time for removing and placing the plugs.
9. Shake the bottle thoroughly after inoculation to get early and uniform growth.
10. Incubate bottles at $25 \pm 2^{o}C$ after inoculation.
11. Store bottles at a temperature of $4^{o}C$ after complete growth.

Check Your Progress - 3 & 4

3. What are the precautions to be taken before and after inoculation of sterilized bottles ?

4. How do you store and transport the spawn ?

Note : (a) Write the answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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3.8. SUMMARY

The pure culture of button mushroom is the one which contains the mycelium of button mushroom only. It can be prepared either by germinating the spores of button mushroom or by growing a piece of inner tissue of the mushroom (at the place where stipe and pileus are attached) in a suitable and sterilized culture medium. Transfer of a bit of tissue or spores of the mushroom aseptically into the culture medium is called inoculation. After inoculation the test tubes or petriplates should be incubated at 25- 27^{o}C for growth. When the mycelium is fully grown on the medium, it can be inoculated to the spawn substrate or stored in refrigerator at 0-4^{o}C for further use.

Spawn is the planting material that consists of vegetative mycelium and its substrate. It is analogous to the seed of higher plants. Spawn preparation is an important step in mushroom cultivation. Various spawn substrates like wheat or

jowar grains, used tea leaves, cotton waste, paddy straw are used, of which wheat and jowar grains are the most commonly used substrates. Half-cooked grains are drained to remove excess water and dried for one hour. Chalk powder (6%) and gypsum (2%) are mixed in the grains and filled in glucose bottles or polypropylene bags (2/3rd of the bottle or bag). They are then plugged with non-absorbent cotton and wrapped with paper and sterilized for 2 hours at 22 lb pressure in an autoclave. After sterilization the bottles are kept at room temperature for two days to check for any fungal or bacterial growth in the spawn substrate. The bottles are then shifted to UV-chamber sterilized with 2% formalin and UV lamp should be switched on for half an hour to one hour. Prior to inoculation UV light should be switched off. A bit of culture of about 1 cm, is taken out from a culture tube with the help of inoculation needle and inoculated into the spawn Substrate. The bottles or bags are then incubated at a temperature 25 $\pm$ 2^{o}C. The bottles or bags should be checked for contaminants once a week and such bottles or bags should be removed. The spawn prepared from the culture is called master spawn or mother spawn which can be used for further multiplication of spawn.

Always fresh spawn should be used for growing mushrooms. However, when the spawn needs to be stored, it should be stored at 0-4^{o}C for 4 to 6 months. Spawn should be transported either in refrigerated vans or during night time when the temperature is low. Quality control is very important in spawn making. One needs to take every precaution to maintain the quality of spawn.

3.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The Common media used for raising the pure culture of button mushroom are: Potato Dextrose Agar (PDA) Medium, Malt Extract Agar (MEA) Medium and Complete Medium (CM).

2. Subculture is the inoculation of small piece of pure culture on fresh medium to get fresh culture.

3. The sterilized bottles of spawn substrate are to be transferred to an inoculation chamber sprayed with 2% formaldehyde. The UV lamp should be switched on for half an hour to one hour prior to inoculation. UV light should be switched off while entering the inoculation chamber. Inoculation should be done over the burning spirit lamp. The inoculated bottles should be incubated at 25 $\pm$ 2^{o}C. The bottles should be checked once a week for contamination.

4. Button mushroom spawn should be stored at 0-4^{o}C for 4 to 6 months. Spawn should be transported either in refrigerated vans or during night time when temperature is low.

3.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write an essay on raising of pure culture of button mushroom.
2. Describe in detail about the preparation of spawn of button mushroom.

II. Answer the following questions in about 10 lines each.

1. Write a short note on the culture media used for raising pure culture of button mushroom.
2. Write a brief note on various spawn substrates used for preparing button mushroom spawn.
3. How the storage and transportation of spawn is made ?
4. What are the precautions to be taken in maintaining the quality of button mushroom spawn.

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Ms. K. Prasunamma

UNIT - 4 : PREPARATION OF COMPOST AND CULTIVATION OF BUTTON MUSHROOM

Contents

4.1. OBJECTIVES

After going through this unit you will be able to:

- define the compost.
- list out the materials used for compost making,
- list out the various compost formulations,
- describe the methods of compost preparation,
- explain the qualities of a good compost and advantages of bulk pasteurization,
- describe the procedure of spawning, casing and cropping of button mushrooms.

4.2. INTRODUCTION

Agaricus bisporus and *A.bitorquis* are popularly called white button mushrooms. These mushrooms are coprophilous and require dung or synthetic compost for its growth and development. It is the product of fermentation of organic and inorganic substrates brought about by many mesophilic and thermophilic fungi.

Compost is the decomposed substrate in which the mushroom mycelium grows. The compost is mixed with the mushroom spawn and incubated for mycelial growth

at 24 ± 1°C. When the compost is fully impregnated with mushroom mycelium casing soil should be spread over it. Casing soil initiates the fruit body formation. Button mushroom cultivation needs high technical expertise and to be grown under controlled environmental conditions.

Check Your Progress - 1

What is a Compost?

Note : a) Write the answer in the space given below.

b) Compare your answer with the one given at the end of this unit.

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4.3. COMPOSTING

White button mushroom (*Agaricus bisporus* and *Agaricus bitorquis*) being coprophilous require dung or synthetic compost for its growth and development. Initially decomposed horse manure was the principal medium for its cultivation. However, in recent times other materials like wheat/ barley/ oat/ paddy straw and hay are being utilized as base material for synthetic compost as horse dung is not avialable every where. The purpose of composting is to make the raw materials specifically suited to mushroom mycelium for its growth.

4.3.1. Materials Used For Compost Making

Though main bulk material for compost preparation comes from horse dung and cereal straw, there are equally useful materials which can be exploited for compost making. Composting materials can be divided on the basis of their role in compost making which are given below.

1. Vegetable base material : This includes straw of wheat, paddy, barley, rye, oat, maize stalks and vegetable plant wastes. They provide cellulose, hemicellulose and lignin which are utilized during spawn running and fruiting, they also provide some quantity of nitrogen. Besides, these materials provide physical structure in heap which facilitates air exchange for aerobic microbes.

2. Supplements : There are several materials which are added to prepare balanced compost and are source of additional nitrogen and carbon compounds. These are further divided into 4 categories on the basis of their nutrients.

Category - 1 : Animal Manure : It includes horse dung, chicken, pig, sheep, mule, yak, goat, cow, bullock and elephant manure. They provide good amount of nitrogen which may vary from about 1% to 5%. Carbohydrates are also present.

Both nitrogen and carbohydrates are released slowly particularly in case of chicken manure. They also contribute to final density of compost.

Category - 2 : This provides readily available nitrogen and carbohydrates.

2 A. Nitrogen rich : Nitrogen fertilizers like Ammonium sulphate, Urea, Calcium ammonium nitrate contain high nitrogen and carbon compounds are either nil or very low.

2 B. Carbohydrates : Molasses, wet brewers grain, potato waste, molasses, sugar-beet pulp, apple and grape pumice and proprietory activators containing molasses.

Category - 3 : Concentrated meals : Here both nitrogen and carbohydrates are available and are released slowly viz., dried brewers' grains, unmolassed sugar beet pulp, corn cobs, wheat/rice bran, seed meals of cotton, soyabean, castor, linseed, sesame etc. Nitrogen contents range from 3-12% except unmolassed sugar- beet pulp and corn cob where it is about 1%. The oil and minerals available in some are of significance in mushroom nutrition.

Category - 4 : Supplements to rectify mineral deficiencies : This includes fertilizers like potash, superphosphate, trace metal mixtures, gypsum and chalk powder. Gypsum also helps to avoid greasiness in compost.

4.3.2. Different Compost Formulations

For selecting materials for compost preparation following points should be kept in view.

1. The physical and chemical characteristics of base materials particularly the nitrogen content.

2. Initial total nitrogen content should be between 1.40 - 2.00 of dry matter. This is achieved by adding animal manure and other nitrogenous supplements like urea, brewer's grain, cotton seed bran etc.,

3. Categories 1,2 and 3 are most important for composting process and inadequate level of carbohydrates result in loss of cellulose/hemicellulose and dry matter. This may also result in a narrow C:N ratio in final compost.

Some compost formulae being used in India and abroad.

1.	Horse manure	430.00 Kg
	Wheat straw	250.00 "
	Chicken manure	100.00 "
	Brewer's grain	30.00 "
	Urea	7.00 "
	Gypsum	20.00 "

2.	Horse manure	1000.00	Kg
	Chicken manure	90.90	"
	Sugar beet pulp	3.40	"
	Cotton seed meal	3.18	"
	Gypsum	7.72	"
3.	Wheat straw	1000.00	Kg
	Chicken manure	1000.00	"
	Gypsum	60.00	"
4.	Wheat straw	300.00	Kg
	Chicken manure	120.00	"
	Rice bran	20.06	"
	Brewer's grain	22.00	"
	Urea	6.00	"
	Cotton seed meal	5.00	"
	Gypsum	10.00	"
5.	Wheat straw	1000.00	Kg
	Chicken manure	300.00	"
	Brewer's grain	72.00	"
	Urea	14.05	"
	Gypsum	30.00	"
6.	Horse manure	1016.00	Kg
	Chicken manure	101.06	"
	Molasses	38.05	"
	Cotton seed meal	15.24	"
	Gypsum	15.24	"
7.	Paddy straw	3.00	tonnes
	Chicken manure	$1\frac{1}{2}$	"
	Wheat bran	125.00	Kg
	Gypsum	90.00	"
8.	Wheat or paddy straw	300.00	Kg
	Ammonium sulphate or		
	Calcium ammonium nitrate	9.00	"
	Super phosphate	8.00	"
	Urea	4.05	"
	Wheat bran	30.00	"
	or		
	Rice bran	15.00	"
	Gypsum	12.00	"
	Calcium carbonate (Chalk Powder)	10.00	"

9.	Paddy straw	150.00 Kg
	maize stalk	150.00 "
	Ammonium sulphate	9.00 "
	Super phosphate	3.00 "
	Urea	4.05 "
	Rice bran	50.00 "
	Cotton seed	6.00 "
	Gypsum	12.00 "
	Calcium carbonate	10.00 "
10.	Paddy straw	600.00 Kg
	Rice bran	100.00 "
	Urea	10.00 "
	Cotton seed	12.00 "
	Gypsum	24.00 "
11.	Wheat straw	300.00 Kg
	Molasses	12.00 "
	Urea	50.00 "
	Wheat bran	50.00 "
	Cotton seed meal	5.00 "
	Gypsum	15.00 "
12.	Paddy straw	300.00 Kg
	Molasses	12.00 "
	Urea	6.00 "
	Wheat bran	50.00 "
	Muriate of potash	2.00 "
	Cotton seed meal	5.00 "
	Gypsum	25.00 "
	Qty. used per m^2 in Kg	
13.	Wheat or paddy straw	30.03
	Ammonium sulphate	0.06
	Urea	0.15
	Superphosphate	0.06
	Calcium Carbonate	0.09
14.	Strawy horse dung	1000.00 Kg
	Chicken manure	100.00 "
	Urea	6.08 "
	Rice bran	20.00 "
	Gypsum	25.00 "

4.3.3. Methods of Compost Preparation

In compost preparation water and air play vital role. Water in compost plays an important role to support microbial fermentation and growth of mushrooms. However, excessively wet compost does not allow air through the compost resulting in anaerobic conditions, unfavourable for aerobic microbes. The microbial build up on straw in initial stage causes rapid increase in temperature which in turn helps in uptake of water by straw and its easy breakdown. High temperatures have also beneficial effect on aeration inside the heap which provides oxygen for the growth and multiplication of microbes. This in turn influences fermentation process. There are two most popular methods of composting. 'Long' and 'Short' Method.

Long Method : It takes about 26 days and 7 to 8 turnings are given at varying intervals without pasteurization. The long method of composting reduces the nutritional value of compost and may be easily attacked by weed moulds, pathogens, insects, mites and nematodes. However, this method is more popular with small growers who cannot afford boiler for pasteurization. The schedule of turning should be -2D, OD, + 6D, + 10D, + 13D, + 16D, + 19D, + 22D, 25D, + 26D compost filling.

Day - 2 : The straw is kept wet for 48 hours and stacked in a heap of 6′ x 5′ length. The mixture of fertilizers and rice/wheat bran are mixed and watered 24 hours in advance of zero day separately.

Day 0 : At this stage moisture content of straw should be 75-77%. Now mix the wet mixture of fertilizers and bran with straw thoroughly and stack in a dimension of 6′ x 5′ length. If any dry patch is noticed it should be watered. To have firm stack, wooden mould (Fig.4.1) should be used and pressing should be given from top. Any increase in height may cause anaerobic fermentation and low height will result in loss of heat which is required for correct fermentation. The temperature of the heap will rise to 65-70°C on second day.

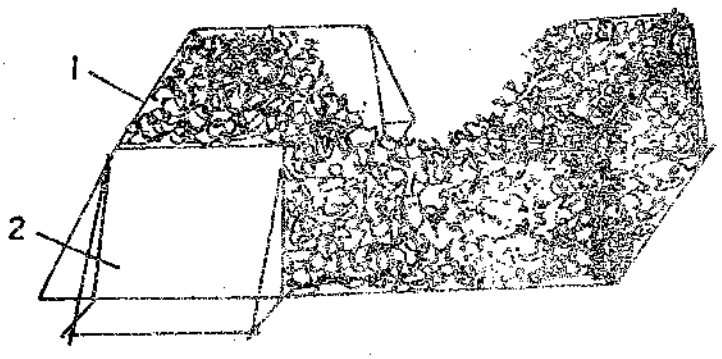

Fig.4.1. Assembled wooden moulds for making compost pile.

Day +6 : The first turning is given. For turning break a portion of stack, loose it for air exchange and do watering if required. Then fill up the mould and press it to make firm stack. Take side boards forward leaving end board and erect them with the help of wooden support and fill up with the compost as done earlier. This way one may turn compost in one line and in a required dimension.

Day +10 : Second turning is given in the same way except it will be in backward position i.e., heap stacked in Day 0 position. Chalk powder (Calcium carbonate) is added during turning. Do watering if required, pressing of heap should be reduced.

Day +13 : Third turning is given in forward position and gypsum is added. Light pressing is required.

Day +16 : Fourth turning is given and cotton seed added (if required according to compost formula).

Day +19 : Fifth turning is given. Care should be taken to avoid lumps. Pressing is not required.

Day +22 : Sixth turning is given. By now ammonia smell should disappear or it should be very low. Do watering if required.

Day +25 : Seventh turning is given. Spread the compost on platform, break lumps if any and stack. Do watering if moisture is less.

Day +26 : Compost is mixed and filled in trays. In case ammonia smell is still noticed, one more turning should be given before filling the trays. At the filling stage compost will be dark brown in colour. It must be free from ammonia and moisture content should be 65-70%.

Short method : This is the most popular method for commercial production of white button mushroom. It is completed in two phases. Phase I also called outdoor composting takes 7-12 days while phase II, called indoor pasteurization has 3-7 days duration. In this method filling is more and yield performance is high with efficient disease control. The most common schedule is -4D, -2D, OD, +2D, +4D, +6D, +8D, +10D and 12D compost filling in trays for pasteurization.

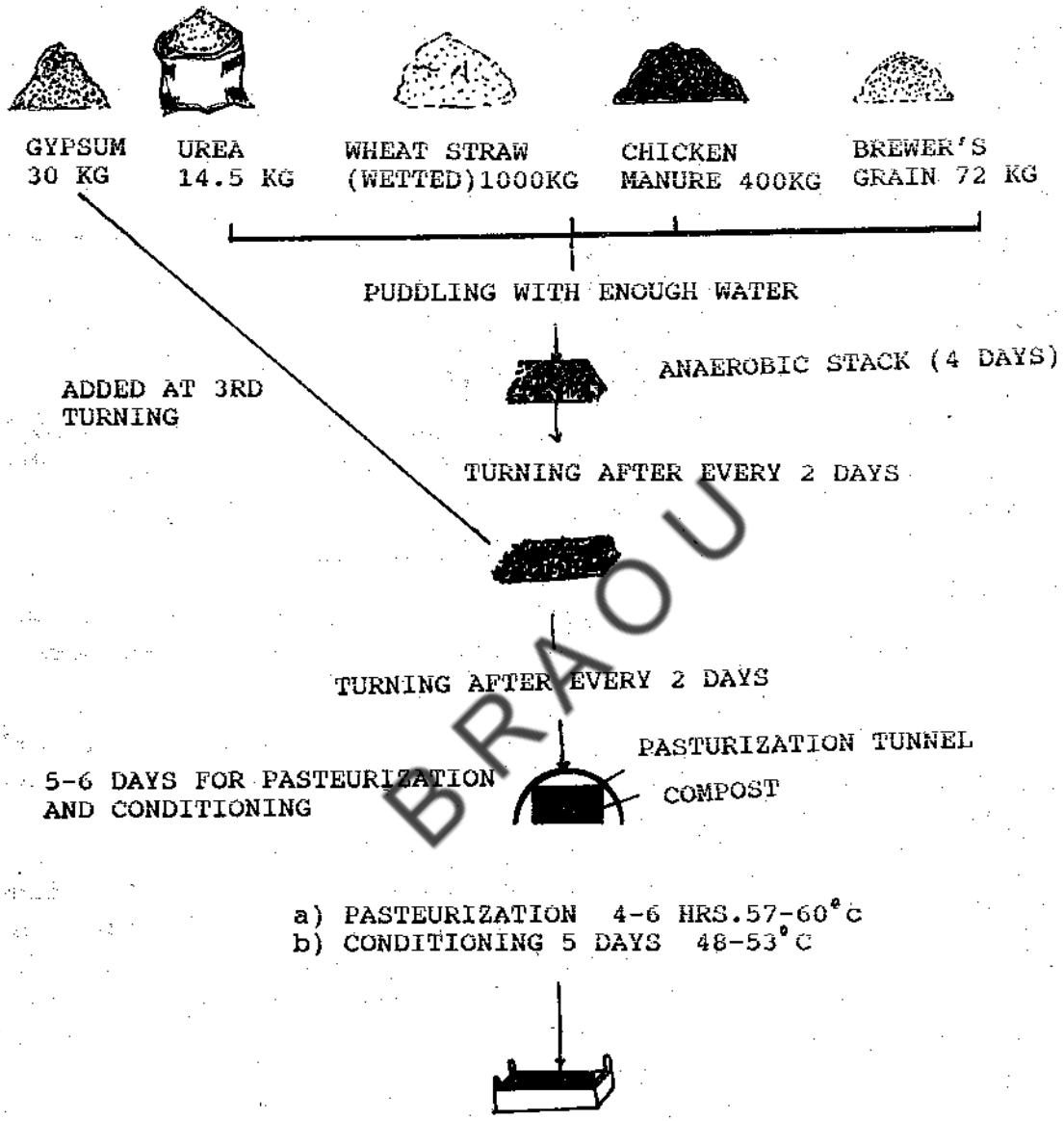

Fig.4.2. Preparation of compost by short method.

Phase I

Day -4 : Preliminary stacking is done putting straw and other ingredients except gypsum and fertilizers in layers. Add sufficient water to wet the stack. The stack should be 1-2′ height.

Day -2 : Turn the stack, do watering reduce the stack size by 1/2′ and add water.

Day 0 : At this stage moisture content should be 75-77%. Mix urea and prepare standard stack (6′ x 5′ x length).

Day +2 : First turning as described earlier and do watering if required.

Day +4 : Second turning, add gypsum and do watering if required.

Day +6 : Third turning

Day +8 : Fourth turning

Day +10 : Fifth turning

Day +12 : Compost is filled in trays for phase II. At this stage compost colour will be dark brown with strong smell of ammonia. Moisture content should be 70-72%

Phase II : It has two main objectives. They are :

a) To complete fermentation of the compost suitable for the mushroom mycelium but not for other weed moulds. Here uniform layer of compost in trays enables proper aeration and temperature control during fermentation.

b) To kill unwanted microbes, nematodes, mites and insects.

The most effective method of pasteurization is by the use of live steam. This process can be divided into three stages : (i) Prepasteurization (ii) Pasteurization and (iii) Post pasteurization.

i) Prepasteurization : Trays filled with compost are stacked in the centre of pasteurization room in tiers. Sufficient space is left between 4 walls and trays for air movement. The gap between top tray and ceiling should be about 3′. After stacking trays water is sprayed on walls, floor and sides of trays, to increase relative humidity to almost 100%. Fan is switched on to recirculate the air which eliminates temperature gradient within the room. All inlets are closed and steam is passed through perforated pipes to increase air temperature upto 40-45^{o}C. By closed ventilation and higher air temperature, microbial activity increases resulting in rise of compost temperature upto 50- 55^{o}C. This is maintained for 24 hours.

ii) Pasteurization : After 24 hours, live steam is introduced through perforated pipes to increase the air temperature upto 60^{o}C and is maintained for 2-4 hours to complete the pasteurization. Due to this, compost temperature also rises upto 60^{o}C resulting in the pasteurization of compost. The difference between top and bottom trays temperature should not be more than 2^{o}C. In case compost temperature goes up, open the ventilators and reduce steam supply. Keep fan on for the recirculation of air.

iii) Post-pasteurization : After completion of pasteurization ventilators are kept 1/3 opened and compost temperature is maintained between 50-55^{o}C for 2-3

days. This temperature (optimum 53.5^{0}C) range is best suited for the conversion of ammonia into the protein. At the end of it there should not be any smell of ammonia. Ventilation during this period is very important otherwise there is a risk of high level of carbon dioxide which may encourage the development of mould like *Chaetomium,* the olive green mould. Once the compost is free from ammonia, temperature is lowered by introducing fresh air. It takes about 2 days. Once temperature is about 25 $\pm$ 2^{0}C spawning is done. The moisture content of compost should be 68-70%.

Some times weed moulds appear in the compost which show shortcomings during pasteurization and are called indicator moulds. Most common moulds are as follows :

i) Ink cap mushroom (*Coprinus* spp.) : It shows the presence of ammonia in compost, indicating over nitrogen in phase I or improper phase II.

ii) Olive green mould (*Chaetomium olivaceum*) : It indicates lack of sufficient oxygen during phase II and higher carbon dioxide in compost.

Composting has great bearing on mushroom crop hence one should take care of the following aspects :

i) **Dimension of stack :** Any significant increase or decrease may adversely affect the quality of compost.

ii) **Moisture content :** It should be maintained in required range otherwise it will affect fermentation process. Low moisture will not favour microbial activity and higher moisture content will inhibit air movement in compost.

iii) **Ammonia :** Its presence during composting is essential. However it is very toxic to mushroom mycelium. Hence at the time of spawning compost should be free from it.

iv) **Air :** During turning proper air exchange is important to maintain quality of compost.

Pasteurization in bulk chamber : Bulk chamber is made of insulated walls and with false perforated floor to help in circulation of inside air mixed with 10-15% of fresh air. The capacity of these chambers may be 20-100 tonnes and accordingly their sizes vary. Bulk chamber with a capacity of 20 tonnes will be 3x4x12m. It is connected with the blower to circulate air of 150-200 cubic meters/ton of compost. Fresh air (filtered) is mixed through another duct connected to the blower. The blower may be installed either at the ground level or on top of the chamber but air circulation should be blown under false floor.

Once compost is loaded its temperature starts rising and gets established in 10-12 hours. Compost and air temperature is maintained between 58-60^{0}C for 8-10 hours to achieve pasteurization. During this, period fresh air requirement is negligible and provided only to maintain temperature. This helps to kill harmful microbes, insects, mites and nematodes. After this, temperature is lowered to 50^{0}C gradually and maintained till ammonia drops below 10 ppm. During this

period fresh air supply is maintained for aerobic fermentation and it takes about 3-4 days. This helps to complete the fermentation resulting in compost with biomass free from ammonia and having moisture content about 65-68%. At this stage nitrogen content should be about 2-2.2% on dry weight basis. This process results in loss of about 30% of dry matter. Compost is rapidly cooled down at 25°C. The whole process is completed in 5-6 days.

4.3.4. Qualities of a Good Compost

A good compost is dark brown in colour. It has a distinct inoffensive smell. It is free from the smell of ammonia. The moisture content is 68-70%. The compost will not be greasy or sticky. pH of the compost is 7.2-7.8. The compost should be free from insects, nematodes and should not have any visible growth of other microorganisms except fire fangs.

Check Your Progress - 2 & 3

2. How many methods of composting are there ? What are they ?

3. What are the qualities of a good compost?

Note : (a) Write the answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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4.4. GROWING SYSTEMS

Some important methods in the evolution of mushroom production are given below.

Outdoor ridge beds : Tournefort (1707) for the first time described the process of cultivation in ridge beds. The beds are made in the open area, spawned and cased with 2.54cm of rotten leaves. At this stage people had recognised the importance of cooling of the compost before spawning. The ridge beds were 1.2-1.5m wide drawn into a sharp ridge of 1.2-1.5m high and 15m long. Parallel ridges were laid side by side keeping enough space to walk.

Ridge beds under cover : In England people started using covers, sheds and glass houses to grow under cover. In France caves were used to grow mushrooms.

Early shelf system : Ridge beds are modified as flat, well drained floor beds of about 12m long and 2-4m wide, back and end walls supported by 0.6m wide shelves. This was the most popular method adapted in U.S.A for about 70 years and has formed base for future development.

Development of shelf system : Since caves were not available to every one, people started using shelf system and improved it. During 1894 first commercial farm was started in U.S.A. well known as "American double" with several tiers of wooden shelves. This system formed the base for the present systems and helped U.S.A. to become major mushroom growing country in the world. With the improvement in ventilation system production has increased. This system was also adapted by other European countries particularly Dutch people who were more aggressive resulting their dominance in the world. They further improved and mechanised the system and also developed bulk chambers for the pasteurization of compost.

Rack system : This was a variation to shelf system adopted in England. This included mechanisation similar to tray system retaining single zone shelf method. These racks were made of metal frame with short shelves in four tiers easy to shift for both filling and emptying. This helped to do cultivation in single zone.

Tray system : The tray system was developed to facilitate the movement particularly in multizone system of cultivation. Knaust brothers (1934) developed two zone system i.e., spawn run and cropping in separate rooms which later on helped to carry out 3-5 zone system. This was very convenient particularly for small growers. This also helped to develop mobile shelves using large trays.

Bag system : Plastic bags holding 15-30 kg. compost were filled to a depth of 60-70 cm. Now a days polythene bags are being widely used as these are more convenient and can be kept in shelves and shifted easily. Initially trays were required to pasteurize the compost. The bag system made an ideal container in Ireland for inexpensive polyhouses.

Trough system : This system was developed by utilizing bulk pasteurization where Phase II of composting (pasteurization) and spawn running are carried out in one place.

Now a days cultivation technology is based on bulk tunnels and environmentally controlled cropping rooms. The environment of both tunnels and cropping rooms are controlled by computers with software to take corrective decisions as and when required to maintain required parameters.

4.5. SPAWNING AND AFTER CARE

Spawning means broadcasting spawn in compost. This provides points of further growth of mushroom mycelium in compost. Generally grain spawn provides more points of contact for faster mycelial growth. There are three methods of spawning.

1. **Surface spawning :** As name indicates it is done almost onto the surface of compost. About 1-1 $\frac{1}{2}$ inch top compost is lifted and grain spawn is broadcast and ruffled with fingers into 1-2 inches of compost. After spawning, lifted compost is put back and pressed lightly to make uniform top surface. In this method one spawn bottle (500 ml) will be enough for 3 trays (5′ x 2′ x 6′),.

2. **Layer Spawning :** In this method spawning is done in two layers. First layer is spawned about 3-3 $\frac{1}{2}$ inches below from the top by removing compost and second as surface spawning. Here one spawn bottle will cover two trays.

3. **Through spawning :** Grain spawn is mixed evenly and throughout the compost. One spawn bottle is used to cover one or two trays.

Spawn running : After spawning compost is pressed to have uniform top surface and trays are covered with newspapers dipped in 2% formaldehyde solution. Trays are checked everyday for moisture content. If top gets dried watering should be done. First 24 hours are crucial and care should be taken that compost temperature does not increase beyond 34°C otherwise mushroom mycelium may be damaged. If temperature shows increasing tendency, watering should be done and ventilators should be opened. Twice or thrice watering should be done on the walls, floor, trays, and newspaper to maintain high humidity. After spawning, mycelium from grain spawn starts spreading and permeates through the compost. This process is called "Spawn running". The method of spawning and temperature influences the spawn running . It covers the entire compost as whitish grey thread like strands of the fully grown mycelium in about 14-18 days period and turns compost colour from dark brown to light brown.

Environment : Temperature, relative humidity and air are important environmental factors affecting spawn running. During this period room temperature should be 25 ± 2°C (Optimum 24 ± 1°C). Low or higher temperature results in slow growth and beyond 34°C may be lethal to mushroom mycelium. Relative humidity should be about 90%. Mushroom mycelium produces CO_2 which to some point stimulates mycelial growth but at higher level inhibits the growth. Hence in closely packed rooms occasionally air should be replaced. Even partial opening of ventilators may serve the purpose.

Reasons for poor spawn running : Too wet or dry compost will delay spawn run. In dry compost spawn will appear sparser whereas in wet compost it forms white fluffy growth. Kligman had given following reasons for poor spawn running.

i) Excessive moisture or dryness

ii) Excessive temperature (over $30^{o}C$)

iii) Improper composting : Manure too green and anaerobic manure in poor physical condition, over composted or under-composted, encouraging unwanted moulds.

iv) Improper pasteurization : Compost temperature too high (over $65.5^{o}C$).

v) pH too high (over 8.0) : This is really due to improper composting; under composted may have a high pH.

vi) Presence of pests, competitor moulds and pathogen which attack spawn.

Check Your Progress - 4

What is spawning ? How many methods of spawning are there ?.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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4.6. CASING

It has been known for the last two hundred years that compost fully grown with mushroom mycelium must be covered with a layer of soil to initiate fruit body formation. This process is known as casing.

The various functions of the casing layer are as follows :

(a) To provide water for the growth and development of mycelium and fruit bodies,

(b) To protect compost layer against drying out and fast disappearance of metabolites.

(c) To provide suitable environment conductive for the growth of both mushroom mycelium and certain bacteria useful for fructification.

(d) To allow gases like carbon dioxide to escape,

(e) To provide physical support to fruiting bodies.

A good casing material must have the following properties.

(a) Good water holding capacity without sealing effect.

(b) pH should be 7-8 (optimum 7.5).

(c) Texture should be light and open. Its porosity should be such that carbon dioxide and other gases formed can escape.

(d) It should be free from disease causing organisms and under composed organic matters.

The following materials are used for casing soil.

i) Peat : It is most commonly used material for casing. Peat is mixed in different ratios with limestone and soil.

ii) Soil and sand (1:1) or sandy soil,

iii) Rotten cow dung and soil (3:1)

iv) Farm yard manure and loam (1:1)

v) Spent compost, sand and lime (4:1:1).

Cow dung, farm yard manure and spent compost should be more than 2 years old. Lime or chalk powder is added to adjust pH. Peat has very high water holding capacity without creating sealing in casing layer. It is being widely used in western countries and in India some farmers are using it. Mixtures like shredded tree bark and paper mill waste have also been used.

Pasteurization

Pasteurization is a must to eliminate harmful microbes and insect pests from casing material. There are two ways to achieve it, i.e., (i) Steam pasteurization, and (ii) Chemical pasteurization. At the time of pasteurization casing material should be loose and moist.

i) Steam pasteurization : Though harmful microbes and insect pests are killed at 65^{o}C for 30 minutes it is difficult to achieve this temperature in all parts of casing material in short time. Hence to have effective pasteurization moist casing material is filled in wooden trays (6-7" deep) with 2" legs and stacked in the centre

of casing pasteurization chamber in tiers leaving gap between walls and trays. The perforated pipes are laid at ground level and trays are stacked at about 2 feet above the ground with brick support which should not block steam movement. Door is closed and steam is released to maintain casing material's temperature at 65^0C for 5 to 6 hours. Steam pasteurization should be done 24 hours in advance of casing. Stem is most efficient way of pasteurization.

ii) Chemical pasteurization : Chemical pasteurization is done when there is no facility for steam pasteurization, Formaldehyde, methyl bromide and chloropicrin are the chemicals used for pasteurization. However, formaldehyde is most popular. For Methyl bromide closed chamber should be used and care should be taken to avoid inhaling this gas as it is odourless and poisonous. Moist casing material is spread on cement floor and is drenched with 5% formaldehyde solution (50 ml/litre of water). Fifteen litres of solution is used for 1/2 cubic meter of casing material. Solution should be poured after making channels and covered with removed soil. After chemical treatment, it should be covered with polythene sheet. After 2 days, soil is turned and turning is repeated every alternate day till casing. This helps to remove formaldehyde from casing material. Chemical treatment is performed 2 weeks in advance of casing as it takes time for getting casing material free from formaldehyde smell.

Time of casing : Best time of casing is when the compost is fully covered with mushroom mycelium. However, time taken for this depends upon the depth of compost, spawn rate and environmental conditions etc.

Depth of casing : At the time of casing compost should be uniform. Casing thickness ranges between 1-1 $\frac{1}{2}$" for soil, 1" - 2" for peat, farm yard manure and spent compost. Correct and even thickness of casing layer is an important factor for good cropping.

Water management : The water content of the casing and amount of water sprayed affect the mycelial growth and subsequently yield. When moisture in casing is low it results in the growth of fine hyphae whereas higher moisture content encourages thick strands but slow growth. The water management also depends on the casing material viz., peat moss, farm yard compost and spent compost can hold more water content than soil. A casing which has been kept moist from the start should present little problem but one should avoid excessive watering in early stage of casing as it may not allow mycelium to come on top surface due to sealing effect. It should be preferred to bring casing material to saturation point gradually. Some growers ruffle the casing layer after 6-8 days of casing. It helps in uniform distribution of mushroom mycelium in casing layer resulting in uniform crop (Fig. 4.3).

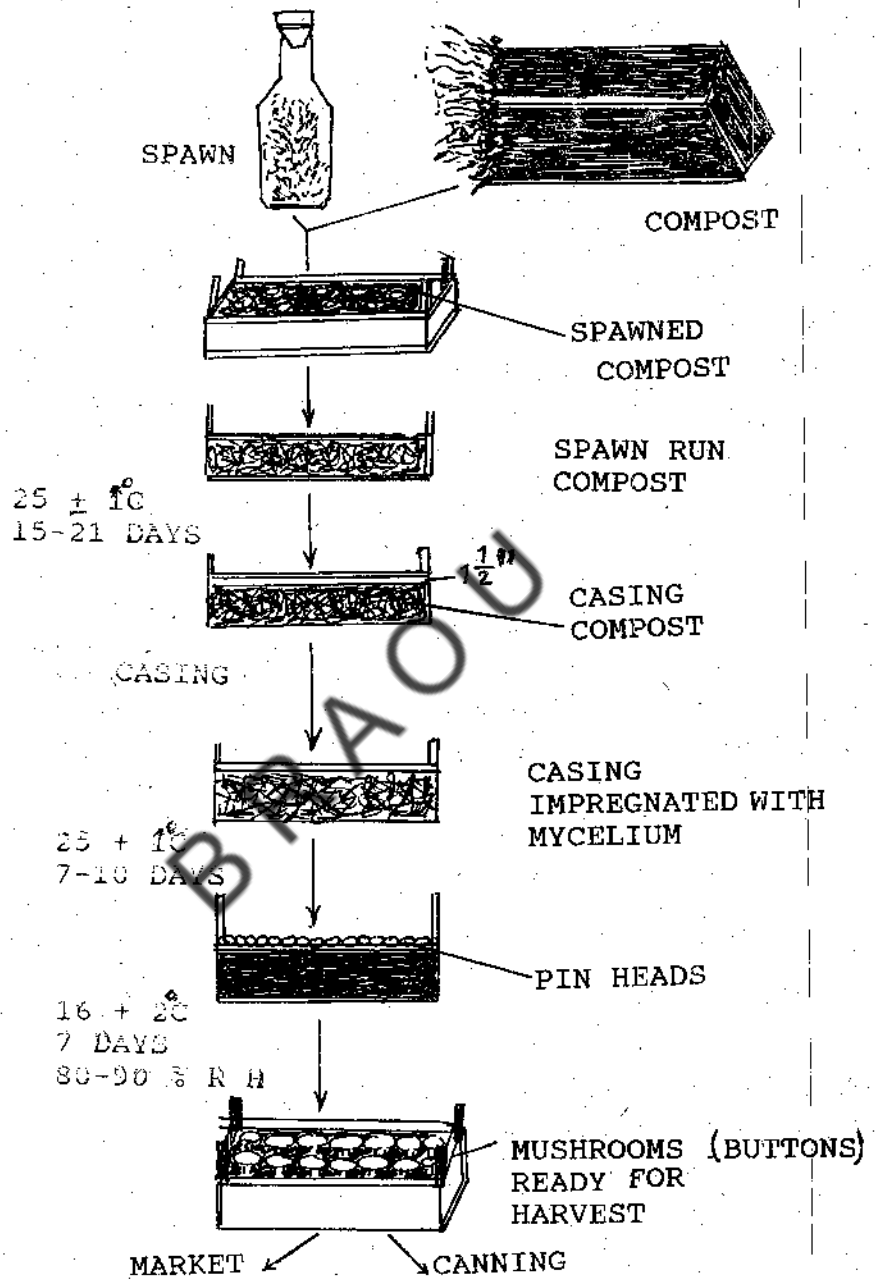

Fig.4.3. White button mushroom growing at a glance.

4.7. CROPPING AND HARVESTING

After casing in about a week's time mycelium spreads in the casing soil. At this stage the temperature of the cropping rooms to be brought down to 14-18°C.

Temperature range and other environmental conditions for *Agaricus bisporus* and *A. bitorquis* are given below :

A. White Button Mushroom (*Agaricus bisporus*)

Mushroom mycelium in its vegetative stage continues to grow after spawning and casing. Once mycelium has grown through casing layer it is transformed into reproductive stage by changing environmental condition., particularly temperature. Room temperature at $23^0C \pm 2^0C$ is maintained for 8-10 days after casing. During this period there is little necessity of watering and fresh air. This period is required by mycelium to reach on top of casing. This is the time when fruit body formation is initiated by lowering down the temperature to $16^0 \pm 2^0C$ and introducing fresh air to reduce carbon dioxide level between 0.05 - 0.08%. Relative humidity should be maintained at 90% to prevent drying out of fine hyphae at this stage.

Watering should also be increased. Sudden changes in climatic conditions result in transforming vegetative mycelium into fruitification in casing layer. This is the most important stage in the whole process of mushroom cultivation. Tschierpe has explained these environmental changes in detail. In his opinion fruiting is established by creating carbondioxide gradient between high levels in spawn run compost and low levels in the growing rooms atmosphere. Simultaneous changes in air temperature, compost temperature, humidity and composition of air results in fruit body initiation and after ninety six hours one can see the pinheads or primordia.

Once fruiting is established these conditions are maintained until the end of crop. The crop needs room temperature of $14\text{-}16^0C$ and enough fresh air to maintain the carbondioxide below 0.1% and relative humidity at 80-90%. Hence ventilation and watering are important factors during cropping. Fresh air is required not only to meet the demand of oxygen during fruitification (fruit body formation) but also to flush out excess carbondioxide from the surface of casing layer. Enough water is required to prevent casing from drying which may otherwise create dehydration of mycelium restricting translocation of nutrients through casing layer and ultimately affecting the production. Watering should be done regularly and evenly.

The fruitification starts with the initiation of large number of pinheads or primordia but only a few develop into fruit bodies and rest abort. There will be a flush at every 7-10 days interval. However, the first crop is considered most crucial in overall mushroom production. There is no information about the mechanism of flushing or breaks. The crop starts producing mushroom in 3rd week after casing and continues for 10-12 weeks. Growers in advanced countries take crop for shorter duration of 5-6 weeks which enables them to have 6-7 crops per room

per annum. In India commercial farms take crops for 7-10 weeks or 5 crops per room per annum.

Mushrooms are picked by gripping the cap and twisting gently to break off from the base without disturbing other growing mushrooms. Mushrooms are harvested when they are still closed or button stage. Their keeping quality is always better than opened ones. Mushrooms increase in their weight upto opening stage. Once opened, mushrooms market value is reduced. Button stage is generally preferred for canning purpose. After harvesting mushrooms, stalk is trimmed from the soil portion, cleaned gently with soft cloth and packed in perforated polythene bags (100 guage). Holes left in the beds after harvesting should be filled with sterilized casing material.

The yield reported in western countries is about 20-38 kg/Sq.m and in India 10-16 kg/Sq.m. With the introduction of pasteurization system higher yield has been achieved. It is also influenced by the compost filled in per Sq.m area. With the proper composting procedures one tonne of dry straw makes 2.5 tonnes of compost giving an average yield of 450 kg fresh mushroom in U.K. In mushroom production, selection of strains for particular season or place is equally important. At the end of cropping, spent compost should be disposed off far away from the farm. It can be utilized as farm manure.

B. White Button Mushroom (Agaricus bitorquis)

This variety has good scope in subtropical regions as it can be grown in moderate temperature range of 20-28^{0}C (Optimum 24 $\pm$ 2^{0}C). However this variety drew attention due to its resistance to die-back (vius disease). *Agaricus bisporus* is known to be susceptible to viruses. A virus infected farm can be made virus-free by growing, *A.bitorquis* and taking strict hygienic measures. It has better tolerance to CO_2 and superior shelf-life due to solid fruiting bodies. The commercial production is done in some European countries viz., The Netherlands where growers take its cultivation during summer in rotation with *A. bisporus*.

The composting process is similar to *A. bisporus*. However, after spawning temperature of 28-30^{0}C and relative humidity of 90-95% are to be maintained. Casing, is also similar to *A. bisporus*. After casing temperature at 28-30^{0}C is maintained for about 7-10 days when mycelium impregnates the casing layer. This is the time when required fresh air is introduced and temperature is lowered to 24 $\pm$ 2^{0}C. The pinheads start appearing within 3-5 days and they take another 3-5 days when mushrooms are cleaned with soft cloth and packed in perforated polythene bags. This variety produces 10-20 kg/100 kg compost. Since this variety is grown at higher temperature it is prone to various diseases and competitor moulds, hence immediately after spawning mixture of bavistin (0.1%) and formalin (1%)

should be sprayed at weekly intervals. Just before and after casing, the mixture of these chemicals should be sprayed on compost and casing soil respectively.

Check Your Progress - 5

What are the temperature requirements for *Agaricus bitorquis* ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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4.8. SUMMARY

White button mushrooms are coprophilous fungi. Technical know how is needed for their cultivation. The first step in button mushroom growing is the preparation of compost. Vegetable base materials like wheat, paddy, barley, rye, oat, maize stalks and other vegetable plant wastes are supplemented. Four categories of nutrients viz., animal manures (horse dung, chicken, pig, sheep, mule, yak, goat, cow, bullock and elephant manures), nitrogen fertilizers, (ammonium sulphate, urea, Calcium ammonium nitrate) and carbohydrate sources (molasses, wet brewers grain, potato waste, molassed sugar-beet pulp, apple and grape pomice and concentrated meals such as dried brewers' grains, unmolassed sugar beet pulp, corn cobs, wheat/rice bran, seed meals of cotton, caster, soyabean, linseed etc and minerals (Potash, super phosphate, trace metal mixtures, gypsum and chalk powder). Various compost formulations are in use according to the availability of raw materials and supplements where they are cultivated. There are two methods of compost preparation namely long method and short method. Long method requires 28 days and the short method takes about 10-17 days for compost preparations. Long method is more popular among small growers who cannot afford boiler for pasteurization. This method reduces the nutritional value of compost and easily attacked by weed moulds, pathogens, insects, mites and nematodes. Short method is popular among commercial growers. it consists of two phases. Phase-I is accomplished in outdoors and requires 7-10 days while phase-II is done indoors and requires 3-7 days. Bulk chamber is also used for phase-II. In short method yield is very high with efficient disease control. A good compost is dark brown in colour with 68- 70% moisture content.

There are different kinds of growing systems for button mushroom cultivation. They are outdoor ridge beds, shelf system, rack system, tray system, bag system etc. Broadcasting of spawn in the compost is called spawning. There are different kinds of spawning methods viz., surface spawning, layer spawning and through spawning. Spreading of mycelium from grain spawn into the compost is called spawn running. Spawn running completes within 14-18 days. Optimum temperature for spawn running is 24 $\pm$ 1^{0}C and relative humidity is 90%. After spawn running is completed the compost must be covered with a layer of nutritionally deficient soil called casing soil for the initiation of fruitbodies. Various formulations are in use for casing layer. They are peat mixed in different ratios with lime stone and soil, soil and sand (1:1), rotten cow dung and soil (3:1), farm yard manure and loam (1:1) and spent compost, sand and lime (4:1:1). In about a week's time after casing the mycelium spreads throughout the casing layer. At this stage the temperature of the growing rooms should be brought down to 14-18^{0}C and the carbon dioxide level should be reduced to 0.05 - 0.08%. Relative humidity should be maintained at 90%. Pinheads appear due to the sudden change in the environmental conditions which grow in size to fully developed fruiting bodies. Of the two species of *Agaricus*, *A. bisporus* requires 24 $\pm$ 1^{0}C for spawn running and 14-18^{0}C for pinhead formation where as *A. bitorquis* requires a temperature range of 28-30^{0}C for spawn running and 24 $\pm$ 2^{0}C for pinhead formation. *A. bitorquis* is resistant to a virus disease called dieback where as *A. bisporus* is susceptible for the disease. Apart from this, *A. bitorquis* has better tolerance to CO_2 and superior shelf-life of the fruit-bodies. However, being a high temperature variety it is prone to various diseases and competitor moulds.

4.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Compost is the fermentation product of organic and inorganic substrates brought about by many mesophilic and thermophilic fungi.
2. There are two methods of composting namely long method and short method.
3. A good compost is dark brown in colour with a distinct inoffensive smell. The moisture content is 68-70%. The compost should not be greasy and should be free from visible growth of micro - organisms.
4. Spreading or broadcasting of spawn in the compost is called spawning. There are three types of spawning namely surface spawning, layer spawning and through spawning.
5. *Agaricus bitorquis* requires 28-30^{0}C for spawn running and 24 $\pm$ 2^{0}C for pinhead formation.

4.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write an eassy on various compost formulations commonly used in button mushroom cultivation.
2. Describe in detail about long method of composting for growing button mushrooms.
3. Write an eassy on the method of cultivation of button mushrooms.

II. Answer the following in about 10 lines each.

1. Define compost. What are the qualities of a good compost ?
2. What is casing ? What are the various formulations of casing ?
3. What are the growing requirements of *Agaricus bitorquis* ?

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Ms. K. Prasunamma

UNIT-5: FACTORS AFFECTING BUTTON MUSHROOM PRODUCTION

Contents

5.1. OBJECTIVES

After going through this unit you will be able to:

- describe the environmental factors required during spawn run and cropping.
- list out the abiotic disorders affecting white button mushroom cultivation and
- list out the biotic disorders affecting white button mushroom cultivation.

5.2. INTRODUCTION

Cultivation of white button mushroom is mainly based on the quality of compost, casing soil, spawn and environmental factors. Uniform climatic conditions throughout the period of cultivation shall not give good results for this mushroom. The fungus demands different environmental factors during spawn run and cropping. Like any other organism, mushroom is affected by many abiotic and biotic disorders. Hence, one should be careful in manipulating and managing the climatic factors and biotic disorders respectively.

5.3. ENVIRONMENTAL FACTORS

The success of white button mushroom cultivation depends on the quality of compost, spawn and abiotic or environmental factors. The management of environmental factors viz., temperature, relative humidity, moisture content and air is important for spawn run and fruit body formation of mushrooms.

5.3.1. During Spawn Run

i) **Temperature** : The mycelium grows best at a temperature range of 24-27^{o}C for *A. bisporus* and 28-30^{o}C for *A. bitorquis*. During early stages of spawning compost temperature goes up due to microbial activities particularly during first 48 hours. Spawn running also generates heat. The dose of spawn influences the growth and heat produced. Spawn dose should be 0.5-0.75 per cent (i.e., 500g-750g spawn for 100kg compost, otherwise it may raise compost temperature. The temperature above 28^{o}C (*A. bisporus*) and 32^{o}C (*A. bitorquis*) results in poor growth and a temperature of 34^{o}C and above is lethal for button mushroom mycelium. Temperature starts raising between 7th and 9th days due to very active spawn growth, hence provision should be provided to check it by introducing fresh or cooled air and by spraying water.

ii) **Relative humidity (RH) and moisture content** : The R.H. should be maintained between 90 and 95% inside spawn running room. Moisture content of compost should be 68-70% in trays/shelves and in polythene bags it should be 65-68% since moisture loss from polythene bags is slow. News papers are spread over compost and should be kept moist by watering so that moisture content in compost is well maintained.

Watering should be done frequently during dry season or when fresh air is introduced to maintain temperature, particularly on floor and walls. Similarly during humid weather or rainy season, watering should be reduced. Moisture loss from paper also indicates low R.H. If top layer of compost shows dryness paper should be removed and water should be sprayed and again covered with paper. Water spraying is done mainly to prevent moisture loss from compost and in no case moisture content should be increased through watering. This can also be managed by covering trays/shelves with thin polythene sheet and closing the mouth of polythene bags. However, it demands more attention as there is possibility of rise in temperature.

iii) **Air** : During spawn run requirement of fresh air is low and it needs carbon dioxide upto 4% for good spawn growth. This can be easily achieved if compost temperature is maintained without fresh air. Hence, fresh air should be supplied only when it is must to check rise in temperature as temperature maintenance is the most important step.

5.3.2. During Cropping

i) **Temperature** : After casing air temperature between 24-25°C (*A. bisporus*) and 28-30°C (*A. bitorquis*) should be maintained for mycelium to grow in casing soil. After 10 days of casing when mycelium covers casing soil the temperature should be maintained between 14-18°C (*A. bisporus*) and 22-26°C (*A. bitorquis*) for fruit formation. Mushroom yield is affected both in very low or high temperature. The initial stage or pinning of *A. bisporus* is sensitive to temperature and need about 16°C. However, once pins are 5mm and above they grow very fast in higher temperature and those fruiting bodies smaller than 5 mm cease to grow and die. Hence utmost care should be taken to maintain low temperature. However, there are some reports where temperature is manipulated to control cropping. Initially low temperature (16°C) is provided for pinning and once fruit size is 5-7 mm and above, temperature is raised for faster growth. When mushrooms are ready for harvest again temperature is lowered for next flush to start. However, it needs careful study as strains may differ in their requirement. However, *A. bitorquis* grows well at high temperature i.e., 24 ± 2°C.

ii) **Relative humidity (R.H.) and moisture content :** Relative humidity of 80-90% should be maintained during cropping. Higher Relative humidity may cause bacterial blotch and low R.H. will reduce yield. When pins are 5 mm diameter, pea size, they need more water. At this stage casing soil should be sprayed with water. The water requirement also depends upon the quality of casing material and ventilation provided. Casing soil should be always moist and not allowed to dry as small pinheads may fail to develop into mushrooms. More amount of water is required during I and II flush when maximum crop is produced. As the yield decreases watering is also to be reduced.

iii) **Air :** Requirement for oxygen increases during cropping period. This also reduces the carbon dioxide concentration inside the cropping room. The quantity of air required can be worked out from the principle that for every Kilo of mushroom there must be 1 m^3 air/m^2/hr. at compost temperature of 16-18°C and for every 1°C increase in temperature 20% extra air should be provided. Air should be changed 10 m^3/m^2 per hr. at 18°C when yield is 10 kg/m^2. This should be achieved shortly before and during harvesting of mushrooms. This process is to be started with 5 m^3/m^2/hr. When pinning starts the amount of air should be gradually increased to 10 m^3/m^2/hr. With reduction in yield air requirement also decreases. There will be continuous production of CO_2 in cropping rooms. However to get good crop CO_2 concentration should be 0.07-0.09% (700-900 ppm). When CO_2 content is high in cropping room, mushrooms appear elongated and in case CO_2 is too high mushrooms appear with very thick stalk and small cap which also indicates that aeration is poor in cropping room. The speed of the air should be 0.2-0.4m/sec. but should not be more than 1m/sec. High speed of air may cause scale formation and cracks in caps particularly when relative humidity is low.

Check Your Progress - 1

What is the amount of air required during cropping ?

Note : (a) Write the answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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5.4. ABIOTIC DISORDERS

Environmental or abiotic factors play a key role in button mushroom cultivation. The following abiotic disorders are commonly observed during the cultivation of white button mushrooms.

i) **Brown discolouration :** In seasonal mushroom farms browning of small pin heads occur. This may be due to high temperature, spraying water at high pressure (maximum pressure is 0.4 atm.), spraying of high concentration of chlorine water (maximum rate is 500 ml per 100 litres water) or spraying mushrooms with formalin solution.

ii) **Stroma and Sectors :** Aggregation of mushroom mycelium on the spawned compost or casing is called stroma. An extra-white, extra-dense, fluffy portion of spawn in the compost or on the casing is called a sector. Formation of stroma and sectors are genetically related traits of the spawn and also sometimes induced due to the exposure of spawn to harmful chemicals, detergents, petroleum based fumes during preparation, storage or transportation to the farm.

iii) **Flocks, hard caps and open veils :** Malformation of mushroom's cap and gill tissue is called a flock. Hard cap is the cap or pileus of the mushroom that appear disproportionately small when compared to stipe's diameter. Premature opening of veil with abnormally developed gills is called open veil. Diesel exhaust, certain anticorrosive chemicals in steam boilers and certain diseases like false truffle, die back and brown plaster induce flock and hard cap formation and open veils. Open veil also occurs when the fungus undergo water stress of 1 to 3 days followed by generous watering.

iv) **Weepers, leakers and stinkers :** Weepers are those mushrooms that exude water from mushroom cap which flows from the mushrooms. Mushrooms that exude water in the form of droplets from the stem or cap are called leakers. Water that is collected on the casing soil beneath a weeper develops an offensive odour and such mushrooms are called stinkers. Low moisture compost (less than 64 per cent) and high moisture casing may be the probable reason for the formation of weepers, leakers and stinkers.

v) **Scales or crocodiles :** The surface tissue ceases to grow due to poor climatic control like high air velocities and drying while the cap continues to develop further leading to the appearance of scales. The so called crocodile skin is

also formed when the outer layer of the half-grown mushroom tears-off and the mushroom continues to grow. This is formed due to strong vapours of pest-control products and formaldehyde.

vi) **Hollow core and brown pith** : Circular gap in the centre of the stem is called hollow core. When the hollow cut end portion is brown in colour it is called brown pith. These are due to abnormalities that occur during watering.

vii) **Rose comb** : Rose comb is the formation of swellings and large lumps on the cap or pileus of the mushroom which may occur due to the polluted casing soil, vapours from paint or oil products etc.

viii) **Purple stem** : Within few hours of harvest the cut ends of stipe appear purple in colour which is due to the excessive formation of enzyme polyphenol oxidase at the later flushes of mushrooms. Irregular watering before harvest may be the reason for the formation of excessive amount of enzyme.

ix) **Long Stemmed Mushrooms** : Formation of long stems is due to high concentration of CO_2 in cropping rooms.

x) **Cryptomummy disease (pinheads death)** : It is due to over watering of the beds.

Check Your Progress - 2 & 3

2. Differentiate between a weeper and a leaker ?

3. What are stroma and sectors ?

Note : (a) Write the answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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5.5. BIOTIC DISORDERS

White button mushrooms though grown under controlled conditions are prone to certain biotic disorders. Biotic disorders are the abnormalities caused by living organisms like fungi, bacteria, viruses, pests and nematodes. The organisms that affect white button mushrooms are differentiated into competitor moulds, parasitic moulds, bacteria, viruses, pests and nematodes.

5.5.1. Competitor Moulds

Competitor moulds are those fungi that compete with button mushroom for the substrate (compost or casing soil). The common diseases caused by competitor moulds are as follows :

i) ***False truffle (Diehliomyces microsporus)*** : White to cream coloured small tufts of mycelium is formed in the compost and casing soil. The disease commonly appears when the temperature of growing room exceeds 25°C. The temperature of the rooms should be brought down to 15-18°C and treatment with 2% formalin or 0.05% bavistin at the affected areas shall bring down the disease incidence.

ii) ***Brown plaster mould (Papulospora byssina)*** : Whitish round patches in the compost or casing soil turning to rusty brown. When the moisture content is high in the compost and the compost is prepared from old materials the disease appears. Moisture in the compost should be maintained at 70%.

iii) ***Inky caps (species of Coprinus like C. comatus, C. atramentarius, C. lagopus and C. fimitarious)*** : They consist of long stalks with thin caps which disintegrate rapidly to form a black coloured mass. Ammonia should be removed completely from the compost.

iv) ***White Plaster Mould (Scopulariopsis fimicola)*** : White patches of mycelium giving flour like appearance on compost and casing soil are observed. The pH of the compost should be less than 8. Bavistin (0.05%) or Thiram (0.1%) at 10 days interval should be sprayed.

v) ***Olive green mould (Chaetomium olivaceum and C.globosum)*** : Tiny white ball like structures later turning to olive green appear on the compost. Proper pasteurization of the compost, supply of sufficient oxygen during composting and maintenance of below 62°C temperature during composting help to reduce the incidence of disease.

vi) ***Green mould (Trichoderma viridae, T.lignorum, Penicillium sp., Aspergillus sp., Gliocladium sp.)*** : Blue or green coloured cushions appear on the compost and casing soil. Proper pasteurization of compost and maintenance of hygienic conditions in cropping rooms reduce the spread of disease. Bavistin (0.05%) can also be sprayed on infected trays.

vii) ***Yellow mould (Myceliophthora lutea, Sepedonium maheshwarianum, Chrysosporium sp.)*** : Patches are light yellow in colour with fluffy edges. The percentage of nitrogen should be adjusted to 1.5 - 1.75%. Chicken manure should not be used for long method of composting. Calcium hypochlorite (0.15%) should be sprayed on infected portion.

viii) ***Lipstick mould (Sporendonema purpurescens)*** : White mycelial growth changing to pink or buff colour. The infection may come through workers, air or casing soil. Proper moisture (68-72%) in the compost should be maintained. Pasteurization of compost and casing soil should be done properly.

ix) ***Black whisker mould (Doratomyces stemonitis)*** : Black whisker mould forms grey or black bristles in the compost. The mould usually appears when nitrogen is less in the compost. Compost should be prepared with correct nitrogen percentage. The infected portions should be treated with 2% formalin.

x) ***Cinnamon brown mould (Peziza ostracoderma)*** : White mycelial patches with saucer shaped yellowish brown fruit bodies appear on casing soil. The relative humidity in growing rooms should not be more than 95%. The casing soil should be sterilised with the recommended amount of formalin.

5.5.2. Parasitic Moulds

Parasitic moulds of mushrooms are those fungi that live on the mushroom mycelium. There are three parasitic moulds that usually appear on button mushroom. They are given below :

i) ***Dry bubble (Verticillium fungicola)*** : The mould causes downward splitting of stipe, mis-shapen and bent cap along with brown spots on the cap. Dithane M-45 (0.2%) or Bavistin 0.05% should be sprayed once in 10 days. Hygienic conditions should be maintained.

ii) ***Wet bubble (Mycogone perniciosa)*** : Mushroom tissue gets decayed with whitish mouldy growth and offensive smell. Brown to amber coloured liquid oozes out from the infected pinheads. Distorted and swollen stipe occurs with mis-shapen cap (pileus). Dithane M-45 (O.2%) should be sprayed once in 10 days. Hygienic conditions in the growing rooms should be maintained.

iii) ***Cobweb (Cladobotryum dendroides)*** : Pinheads and buttons are engulfed by the fungus resulting in the rottage. Greyish to pinky red cottony mycelial patches appear on casing soil. The infected portions should be treated with 0.15% calcium hypochlorite solution. Dithane M-45 (0.2%) should be sprayed. Excessive humidity in the growing rooms should be avoided.

Check Your Progress - 4 & 5

4. What are the competitor moulds ?

5. Write the symptoms produced by wet bubble disease.

Note : (a) Write the answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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5.5.3. Bacterial and Viral Diseases

Bacterial blotch is caused by *Pseudomonas tolaasii.* Yellowish brown patches appear on the stipe and pileus. Pinheads die prematurely and turn brown in colour. Water should not be sprayed on pinheads directly. Bleaching powder (0.05%) should be sprayed once in 7 days. Diseased pinheads should be removed to prevent the spread of the disease.

Common viral diseases on mushrooms are La France, Watery stipe, X disease and die back of mushrooms. Mycelium affected with virus penetrates partially into the casing soil. Pinhead appearance is delayed and appear in clusters. Mushrooms consist of long and bent stipe which is loosely attached to the substratum. The bags and trays should be sprayed with 2% sodium pentachloro phenate and 0.5 - 1.0% sodium carbonate. Strict hygiene should be maintained. The room and the compost should be heated upto 70^{o}C for 12 hrs. after the crop.

5.5.4. Pests and Nematodes

Mushroom mites (*Tarsonemus myceliophagus*), mushroom flies (Sciarids, Phorids and Cecids) and springtailes (*Lepidocyrtus cyaneus*) are the common button mushroom pests. Mushroom mites affect the spawn run by feeding on mushroom mycelium. Stipe shows reddish brown discolouration. The compost after the crop should be treated at 70^{o}C for 20 min. Kelthane (0.1%) can be sprayed on the infected trays.

Mushroom flies are seen in the compost prepared by long method and in improperly pasteurised compost during phase-II by short method. The larvae feed on mycelium affecting spawn run. They make tunnels in the stipe and pinheads turn brown and leathery. BHC or Lindane 0.3 to 0.4% should be added in the compost when it is prepared by long method. Casing soil should be treated with Nuvan or Malathion (0.1%). The room along with the compost should be heated for 8-10 hrs at 70^{o}C, after the crop.

Springtailes are the small wingless insects that usually jump in the air. They make tunnels in the stipe and cap and also feed upon mushroom mycelium. BHC at the rate of 400g/tonne of compost should be added during last turning.

Mushroom nematodes are of two types they are saprophagous (*Rhabditids* sp.) and myceliophagous nematodes (*Ditylenchus myceliophagous and Aphelenchoides composticola*). Saprophagous nematodes reduce yield when they are present in large number and not harmful in small numbers. Myceliophagous nematodes feed on mushroom mycelium and affects spawn run severely. Pasteurised compost is recommended for use. Carbofuran (0.04%) may be added at the 4th turning (400g/tonne of straw) when compost is prepared by long method. The trays should be treated with 2% farmalin after the crop. The infected compost should be cooked out at 70^{o}C for 8-10 hours.

5.6. SUMMARY

White button mushroom cultivation demands so much care and attention. One should be careful about the quality of compost, casing soil, spawn and the

environment. During spawn run the temperature range of 24-27^{0}C for *Agaricus bisporus and* 28-30^{0}C for *A. bitorquis* and relative humidity at 90-95% are required. Moisture content of compost should be 68-70% in trays and shelves whereas in polythene bags it should be 65-68%. During cropping the temperature range of 14-18^{0}C for *Agaricus bisporus* ; 22-26^{0}C for *A. bitorquis* and relative humidity 80-90% are required.

Abiotic disorders affect button mushroom cultivation drastically leading to poorer yields. Brown discolouration, formation of stroma, sectors, flocks, hard caps, open veils, weepers, leakers, stinkers, scales, crocodiles, hollow core, brown pith, rose comb, purple stem etc., are some of the diseases seen due to the abnormal environmental factors. White button mushrooms are also affected by living organisms. Some of them are competitor moulds like false truffle, brown plaster mould, inky caps, white plaster mould, olive green mould, green mould, yellow mould, lipstick mould, black whisker mould, cinnamon brown mould etc., parasitic moulds like dry bubble, wet bubble, cobweb etc., bacterial, viral diseases, pests and nematodes.

5.7. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Fresh air requirement during cropping must be m^3 air/m^2/hr. at compost temperature of 16-18^{0}C and for every 1^{0}C increase in temperature 20% extra air is to be provided.

2. The mushrooms that exude water from mushroom cap which flows out from the caps are called weepers whereas the mushrooms that exude water in the form of droplets from the stipe and cap are called leakers.

3. Stroma is the aggregation of mushroom mycelium on the spawned compost and casing soil. Sector is an extra white, extra-dense, fluffy portion of spawn in the compost or casing.

4. Competitor moulds are the fungi that compete with mushroom mycelium for the substrate (compost and casing soil).

5. Decay of mushroom tissue, whitish mouldy growth with offensive smell, distorted, swollen stipe, mis-shapen cap and oozing out of brown to amber coloured liquid from the infected pinheads are the symptoms produced by wet buble disease.

5.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write an essay on the environmental factors required during spawn run and cropping of white button mushroom.

2. Give an account of abiotic disorders of white button mushroom ?

3. Write briefly on biotic disorders of white buttoh mushroom.

II. Answer the following questions in about 10 lines each.

1. Write a note on abiotic disorders of white button mushroom.
2. What are parasitic moulds ?
3. Define competitor moulds. Add a note on the competitor moulds of white button mushroom.
4. Write a short note on bacterial and viral diseases ?
5. Give a brief note on pests and nematodes of white button mushroom ?

Dr. M. Ramachandraiah

UNIT - 6 : PACKING, PRESERVATION AND MARKETING OF BUTTON MUSHROOM

Contents

6.1. OBJECTIVES

After going through this unit you will be able to :

- describe the packing methods of white button mushrooms,
- describe the preservation methods of white button mushrooms and
- explain the marketing aspects of white button mushrooms.

6.2. INTRODUCTION

White button mushrooms are highly perishable and become unsuitable for human consumption due to many physiological changes that occur after harvesting the mushrooms. They are made up of a mass of intricate delicate hyphae which continue to grow even after the harvest. Hence, the correct size of mushroom during harvesting is very important to arrest the post-harvest growth. The white button mushrooms should have the cap size of 30-45 mm in diameter at the time of harvest. They consist of 90% moisture. Free exchange of water vapour from inside the mushroom to outside air takes place due to the presence of interhyphal spaces. Due to the loss of water the mushrooms loose their turgidity, the stipe and pileus toughen and contract. Freshness and weight of the mushrooms are lost. Mushrooms when stored at 15^0C, loose 25% of the initial weight after 96 hours. Mushrooms contain an enzyme polyphenol oxidase that changes the white colour of mushrooms to brown after harvest. Moreover, fresh mushrooms respire at a high rate enhancing rapid deterioration. Hence keeping all these factors that reduce the market acceptability in view, methods of storage should be followed to check the physiological changes of mushrooms and to ensure longer shelf-life. Mushrooms are packed in plastic crates, high density (HD) plastics, expanded polystyrene (EPS) cans etc. The white button mushrooms can be

preserved by various methods like canning, pickling, dehydration, freeze-drying, low-temperature storage, steeping preservation etc., of which canning is the most suitable method. These mushrooms have good market in metropolitan cities. Delhi provides the largest market for fresh mushrooms. Bombay, Bangalore, Hyderabad and Madras are also good market centres. These mushrooms have a good export potential.

6.3. PACKING OF WHITE BUTTON MUSHROOMS

Before packing mushrooms are to be graded on the basis of the size of buttons, opening of gills and shape of the pileus. Buttons are graded No.1 and have high acceptability. Cups are graded No.2 and umbrella shaped ones are graded No.3. The mushrooms are washed in clean water to remove the residues of compost and casing soil. They are then washed in a solution of sodium or potassium metabisulphite (0.025 to 0.05 percent) to retain the whitness of mushrooms. The mushroom tissues should not be damaged during washing. Damage of mushroom tissue causes discolouration during storage.

Mushrooms are usually packed in packings of 200g or 400g and 250g or 500g. They are packed in polythene bags of less than 100 gauge thickness. It has been reported that the polythene bags should not be perforated and should be sealed properly. These airtight packs stored at 5^{0}C shall retain their freshness for 4 days. Expanded polystyrene or pulp board punnets over-wrapped with differentially permeable polyvinyl chloride (PVC) or polyacetate films are also used for distant transprot. The over-wrappings create a modified atmosphere in the punnets by producing about 10 percent carbon dioxide and 2 percent oxygen that helps in conserving freshness of mushrooms for about 3 days at 10^{0}C. Other packing systems broadly in use abroad are 5lb platic trays (400 x 300 x 100mm height and 0.66mm thickness) with perfortated polythene cover (225x135mm), 5 lb expanded polystyrene containers (EPS) of 330x280x145mm height and 13mm thickness with thin card lid consisting of four 18mm holes and 10 lb EPS containers (400 x 300 x 167 mm).

The preserved mushrooms are packed in polypropylene bags, polythene bags, pouches lined by aluminium foil, cans, jars etc.

Check Your Progress - 1 & 2

1. What are the factors involved in rapid deterioration of white button mushrooms after harvest ?

2. What are the packing methods of white button mushrooms ?

Note : (a) Write the answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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6.4. PRESERVATION OF WHITE BUTTON MUSHROOMS

White button mushrooms can be preserved by various methods like canning, dehydration, freezing and steeping preservation.

Usually the costliest mushrooms are used for canning while the cheaper ones for dehydration. Further, for canning only very small buttons without stem are used, while the opened mushrooms are used for drying (also used subsequently in soup mixes). Freezing has its own advantages over canning and hence mushroom freezing is considered to be the latest method in mushroom processing. Important processing aspects are given below (Fig. 6.1.)

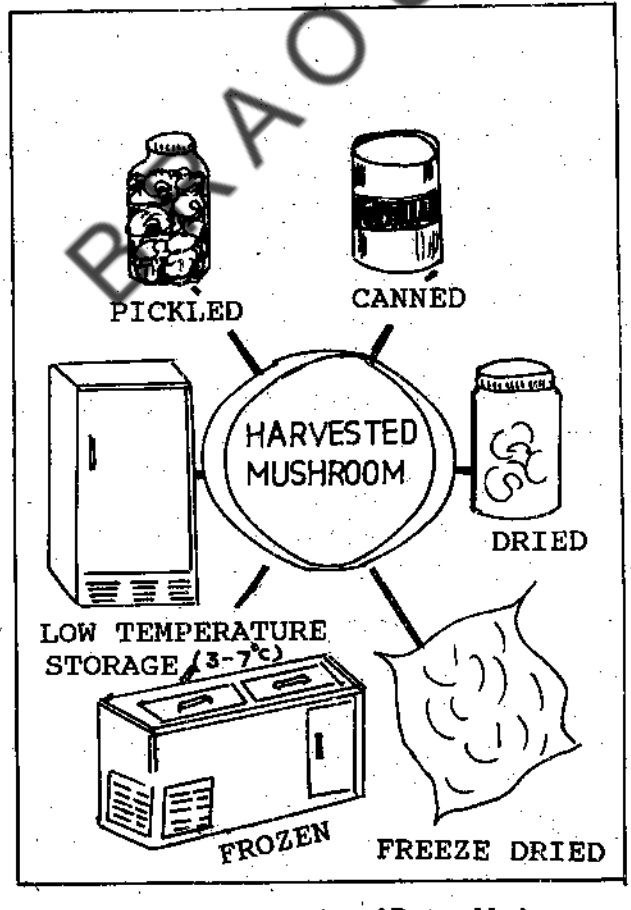

Fig. 6.1. Preservation of Button Mushrooms

1. Canning

'Button Mushrooms' are mainly used for canning purpose. The mushrooms with small buttons and with 0.5 to 1 cm stems are to be selected, and then stalk is cut close to the button. The buttons are then blanched for about 5 min in steam or boiling water followed by prompt cooling. Blanching removes gases, inactivates enzymes, improves texture and gives greater drain weight in the cans. To improve the colour any of the treatments like use of 0.1 to 0.2% citric acid solution for blanching purpose, immersing in brine containing ascorbic acid and EDTA (Ethylene diamine tetra acetic acid) at 0.1% and 1000 ppm respectively. Immersing in KMS (Potassium metabisulphite) solution before blanching could also be done. Blanching causes 25-30% loss in weight, which is an unavoidable one. Blanched buttons are filled in plain cans. Filling rate is to be kept at about 200g/1 lb jam size can with about 250 ml brine so as to get atleast 4-5% drain weight. Boiling hot brine containing 1-2% salt and 0.1% citric acid should be poured to fill it upto brim leaving 1.5 cm Head-space. Brine with 2% salt, 2% sugar, and 0.3% citric acid has also been in use for this purpose. Tomato juice has also been tried successfully as a new canning medium at the Indian Institute of Horticultural Research, Bangalore. Next step is exhausting where filled can is heated to attain the temperature of 80°C in the centre of the can. This will remove extra fill as well as air entrapped both in the mushroom tissue and the liquid media used. After exhausting, the cans are hermetically sealed and processed in a retort for about 25-30 minutes at 10 lbs/psi/steam pressure, or for 15-20 minutes at 15 lbs/psi/steam pressure. Further processing time should be increased by 2 minutes for every 500′ elevation from sea level. Prompt cooling is necessary after processing and then only cans should be stored in a cool dry place. An automatic canning line is essential for this purpose (Fig.6.2.).

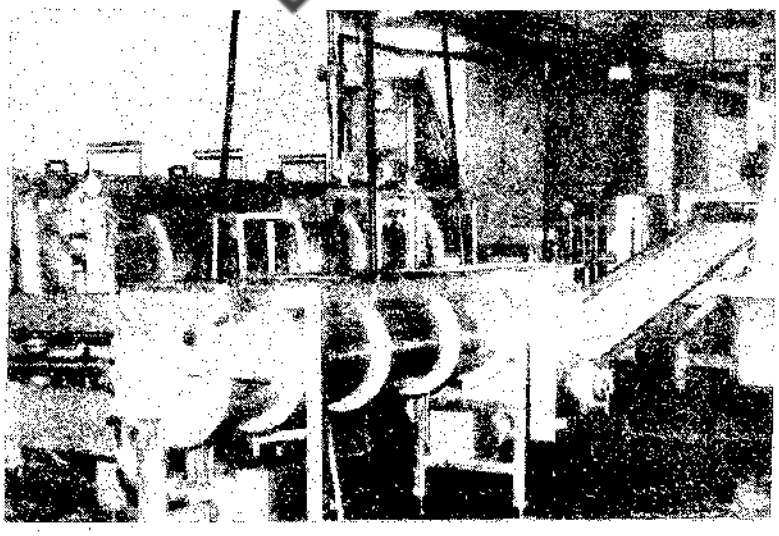

Fig.6.2. An automatic canning line (courtesy : Teg's Masrado, Chail, H.P.).

2. Dehydration

i) Ordinary dehydration : Mature Mushrooms with full stalk are used for drying purpose. Early break (i.e. 1st flush) consists of low tyrosine content and gives better produce. It may be dried whole or diced. After washing, they are blanched for 3-5 minutes in live steam or boiling water. Blanched mushrooms are given 5 minutes dip in sulphite and chlorine solutions of 300 ppm SO_2 and 400 ppm Cl_2 respectively for better colour and lesser bacterial count. Drying can be done in sun or in a mechanical drier (at 50-60^{o}C temperature). Dried mushrooms would weigh about 1/8 to 1/12th of their original weight depending on the species used. The moisture content in dried product should be about 5 percent. The dried mushrooms are packed in hermetically sealed air tight tins for retention of quality and then stored at a cool dry place. For reconstitution, sucrose solution with ascorbic acid is preferred. However, the dried mushrooms are normally powdered and used for preparation of soup mixes. Drying of white button mushrooms is very less in practice.

ii) Freeze drying : *'Agaricus bisporus'* is used for this purpose. It should be processed within 3 hours of harvest. For inhibiting the activity of polyphenol oxidase enzyme, it may be dipped for 30 minutes either in 0.5 percent sodium metabisulphite solution or 2 percent sodium cloride solution. Then blanching is done for 2 minutes in boiling water followed by prompt cooling. Mushrooms are diced/sliced into 5 mm thick pieces and frozen at -34^{o}C by dipping in Freon-12 for about a minute, as quick freezing gives a better quality product. Frozen mushrooms are then dried within 6-8 hours at low temperature under partial vacuum to a 3 percent moisture level. For better retention of quality, freeze dried mushrooms should be packed in aluminium foil containing pouches under N_2 (Nitrogen) atmosphere and then stored at lower temperature. 12 kg fresh mushroom gives 1 kg freeze-dried product which can yield 8 kg. of reconstituted material.

3. Freezing

'A. bisporus' is used at the button stage as in case of canning. The buttons are pre-cooled to 2 to 4^{o}C; then washed with water containing 50 ppm chlorine followed by 2 to 3 minutes blanch in water containing 0.1% citric acid. They can then be frozen as such or after packing in pouches. Freon-12 is used for quick freezing. Frozen mushrooms are to be stored only at -20^{o}C. Entire chain used for its marketing (i.e. from freezing till it is consumed) has to be a refrigerated one maintaining a temperature of - 20^{o}C throughout. Quick frozen mushrooms have got better demand in the world market because these could be stored even upto 1 year in storage chamber of the deep - freeze without any loss of flavour.

4. Steeping preservation

After washing, mushrooms should be blanched for 5 minutes in water containing 0.1% citric acid followed by washing in cool plain water. Then mushrooms are put in 15 per cent salt solution containing 0.05 per cent citric acid and 100 ppm SO_2. By this method mushrooms are preserved only for a short period (about 2 months or so).

6.5. MARKETING OF WHITE BUTTON MUSHROOMS

In India white button mushroom is produced and consumed mostly in big cities. A fraction of the produce is canned in India. U.S.A., Germany, Belgium, UK and Denmark are the main consumers of fresh mushroom. After harvest, mushrooms are graded as buttons, cups and open or flats. Buttons are prefered for canning. Closed cups are taken fresh. Open and flat types are considered to be low grade and sold at cheaper rates.

Delhi provides the largest market for fresh mushrooms. From various production centres Delhi receives mushrooms in bulk during winter and low supply during the rest of the year. It is relatively cheaper to produce mushrooms at the hills, but their marketing poses difficulties due to long distance transportation, increased costs and loss due to deterioration in transit. Production must be regularised in such a way that continuous supply is ensured for atleast five months, if marketing is to be integrated with production. However price fixations are very high in Delhi market.

Bangalore, Hyderabad and Madras are also good market centres. In fact the South Indian markets are more stable providing a constant price of Rs. 40/- to Rs. 50/- per kg as compared to Delhi. In Bombay and Calcutta they are sold at Rs. 80/- to 90/- per kg fresh mushroom. In Delhi the market price range from Rs. 20/- to Rs. 50/-.

There is good scope of export. Organised marketing by Governmental agency like APEDA will be of great help in this field.

Check Your Progress - 3 & 4

3. Enumerate the various methods of preservation of White button mushrooms.

4. What is meant by canning ?

Note : (a) Write the answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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6.6. SUMMARY

White button mushrooms due to post harvest physiological changes are perishable when stored at room temperature for longer periods. The size of the mushroom (cap size 30-45 mm diam.) at the time of harvest is an important factor to check further deterioration. Due to the presence of an enzyme, polyphenol oxidase, the initial colour of mushrooms changes to brown after harvest. Moreover, mushrooms consist of high rate of respirations even after the harvest causing rapid deterioration. Hence, proper methods of package and preservation are essential for this mushroom. The mushrooms are packed in polythene bags of less than 100 gauge thickness, expanded polystyrene (EPS) and plastic punnets. The preserved mushrooms are packed in polythene or polypropylene bags of less than 100 guage thickness, pouches containing aluminium foil, cans and jars.

White button mushrooms are preserved for long time by canning, dehydration (ordinary and freeze drying) freezing and steeping preservation. Canning and freeze drying are the common methods usually followed for long term storage.

In India white button mushrooms are marketed mostly in big cities like Delhi, Bangalore, Madras, Calcutta and Hyderabad. These mushrooms have very good export potential.

6.7. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Presence of 90 percent moisture, presence of an enzyme polyphenol oxidase that is responsible for brown colour of mushrooms and high rate of respiration are the main factors involved in rapid deterioration of button mushrooms.
2. Various packing methods of white button mushrooms are packing in polythene or polypropylene bags of less than 100 guage thickness, expanded polystyrene containers or pulp-board punnets over-wrapped by polyvinyl chloride or polyacetate films, cans, jars and pouches lined by aluminium foil.
3. Various methods of preservation of white button mushrooms are canning, dehydration (ordinary, and freeze drying), freezing and steeping preservation.
4. Canning is one of the methods of preservation where button mushrooms are blanched in 0.2% citric acid (for 3-5 min), filled in cans containing hot brine solution (1-2% salt and 0.1% citric acid), exhausted at 80°C, sealed, processed for 25-30 minutes at 10 lbs/psi steam pressure and promptly cooled.

6.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write an essay on preservation of white button mushrooms.
2. Give a brief account on packing, preservation and marketing of white button mushrooms.

II. Answer the following questions in about 10 lines each.

1. Write a note on packing of mushrooms.
2. Write a brief note on canning of mushrooms.
3. How many methods of dehydration of mushrooms are generally followed ? What are they ?
4. Write a note on steeping preservation.
5. What are the market potentialities for white button mushrooms ?

Dr. M. Ramachandraiah

BLOCK - 3
OYSTER MUSHROOM

UNIT - 7 : MORPHOLOGY AND COMMERCIAL PRODUCTION OF OYSTER MUSHROOM

Contents

7.1. OBJECTIVES

After going through this unit you will be able to :

- describe the morphology of various species of oyster mushroom,
- describe their cultivation process including harvesting, hygiene etc.

7.2. INTRODUCTION

Mushrooms belong to a group of plant kingdom known as fungi. They lack chlorophyll, hence can not produce their own food and depend upon organic matter for their nutrition. They grow saprophytically on various substrates or parasitically and symbiotically on or with living plants.

On the basis of the natural habitat they are divided into 3 groups

1. Humicolous fungi e.g., *Volvariella* sp.
2. Lignicolous fungi e.g., *Pleurotus* sp.
3. Coprophilous fungi e.g., *Agaricus* sp.

Generally the term "Mushroom" is referred to fruiting bodies of gill fungi. The oyster mushroom (species of *Pleurotus*) grows under natural conditions on trees or dead woody branches of trees as saprophytes and as primary decomposers.

Pleurotus is one of the choicest edible mushrooms which can be cultivated in tropics. In Europe it is known as oyster mushroom, while in China it is called abalone mushroom. Cultivation of *Pleurotus* on tree stumps and logs was first described at the beginning of 20th century (Flack, 1917). Twelve years later, Etter (1929) produced fruiting bodies of *Pleurotus*. Life cycle of the mushroom was studied by Kaufert (1935). Block etal (1958, 1959) appeared to be the first to write an extensive account on the requirements of the mushroom cultivation.

The earliest record for *Pleurotus* cultivation in India appears to be that of Bano and Srivastava (1962). Jandaik (1974) first introduced the tropical *Pleurotus* sp. like *P. sajor-caju*.

The different species of *Pleurotus* grow well within a temperature range of 15 to 35°C. The morphology of various *Pleurotus* species is detailed below :

7.3. MORPHOLOGY

i) *Pleurotus sajor-caju* : It is an indigenous species first cultivated on banana pseudostems by Jandaik in 1974. The species is naturally found growing on *Euphorbia royleana* plants in Jammu and Dehradun region. The fruiting bodies are oyster shaped, often lobed and white to dull brown in colour with good aroma. Surface is smooth, margin irregular and incurved. Temperature requirement for the initiation of the fruiting bodies varies from 15°C to 30°C and also for the mycelial growth.

ii) *P. cornucopiae* : It grows on wood of *Quercus, Fagus* etc. It grows well at 15 ± 2°C. The stipe is central or eccentric and pileus is dull brownish yellow or pallied whitish to light yellow colour, 4-10 cm in diameter and lobed.

iii) *P. flabellatus* : Sporophores grow on dead trunk or on ground. Base of sporophores are sponge like, fruit body short, fan shaped, first pink then pure white in colour with eccentric stipe. Fruit bodies always appear in large clusters. The pileus is having thin flesh with mild aroma. On cooking it gives slightly leathery or fibrous texture, specially the stipe portion. Temperature requirement varies from 15 to 28°C for primodial initiation and 20 to 30°C for mycelial growth.

iv) *P. florida* : Sporophores fan shaped and the colour of this species changes with temperature. At low temperatures (about 5°C) the pileus is light brown in colour; at maximum temperatures (26°C to 27°C) it turns paler to a pallid yellow or white.

v) *P. ostreatus* : It is a wood destroying saprophytic fungus although sometimes appears as parasite, is wide spread in temperate zones. It can fruit at temperature upto 15°C. The pileus is stemmed at the side and is spatula or tongue shaped and later depressed. It grows to 5 to 15 cm and is of grey brown or slate grey colour. Its spores are known to be causing allergy in many cases.

vi) *P. eryngii* : This is a typical fungus of the flora of subtropics and steppes. It is widespread in southern Europe and the areas of Central Asia and North Africa. In India, it is found in Jammu and Kashmir. It occurs as parasite on *Eryngium campestre* and other hosts. The pileus is reddish brown, grey brown to dirty yellow, 4 to 5 cm wide. The weight of simple fruit body is 300 to 400 gm. The lamellae are white or greyish, decurrent. The stipe is white, 3 to 10 cm long. The mycelium grows slowly and is very much susceptible to other microorganisms.

Check Your Progress - 1

What are the temperature requirements for various *Pleurotus* spp.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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7.4. CULTIVATION PROCESS FOR COMMERCIAL PRODUCTION

Preparation of Substrate : The *Pleurotus* species has the ability to break down cellulose and lignin bearing materials. A well ventilated place having a cemented floor can be used for raising the mushroom crop. Oyster mushroom is usually grown on various agricultural based materials like wheat or paddy straw, maize stalks, maize cobs, cotton waste, wooden logs, saw dust, vegetable plant residues etc. Paddy straw is widely used because it is easily available. Any substrate should be selected in such a manner that it is fresh, dry and disease free.

The mushroom is usually grown on chopped paddy straw (1-2 cm long) in wooden trays measuring 100 x 50 x 15cm each or in polythene bags. The straw is soaked overnight in water. This is done to achieve the moisture content of 70%. It also helps in the removal of some surface contaminants on paddy straw.

In case of maize stalks or maize cobs soaking period should be 30- 40 hours. Old, broken and rotten straw and stagnant water should never be used. Wet substrate is spread on wire mesh to remove excess moisture.

Pasteurization : Pasteurization is done by either of the three ways given below :

i) Chemical pasteurization : It is done with fumigants like formaldehyde, Chloropicrin, methyl bromide and vapam. These chemicals are used before

soaking the substrate in water. During fumigation turning should be given for sufficient aeration. Usually 125 ml of formaldehyde and 7g of bavistin mixed in 100 litres of water is used for sterilizing 10 kg of straw. Straw should be soaked for 12-16 hrs in that solution.

ii) Steam pasteurization : Steam pasteurization is done by ejecting the steam generated in the boiler to a chamber stacked with substrate material to be disinfected. Thorough disinfection occurs only if the temperature is maintained in the chamber at 60-65^{0}C for 4 hr or 80^{0}C for 30 minutes.

iii) Hot water pasteurization : Hot water treatment is given by plunging the substrate in boiling water (80-85^{0}C) for 30 min. Heating should be continued to carry out the disinfection process effectively. The stem pasteurization or hot water treatment is many times advantageous over chemical treatment for having no residual effect with substrate and also the higher temperature ensures the thorough killing of the pathogens and competitor moulds.

Spawning : Spawning is the process of broadcasting the spawn on substrate. This could be regarded as analogous to seed sowing. When pasteurized substrate is cooled down to room temperature, it is ready for filling and spawning. At this stage the moisture content should be 65%. Non-coloured polythene bags (35 x 50cm, 80 gauge) and trays are used for its cultivation. 2% spawn on the basis of weight of wet straw is used. The following methods are employed for spawning (Singh, 1981).

a) Surface spawning : Spawn can be broadcast evenly on the surface of the substrate (chopped paddy straw).

b) Double layer spawning : The substrate is filled, to a depth of 8-10cms gently pressed and spawned 2-5 cms layer. Again substrate is filled upto 3/4 of the bag and spawned (2-5cms layer) at the surface.

c) Through spawning : Spawn is mixed thoroughly with the substrate.

d) Shake up spawning : Substrate containing active mycelium is thoroughly mixed and placed in the new trays.

e) Spot spawning : Spawn is placed in lumps 15 x 15cm apart on the surface of the substrate at a depth of 2.5cm.

f) Active mycelium : The substrate is spawned by surface spawning method and when completely impregnated it is used as active mycelium to spawn the beds.

Double layer spawning and through spawning are superior in giving higher yields. The lowest yield is obtained by shake up spawning. Also the spot spawning and the shake up spawning encourage development of other saprophytic moulds.

Spawn running : After the operation of spawning is completed, the trays are covered with polythene sheets in order to retain the moisture. In the case of polythene bags the mouth of the bag is tied with a thread. Spawned trays/bags are kept in a dark place with minimum air movement. The room is kept moist by sprinkling water at intervals of twice a week in both cases. The polythene sheet is removed after 15-20 days of spawning or the polythene bag is removed and watering is done once daily. It prefers a little high CO_2 during spawn running.

During spawn running relative humidity of around 70% is maintained. The temperature is kept around 21-28^{o}C.

Cropping : Twenty days after spawning, there is complete mycelial ramification in the substrate which becomes white in colour due to the cottony growth of the fungus. At this stage the vegetative mycelium enters the productive phase. Apart from the culture factor of genetic origin, a number of other environmental factors influence the development of fruit bodies. Zadrazil and Schneiderent (1972) studied the effect of some environmental factors on fruit body development. The effect of light beyond certain optimal conditions makes the stipes very long and pileus gets reduced. Insufficient ventilation (1-2% by vol CO_2) and low light exposure induce a bunched growth regeneration.

Light is the initiating factor in the development of primordia and is therefore needed for atleast 15 minutes per day. Temperature and humidity too have an effect on the yield (Singh, 1981).

Significantly better yields are obtained when average temperature and relative humidity are in the range of 19^{o}C - 30^{o}C and 65 - 85 per cent respectively.

Check Your Progress - 2, 3 & 4

2. What is meant by chemical pasteurization ?

3. What is meant by double layer spawning ?

4. What are the requirements for cropping ?

Note : (a) Write the answers in the space given below.

(b) compare your answers with those given at the end of this unit.

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7.5. VARIOUS CULTIVATION SYSTEMS

I. Pillar system of cultivation : A self supporting structure is created by inserting a perforated cement or PVC tube inside the pillar containing pasteurized substrate. As the size of the container increases the bed temperature rises. The perforated tube gives chimney effect for exhange of gases. Polythene tubes with 1-1 $\frac{1}{2}$ ft diameter and a height of 5-6 ft would accommodate a minimum of 25 kg dry straw and yields a maximum of 12 - 15 kg. of fresh mushrooms.

II. Bed system of cultivation : The racks made out of bamboo can be utilised for this type of cultivation. The inoculated substrate should be spread on the racks to a thickness of 9 inches and covered with polythene sheet for good spawn run and also to minimise the evaporation of water. The size of the bed may vary but the thickness should not be more than 10 inches. By this method a minimum of 4-5 kg. fresh mushrooms can be harvested from 10 kg of dry substrate.

III. Tray system : Wooden trays measuring 100 x 50 x 15 cm size can be used. The trays are filled with steeped straw upto a height of 15cm and spawning is done all over the surface of the substrate. A second layer is placed over the first and spawning is repeated. The trays are then covered with polythene sheets in order to retain moisture. Polythene sheet is removed after 20 days of spawning.

IV. Tunnel system : Substrate can be colonized in bulk by *Pleurotus* in special buildings (tunnels) with air recycling. In such system the CO_2 and O_2 concentration can be controlled. To obtain an optimal condition during the entire growth period of mycelium, a concentration of 20% by vol CO_2 can be regulated by adding gas. The mycelial growth will be accelerated. More fastidiously aerobic, competitive microorganisms can be excluded right from the start. After substrate colonisation in the "mass" is completed the substrate can be transferred into smaller containers for the production of fruiting bodies.

Tunnel incubation in mass allows very quick colonisation, but it is very difficult to achieve without practice and theoretical knowledge.

V. Cultivation in pressed blocks : The spawned substrate can be packed in plastic foil and pressed into rectangular blocks for the mycelium growth period. To obtain a harvest two opposite sides are laid open and fruiting bodies develop in this surface.

VI. Polypropylene bags : At present non-coloured polypropylene bags (35 x 50 cm., 80 guage) are the best containers for oyster mushroom cultivation. About 800 g of dry paddy straw can be filled in these bags. The pasteurized substrate

is filled in the polypropylene bags and spawned simultaneously in inoculation chamber or in a sterilized room. The mouth of the bag is tied and kept for spawn running.

General cultivation method : There are many methods of cultivation of *Pleurotus* spp. with little or minor modification (Bano et al 1974).

Dried paddy straw is cut into 1-2 cm long bits and soaked in water overnight. Excess water was drained off and the wet straw is treated with chemicals or boiling water as described earlier. The substrate was then spawned following any method of spawning. The bags were kept in a room at 20-30°C. The mycelial growth appears between 15-20 days by permeating the substrate in bags. It is necessary to cut open the polythene bags from sides without disturbing bed. Water is sprayed onto the beds twice a day. The mushroom crop starts coming up within 3 to 4 days.

Check Your Progress - 5

What is meant by tray system ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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7.6. HARVESTING AND MARKETING

The mushroom should be harvested when the pileus is about 5-8 cm in diameter and before spores are released. The fruit bodies should be harvested by twisting them, so that broken pieces are not left out in the trays and surrounding fruit bodies are not disturbed. For the same reason harvesting by cutting is not recommended as cut portions develop bacterial growth which may spread to the healthy mushrooms. After harvesting, the lower portion of the stalk with adhering debris should be cut with the help of clean knife or blade. This mushroom may be consumed fresh or dried in sun or in mechanical drier at 50-55°C. This mushroom can be easily dried and revived after remoistening. The dried mushroom can be powdered and stored in air tight container and used whenever required.

The dried mushroom can be powdered and stored in air tight container and used whenever required.

The dried mushroom can also be kept in air tight alkathene bags and sent to the market. It can also be stored in refrigerator for 5-6 days.

Check Your Progress - 6

How are Mushrooms harvested and at what stage ?

Note : (a) Write the answer in the space provided below.
(b) Compare your answer with the one given at the end of this unit.

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7.7. MODEL MUSHROOM HOUSE

A model mushroom house of two cropping rooms, one spawn running room, one substrate preparation room each of 15′ x 15′ size will enable the grower to obtain an yield of 5-10 kg daily. Since there are species tolerating wide range of temperatures, oyster mushroom can be grown in an ordinary built structures with very meagre investment viz., thatched huts, shed with Asbestos or light roofing material and polythene tents. Brick wall with thatched roof will be an appropriate house in a rural set up.

The substrate preparation room should have a tub to soak a minimum of 15 kg straw and a seperate container to boil water for pasteurization. There should be a wire meshed side table to spread the pasteurized straw for cooling and also to allow the excess of water to drain off. There should be one more side tables with zinc sheet surface to carry out bag filling operation.

Cropping and spawn running chamber should be provided either with bamboo racks or plastic angular racks to stack the polythene bags. Each room should have 2 to 3 ventilators and all the windows and doors should be provided with additional fine wire mesh shutters to prevent the entry of insect pests. The platform should be either cemented or stone slabs can be spread over the floor. Every room should have a good drainage system. Carpet pit must be there in each room to hold the disinfectant solution. The substrate preparation room can also be utilized for the package work of mushrooms. Growing trees around mushroom house is of further help in keeping the house cool all over the year. The farm lay out of oyster mushroom with six cropping rooms is given below.

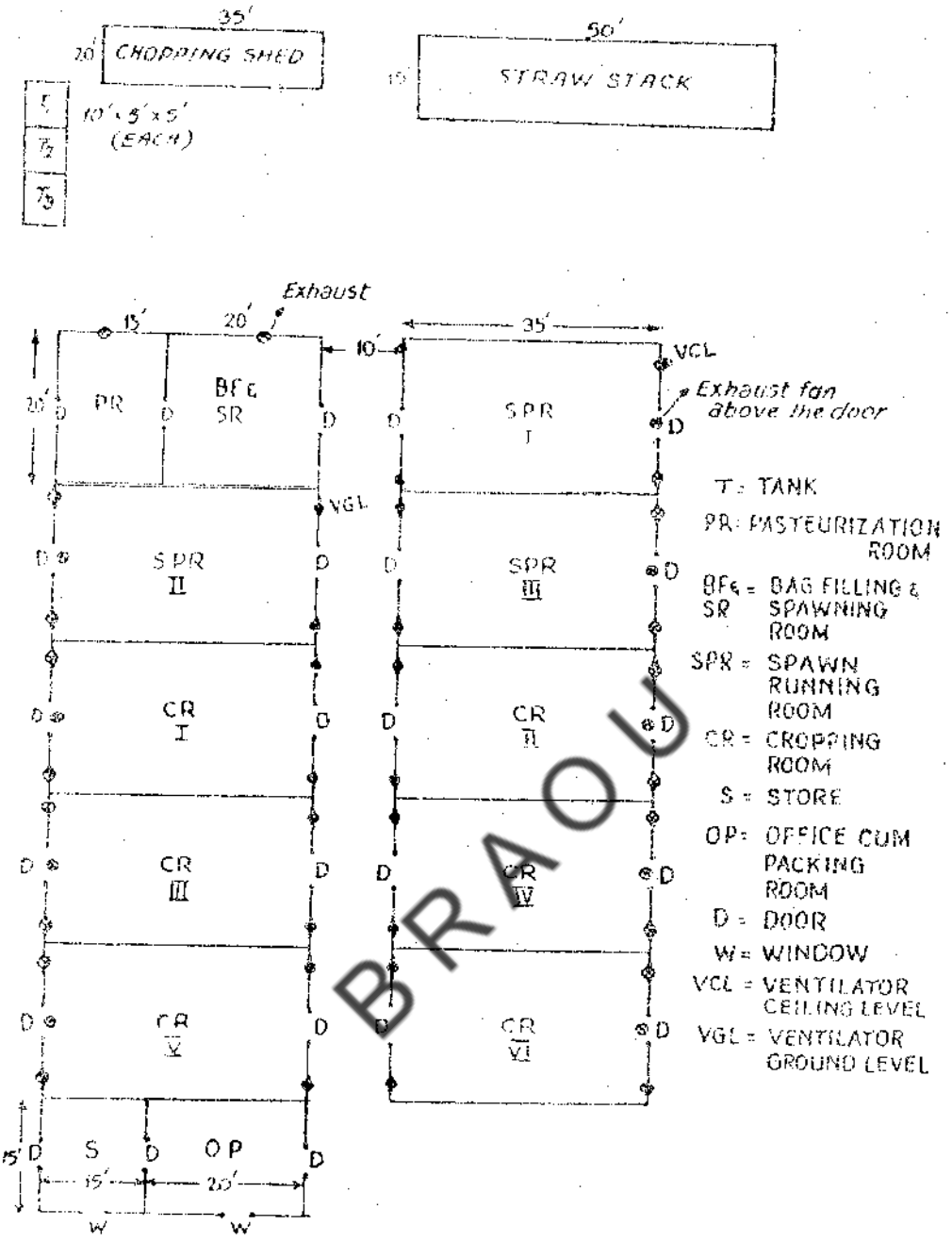

Fig.7.2. Farm layout for oyster mushroom with six cropping rooms.

7.8. PROGRAMME OF HYGIENE

1. Surrounding area should be kept neat and clean. Fine wire mesh should be used on ventilators to prevent the entry of flies.

2. The spawn running and cropping room should be sprayed with 0.1% Nuvan and 5% Formalin 2 days prior to transferring the bags to the chamber.

3. Nuvan spray should be repeated at weekly interval and 2% Formalin spray twice a week. During cropping, spray should be given between the flushes after harvesting mushrooms and Nuvan spray should be avoided.

4. If any weed mould is noticed on bags the spot should be treated with formalin (4%) or Benlate and Dithane Z-78 0.2% should be sprayed after harvesting mushrooms.

5. At the end of the cropping Nuvan (0.05%) and Formalin (5%) should be sprayed and after 24 hours of treatment the spent compost should be disposed.

Check Your Progress - 7

How the hygiene is maintained in the mushroom house ?

Note : (a) Write the answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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7.9. PROSPECTS AND POTENTIALS OF OYSTER MUSHROOM CULTIVATION

1. Low production cost : Due to the abundant availability of raw material like paddy straw, cotton waste, maize cobs and some other agricultural wastages which can be utilized for mushroom production, the cost of production can be kept low.

2. Employment of unskilled labour : It extends employment opportunities for unskilled labour which is a peculiar problem in our country.

3. It can generate employment opportunities for women, retired personnale, unemployed youth and part time employment for many others.

4. Foreign exchange : Mushroom consumption is increasing all over the world; hence mushroom industry will have good opportunity in finding foreign market and foreign exchange.

5. Good source of valuable protein, minerals and salts : Mushrooms are good source of protein, fibre, calcium, phosphorous and iron. Due to its high protein content, it can find an important place in the vegetarian diet.

6. Additional Income : It can provide additional income to the farmers during the lean months of the farming.

7. The produce can be easily sun dried and preserved for long periods.

8. Being an indoor activity, its cultivation is a boon to the landless, small and marginal farmers who are facing the land resource problems.

9. Mushrooms can be good companion crop in vine yards.

10. The spent up compost can be utilised for manuring and fertilizing the horticultural crops and vegetable fields.

Check Your Progress - 8

What are the advantages of oyster mushroom cultivation ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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7.10. SUMMARY

Oyster mushroom is cultivated on various agricultural wastes. Many available species are grown under various temperatures. *Pleurotus florida* is commonly grown. It is usually grown on paddy straw. The paddy straw is cut into 1-2" pieces and soaked in water and it is sterilized in boiling water for 30 minutes. Beds are prepared in polythene covers of 35 x 80 cms size by keeping 2" straw layer in the cover. On top of this layer handful of spawn is spread on the periphery and again 2" straw layer is made and spawn is placed. Process is repeated until 3/4 of the cover is filled. Then the bag is tied and put in the dark room for incubation. After 15-25 days i.e., after complete development of white mycelium over the entire bed the plastic cover is taken out and kept in the cropping room for initiating the fruit bodies. Humidity (of 85%), light, ventilation, air should be provided in the room. After one week fruit bodies will appear all over the bed. Through out the crop period complete hygiene should be maintained in the Mushroom house.

7.11. CHECK YOUR PROGRESS : MODEL ANSWERS

The temperature requirements for various species of *Pleurotus* are :

1. a) *Pleurotus sajor-caju* - 15°C - 30°C ; b) *P.cornucopiae* 15 ± 2° C ; c) *P.flabellatus* 20°C - 30°C ; d) *P.florida* 26°C - 27°C ; e) *P.ostreatus* - 15°C.

2. Chemical pasteurization is the process of sterilizing the substrate (paddy straw) by soaking in the chemical solution (formaldehyde 125 ml + 7 g bavistin in 100 litres of water).

3. Double layer spawning is the process of adding spawn in 2 layers i.e., at the top and bottom of the substrate

4. The requirements for cropping are humidity, temperature, air, ventilation and light.

5. Tray system is the process of mushroom growing in wooden trays of 100 x 50 x 15 cms.

6. Mushrooms are harvested when the gills are completely opened and when the ends of pileus will become thin. They are harvested just by slight twisting.

7. Surroundings should be neat and clean. Two days before keeping the bags 5% formalin and 0.1% nuvan must be sprayed in the rooms. Repeat the spray every week.

The advantages of oyster mushroom cultivation are :

8. a) low production cost, b) employment generation, c) saving foreign exchange, d) good source of protein and e) additional income.

7.12. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write about the salient features of various *Pleurotus* spp.
2. Write briefly about the cultivation process of oyster mushrooms.
3. Write about the various cultivation systems of oyster mushrooms.

II. Answer the following questions in about 10 lines each.

1. What type of hygiene we have to maintain in the mushroom house ?
2. What are the prospects and potentialities of oyster mushrooms ?

Dr. K. Suhasini

UNIT - 8 : PREPARATION OF PURE CULTURE AND SPAWN OF OYSTER MUSHROOM

Contents

8.1. OBJECTIVES

By the end of this unit you will be able to :

- describe the method of tissue culture and spore culture,
- describe the method of preparation of mother spawn and spawn.

8.2. INTRODUCTION

Spawning is the essential first step in the early development of mushroom cultivation. The art of locating, recognising, and obtaining mushroom mycelium from compost heaps and other sources (Natural spawn) forms an important part of mushroom cultivation. Subsequently, more reliable forms of spawn (e.g., French flake and English brick spawn) were developed. Brick spawn consisted of compressed bricks of horse and cow manure and loam or leaves colonized by mushroom mycelium. Flake spawn was essentially dried mycelium filled compost obtained from specially prepared small mushroom beds. Like natural spawn, however, flake and brick spawn are not pure cultures. Neither the identity of the mushroom species nor the absence of pests was assured.

Use of cereal grain as the substrate for mushroom spawn was important in making commercial spawn. The methods of spawn preparation can be divided into three steps.

1. Raising of "pure culture"
2. Preparation of "mother culture" from pure culture
3. Preparation of "spawn" from mother culture.

8.3. RAISING OF PURE CULTURE

Pure culture is prepared either from (a) tissue culture raised from a mushroom tissue or (b) spore culture raised from single or multispores

a) Tissue culture : A big healthy fruit body with veil still intact is selected from cropping tray for tissue culture. Lower portion of the stipe is cut off at the soil level with the help of a pre-sterilized knife and fruit body is cleaned with a bit of cotton moistened in 50 per cent ethanol to remove the soil particles if any and finally dipped in 0.1 per cent mercuric chloride solution for 30-60 seconds to avoid any chance of contamination. Small pieces of the tissue from the junction of stipe and pileus of fruit bodies are cut out under sterile conditions and inoculated onto nutrient medium or Potato Dextrose Agar medium. These tissues develop and can provide the starting point for subsequent spawn preparation (Fig 8.1). The inoculated tissue grows into a colony.

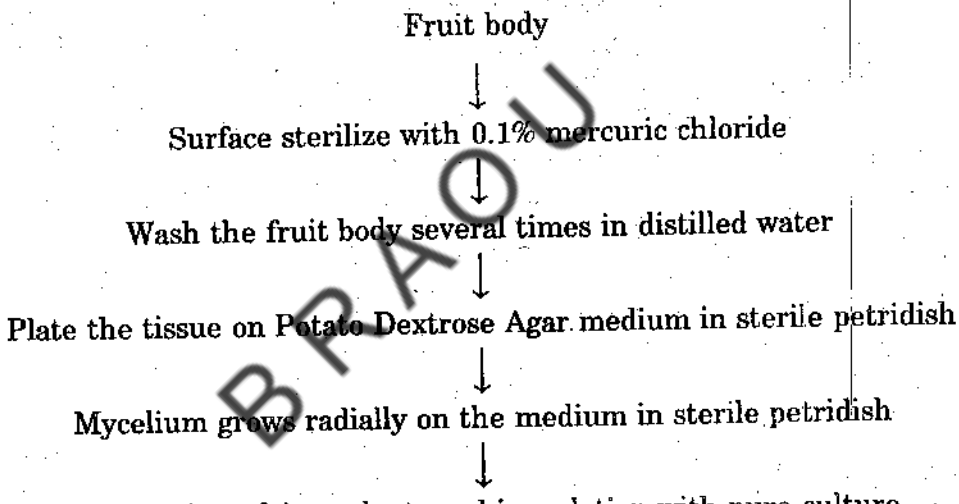

Fig.8.1. Flow chart for tissue culture

Spore culture : A big and healthy fruit body with veil still intact but tightly stretched is selected for basidiospores collection. Lower portion of the stipe is cut off with the help of a presterilised knife and the fructification is washed with distilled water dipped in 0.1 per cent mercuric chloride solution for 30-60 seconds to avoid any chance of contamination. The fruit body is then mounted on a sterilized petridish. This is covered by a sterilized beaker for 24-48 hours. After a thick deposition of spore mass, the glass beaker and mushroom are removed and sterilized lid is placed on the petridish which is then used for raising pure culture either through single spore or multispores. Raising of pure culture by multispore is the best but it should be compared with the original strain before the mycelium is propagated on a large scale.

Check Your Progress - 1 & 2

1. What is meant by tissue culture ?
2. What is meant by spore culture ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

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8.4. SPAWN PREPARATION

Facilities Required

1. Preparation and autoclave room
2. Inoculation chamber (5′ x 6′ x 7′) fitted with ultraviolet tube (3′ in length), one table and double door entrance.
3. Chamber for spawn growth
4. Autoclave
5. Facility to boil grains (hot plate or gas)
6. Container for boiling
7. Milk or Glucose bottle
8. Non-absorbent cotton
9. Spirit lamp
10. Rectified spirit
11. Inoculation needle
12. Jowar or wheat grains
13. Chalk powder
14. Gypsum

Preparation of spawn : Spawn is the fungal seed material. It is the mycelium growing on seed which is the substrate and nutrient source. The following is the procedure for spawn preparation.

Jowar or wheat grains are washed in water and half boiled for 40- 45 minutes. Maize grains also can be used as substrate for spawn production. Care should be taken that the grains are not over boiled and broken. Excess water is drained off and boiled grains are spread on newspapers for about one hour. This helps to break lumps and reduces moisture. Calcium carbonate or chalk powder (6%) and Gypsum (2%) are mixed with half boiled grains and then filled in milk/glucose bottles, not more than 2/3 rd of the bottle. Mouth of bottles are cleaned and plugged with non- absorbent cotton. Plugs are wrapped with paper and bottles are sterilized at 22 lb. pressure in an autoclave for 2 hours. Inoculation chambers are cleaned with surface sterilizing agents such as 2% formaldehyde.

Sterilized bottles are transferred to inoculation chamber. Next day ultra violet tube is switched put on for half an hour prior to inoculation. U.V light should be switched off while entering the chamber for inoculation.

For inoculation, a bit of culture (about 1 cm) is taken out from a culture tube having pure culture. This piece of culture is inoculated into the bottles with the help of inoculation needle. Inoculation should be done near the burning spirit lamp to avoid contamination.

After inoculation bottles are transferred to the spawn growing chamber where temperature is around 25 ± 2°C However, it should not be more than 34°C for Oyster mushroom. However, paddy straw mushroom can grow upto 40°C (optimum 33 ± 2°C). Once in a week all bottles should be checked, contaminated bottles should be removed from the chamber. The fungal mycelium spreads on to the grains and occupies the whole bottle. This full grain culture in spawn bottle is called mother spawn.

The mother spawn can be further used to multiply spawn. One bottle of mother spawn can be used to raise around 30 bottles of spawn by transferring about 10 gms (2 tea spoons) of spawn into each bottle over spirit lamp. This helps in faster multiplication of the spawn.

Precautions : A major source of contamination of growing mushroom mycelium in a spawn making plant is the grain used to prepare the substrate. Modern equipments and facilities for sterilization and maintenance of sterile conditions are capable of reducing fungal and bacterial contamination to 0.1% of the spawn units.

Quality control in spawn making consists essentially of inspections to eliminate spawn units visibly contaminated or exhibiting unacceptable differences in appearance, growth, colour or odour. In addition, study of possible role of spawn cultures and sources of spawn cultures as carriers of bacterial disease is needed in view of the reported attachment of bacteria on spores and hyphae of the mushrooms. Care should also be taken that spawn is free from virus. For this purpose stock cultures should be raised from virus free mushrooms and this can be tested with the help of electron microscope.

Some other things to be borne in mind are :

1. Use of unbroken and half cooked grains only for spawn production.
2. Boiled grain mixed with lime and gypsum should not be kept unsterilized for more than 10 hours.
3. Bottles should be plugged and sterilized properly.
4. Sterilized bottles should be inoculated after 10-12 hrs. of sterilisation.
5. The bottles should be kept under UV-rays for 1 $\frac{1}{2}$ hours before inoculation.
6. The whole process should be carried out in a double chambered closed air tight inoculation room.
7. Inoculation should always be done facing the burner.
8. Give minimum time for removing and placing the plugs.
9. Shake the bottles thoroughly after inoculation to get early and uniform growth.
10. Store bottles at a temperature of $4^{0}C$ when they are fully impregnated with the mycelium until sold.
11. Incubate bottles at $25 \pm 1^{0}C$ after inoculation.

Check Your Progress - 3 & 4

3. What is meant by mother spawn ?
4. What is meant by spawn ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this unit.

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8.5. SPAWN STORAGE

Storage conditions affect its productivity. It is observed that spawn taken directly from the incubation room grew faster than spawn kept at $2^{0}C$. Observations showed that there is no reduction in yield from spawn of any variety due to storage for two years. The yield from oyster mushroom was almost the same when spawn is stored for two months at room temperature or in the refrigeration. However,

spawn stored in refrigerator for four months did produce mushrooms. It is also observed that yield was less as compared to spawn stored for a period of two months. Proper hygiene has to be maintained in storage localities. Duration, temperature and moisture are some of the important factors affecting the viability and survival of spawn. Based on the above the quality of spawn will be assessed.

8.6. IDENTIFICATION OF CONTAMINATED SPAWN

Spawn is subjected to contamination mostly by fungi and sometimes by bacteria. Grain spawn is usually susceptible to green moulds. Brown, yellow, black and green patches due to mycelial growth of contaminated fungi will appear in spawn bottles. Such contaminated bottles have to be removed immediately and such contaminated spawn has to be destroyed. Fungi like *Aspergillus, Penicillium, Cladosporium, Trichoderma, Alternaria, Curvularia, Drechslera* and others form contaminants. The contaminants may also originate from seed or due to non hygeinic conditions. It may also be due to improper sterilization, negligence and also due to rough handling of materials without observing the scientific procedure in spawn preparation.

8.7. SUMMARY

Spwan is prepared in 3 steps. Tissue culture or spore culture is the first step in spawn production. From tissue culture or spore culture mother spawn is prepared which is the second step in spawn production. From the Mother spawn spawn is prepared which is the 3rd step and growers use this for cultivation of mushrooms.

8.8. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Tissue culture is the process of taking out the tissue (small piece of 1 cm) from the mushroom and inoculating it on the nutrient medium.

2. Spore culture is the process of inoculation of mushroom spores on the medium.

3. Mother spawn is the full grain culture of mushroom mycelium in spawn bottle which is obtained after inoculating a small piece of pure culture on the presterilised grain anedium.

4. Spawn is the pure mushroom mycelium obtained after inoculating the mother spawn on the presterilized grain medium.

8.9. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write about the tissue culture and spore culture methods.
2. What are the facilities required for spawn production ?
3. Write about the spawn preparation process.

II. Answer the following questions in about 10 lines each.

1. What are the precautions to be taken in spawn production ?
2. Write a note on tissue culture.

Dr. K. Suhasini

UNIT - 9 : CULTIVATION METHODS OF OYSTER MUSHROOM

Contents

9.1. OBJECTIVES

By the end of this unit you will be able to :

- list out the different types of substrates used for oyster mushroom cultivation,
- mention any five species of *Pleurotus,*
- define sterilization, list out the different methods of sterilization and describe them in detail,
- describe in detail the procedure of bed preparation for oyster mushroom,
- describe cropping room and its maintenance,
- list out the substrate supplements and different fungal contaminants in mushroom beds.

9.2. INTRODUCTION

Oyster mushroom is a cellulose loving fungus and can be grown easily on any agrowaste round the year as several species of this mushroom are available and they can be grown artificially under varied climatic conditions.

Substrate preparation technique is very simple, less time consuming and less labour intensive. Oyster mushroom colonises the substrate very fast in the sterilized straw and produces good quality mushrooms with less crop management.

9.3. SUBSTRATE SELECTION

Pleurotus, the commonly called oyster mushroom is a well known mushroom that is edible and commonly cultivated. Several species of the genus are available for cultivation which include *Pleurotus sajor-caju, P. ostreatus, P. sapidus, P. florida, P. cornucopiae, P. eryngii, P. cystidiosus, P. flabellatus* and *P. opuntiae.* These species are characterised by quick growth under wide range of temperature and has the ability to colonize the substrate in a short span of time. These species can be successfully grown on a wide variety of agro wastes and inexpensive substrate. This can be grown on different substrates like straw of wheat, paddy, ragi, stalks and leaves of maize, jowar, bajra, cotton, sugarcane bagasse, jute, cotton, corncobs, waste paper, used tea leaves and oil palm mesocarp waste.

While selecting the substrate its availability round the year and its cost have to be taken into consideration. Generally, wheat or paddy straw are used for cultivation as they are the commonly available substrates. While selecting the substrate care should be taken to see that substrate is fresh and not exposed to rains. The wet or damp nature encourages other microorganisms which also compete for nutrition, air and space. They may also excrete some toxic secretions which will have an impact on spawn run and affect the yield.

9.4. SUBSTRATE STERILIZATION

Once the substrate is selected it has to be subjected to sterilization. Sterilization means killing or inactivating the organisms present in the substrate so as to promote the growth of mushroom mycelium. Sterilization of substrate can be achieved by the following methods.

1. Chemical sterilization
2. Hot water treatment
3. Fermentation
4. Steam pasteurization

9.4.1. Chemical Sterilization

Take a drum and fill it with 100 litres of water. Cut the selected paddy straw into bits of 2-3 inches size and dip them in water. Add 125 ml of 40% form aldehyde at 7.5 g of bavistin and close the mouth of the drum with a polythene sheet. Allow the paddy straw bits to soak for 12-18 hours. Then remove the soaked straw and keep it on clean slanting concrete floor. Allow the excess of chemical solution to be drained and then it can be used for spawning.

9.4.2. Hot Water Treatment

In hot water treatment, the bits of paddy straw are cut as in case of chemical sterilization and boiled in hot water at a temperature of 70-75^{0}C for one hour. The substrate is put into basket and water is drained off. Care should be taken that the paddy straw does not hold excess water. The indication being that when boiled straw is squeezed, water droplets should not fall. However it should be wet.

9.4.3. Fermentation

In this type of sterilization paddy straw bits are made into pile of 3-4′ height and 5′ wide and kept as such for 2-3 days. This results in microbial fermentation which increase the temperature of the heap and causes the death of microorganisms. The fermented straw after cooling can be used for spawning.

9.4.4. Steam Pasteurization

In this the straw bits are pre-wetted and are placed in wooden trays or piled into a heap. In the pasturization room, it is subjected to a high temperature of 75 - 80^{0}C for 2 hours under steam condition. The steam subjected straw is allowed to cool down and used for spawning.

9.5. SUBSTRATE SUPPLEMENTS

Oyster mushroom does not require other supplements and can be grown with ease on any of the agrowaste after suitable sterilization. However, some of the supplements like ammonium sulphate or urea @ 0.5 to 1% and lime @ 1% can be used. Chicken or horse manure @ 10% can be used in place of nitrogen fertilizers and can be supplemented to the paddy or wheat straw substrate. After supplementing these to the substrate, a heap of 75-90 cm is to be made and kept for 2 days after which a turning is given with the additional dose of 1% super phosphate and 0.5% lime. The mixture thus obtained can be used as such or can be autoclaved for 2 hours at 15 lbs pressure and can be used for spawning.

9.6. BED PREPARATION

Take polythene bags of 60 x 30cm and tie a rubber band to the closed end. Remove the pure spawn in a neat tray smeared with dettol with the help of a steel rod dipped in dettol solution. Add 60 g of any presterilized pulse powder and mix the spawn thoroughly. Place one layer of sterilized straw in the polythene cover upto 5 cm height and sprinkle the spawn all along the circumference of the bag. Put layer after layer of spawn and straw bits till the bag is full. Press the straw bits to make a compact bed and tie another rubber band to close the bed. Make atleast 20-25 holes for providing aeration. Now these bags are incubated in a neat and clean cropping room for 15-20 days. The crop cycle is of 45 days.

3 crops can be harvested from each bed. Daily watering and maintaining of 75% R.H. (relative humidity) should be taken care off. Proper hygeine and care are important.

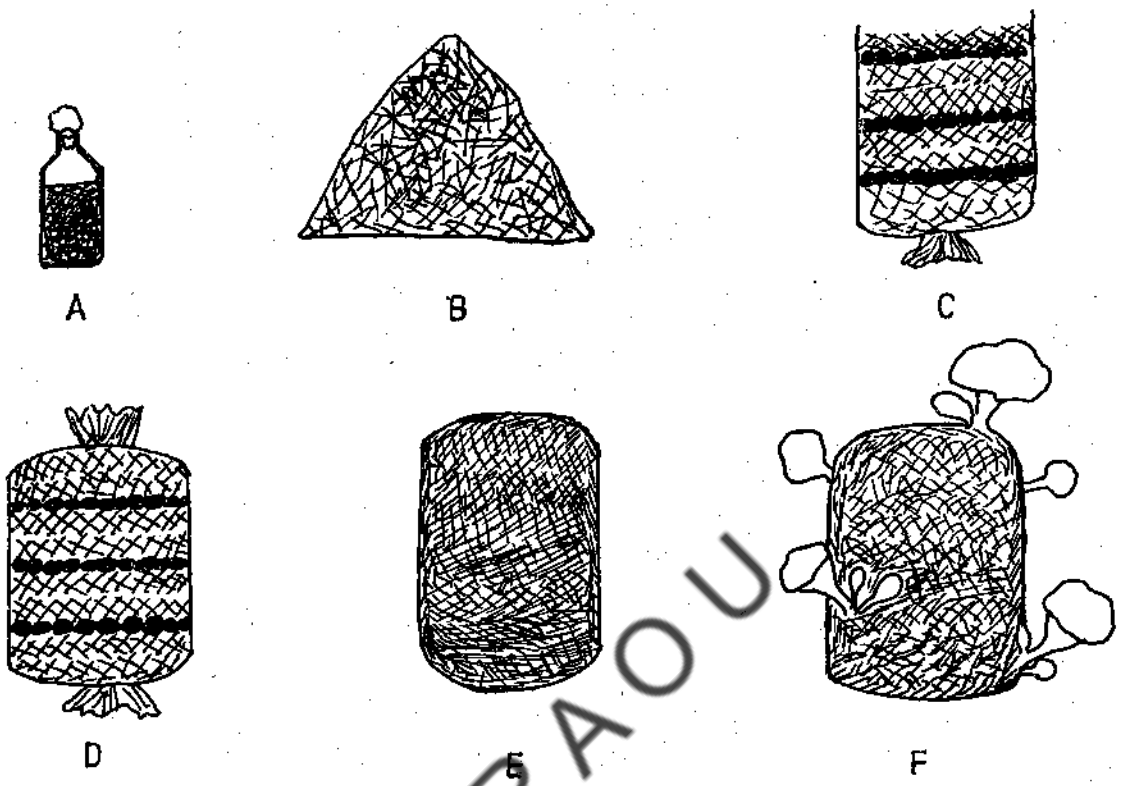

Fig. 9.1. Oyster mushroom production. A. Spawn bottle. B. Straw bits. C. Spawning. D. Bed after spawning. E. Bed with mycelium. F. Bed with mushrooms.

9.7. CROPPING ROOM AND MAINTENANCE

The spawned beds are kept in neat and clean cropping room. The room should be thoroughly washed with water and 2% formaldehyde is to be sprayed 48 hours before the beds are kept in the room.

The room should be provided with a door and an additional door with fine mesh for protecting the beds from rats, lizards and bats. BHC dust should be dusted to avoid ants.

In order to maintain 25-27°C temperature and humidity of 90-95% new wet gunny bags are hanged all along the room and sprayed with water once or twice as per the weather conditions prevailing outside. A layer of sand is also provided at the flooring and spraying of water is done to maintain cooling. Racks prepared

with bamboo or any other type are provided for keeping the beds. Darkness for a period of 10-15 days is maintained in the room for quick growth of the mycelium in the beds. Complete aseptic conditions are to be maintained once the mycelium covers the bed with whitish mycelium, the beds are cut open with a blade and the polythene cover is removed. Care should be taken to discard the contaminated beds infected with fungal organisms viz., inky caps, *Aspergillus, Rhizopus, Penicillium* and *Trichoderma.* Sometimes the growth of the mycelium is completely stopped or arrested by bacterial contamination showing oily or greasy droplets and such beds are also to be discarded.

If all the favourable conditions viz., temperature, humidity and aeration are provided and spraying of beds with fresh water regularly after two days of opening of the beds, 1 to $1\frac{1}{2}$ kg of mushroom can be produced from each bed in two to three flushes. A maximum of 3 pickings can be taken up from each bed.

Check Your Progress - 1 & 2

1. List any five different substrates which can be used for oyster mushroom cultivation.

2. What are the different types of sterilization used for the substrate during oyster mushroom cultivation

Note : 1) Write your answers in the space given below.
2) Compare your answer with those given at the end of this unit.

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9.8. SUMMARY

Oyster mushroom is the easiest mushroom to grow as it can be grown on a variety of substrates like paddy and wheat straw, corn cobs, used tea leaves, oil palm mesocarp etc. Further several species of this mushroom are available and thus can be grown artificially under varied environmental conditions round the year.

Of the different techniques used for sterilisation of the substrate for bed preparation chemical sterilization can be adopted with care for large scale commercial

cultivation. Spawn inoculation of bed can be done by two methods i.e., directly mixing the required quantity of spawn with paddy straw in bulk and the filling in bags or spawning can be done in layers in the bags and incubated at room temperature for 15-20 days in a clean and hygeine maintained cropping room for maximum productivity.

9.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Paddy straw, wheat straw, sugarcane bagasse, jute and corn cobs are the five different subtrates used for oyster mushroom cultivation.

2. Chemical sterilization, hot water treatment, fermentation and steam pasteurization are the different types of sterilization used for the substrate during oyster mushroom cultivation.

9.10. MODEL EXAMINATION QUESTIONS

I. Answer the following question in about 30 lines.

1. Write in detail the different techniques involved in the preparation of substrate, its sterilization, spawning method and cropping room maintenance.

II. Answer the following questions in about 10 lines each.

1. Differentiate between chemical sterilization and hot water treatment of substrate.

2. Write in brief on cropping room maintenance.

Dr. H.A.K. Sarvar

UNIT - 10 : HARVESTING, PROCESSING, PRESERVATION AND MARKETING OF OYSTER MUSHROOM

Contents

10.1. OBJECTIVES

After going through this unit you will be able to :

- distinguish the stage of harvesting of oyster mushrooms,
- describe the method of grading of oyster mushrooms,
- describe different methods of preservation, packing and marketing of oyster mushrooms.

10.2. INTRODUCTION

The recent advances in the cultivation technology have encouraged the adoption of mushroom as a cash crop by the farmers and also the urban elite population. The interest in mushroom cultivation has gone to many folds in mushroom growers. But the short shelf life of mushroom poses a big problem for growers due to its quick perishable nature which causes loss to the growers. Therefore, there is

a need for proper harvesting of mushroom at a proper stage and also require a thorough processing, preservation and timely marketing in polythene packets for maximum profit.

10.3. HARVESTING AND METHOD OF PICKING

The oyster mushroom should be harvested when the cap begins to fold and has attained a diameter of 5-8 cm. The fruiting bodies are to be picked up carefully by cutting with a sharp knife without any damage to the picked up fruiting body or to the adjacent fruiting body. After picking up or harvesting, the fruiting body quickly looses water with a proportional loss in weight with the result it becomes liquiscent and losses its texture, becomes shiny and sheds off spores. This leads to deterioration in quality and ultimately develops undesirable look and emit foul smell. The shed spores are known to cause allergy in some people causing high fever, joint pains etc. Therefore they are to be harvested properly at the proper stage.

Check Your Progress - 1

At which stage the oyster mushroom is to be harvested ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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10.4. GRADING

Mushrooms have a short shelf life and are highly perishable. They are delicate and fragile and are to be marketed afresh. It is advisable to collect the mushroom in plastic baskets or trays without heaping. Ageing may result in breakage and may damage the fruiting bodies, due to over weight or compressing. The collected mushrooms are graded size wise and packed accordingly in polythene packets for marketing. Half matured mushrooms are considered to have more shelf life and with many nutrients, hence graded as good ones. Fully grown mushrooms are prone to mechanical damage, biodeterioration and are with less nutrients hence considered as low grade.

10.5. PROCESSING AND PRESERVATION

To avoid deterioration in mushroom quality due to delay in consumption or marketing certain techniques of processing are required which increase the shelf life of mushroom. The different techniques of processing are freezing, freeze-drying, steeping preservation,dehydration and canning.

10.5.1. Freezing

In this method the collected mushrooms are cleaned, washed and treated with liquid nitrogen at -120°C for 6 minutes and later stored at -25°C in deep freeze. This treatment make the mushroom intact as such without any change in colour or quality. Such mushrooms are called frozen mushrooms. But if storage temperature is decreased to -12°C it may cause brown colouration on mushroom and make them unfit for consumption.

10.5.2. Freez Drying

In this treatment mushrooms are frozen at -20°C and dehydrated by the process of sublimation. This can be done by heating the frozen mushrooms under very low vaccum of less than one tonne for a period of 12-16 hours. This results in loss of water to an extent of 90% of the total weight of fresh mushroom reducing approximately 10 kg of fresh mushrooms to 1 kg of dry frozen mushroom product. This makes the product brittle and lighter in weight due to reduction in weight to ten times to that of the original but in appearance they look similar to the original ones.

10.5.3. Steeping Preservation

First the collected mushrooms are to be cleaned, washed and blanched. Blanching can be done by immersing the mushroom in boiling water containing 1% common salt or 0.1% citric acid. The boiling is to be done for 4-5 minutes by constant stirring. The foam developed on the top while boiling is to be removed with the spoon. The blanched mushrooms are collected and dried on clean blotting paper. The dried blanched mushrooms are preserved in steeping solution of Sodium chloride (2%), citric acid, sodium carbonate and potassium meta bisulphite (0.15%) and kept at 21-28°C for long term preservation for increasing the keeping quality of the mushroom.

10.5.4. Dehydration

The oyster mushroom should be washed in clean water, blanched for 3-5 minutes in live steam or boiling water and cooled immediately. The blanched mushrooms are dipped in solutions of 300 ppm potassium metabisulphite and 400 ppm chlorine solution for better colour. Then they are dried under sun for 36 to 48 hrs or in a mechanical drier at 50-60°C.

10.5.5. Canning

The blanched mushrooms after drying on blotting papers are tinned in tin cans. Clean and dry tins are filled with blanched, graded mushrooms to three fourth capacity of the tins and then filled with blanching solution in a concentration of 15 g of salt/litre of water along with a preservative, citric acid @ 1g. per litre of water. The filled cans are subjected to exhaustion by keeping them in boiling water bath so that a temperature of 85°C is attained in the centre of the can. The

cans are then sealed by hand or by automatic sealers. The sealed tins are to be sterilized to avoid spoilage of the contents during storage. This can be achieved by autoclaving at a temperature of less than 118^{o}C, and are cooled by keeping them in galvanised iron tank with constant over flow of water.

10.6. PACKING

Packing of mushroom is an important item of marketing and this aspect should not be neglected. Packing can be done by packing the blanched, graded fresh mushrooms in polythene packets of 200g or 400g, 250g or 500g with or without labelling depending on the supply and demand. If information is to be required then the polythene packets are to be printed giving the information about the produce, manufacturer, batch and piece etc.

If the dried mushrooms are to be packed, the mushrooms after proper blanching are to be dehydrated. Dehydration can be done either by sun drying or oven drying. Sun drying can be done by beading the mushrooms in a thin wire and exposing it to dry hot sun. Dehydration by oven drying is to be done at a temperature of 55 to 60^{o}C. Due to this the mushroom becomes sufficiently dried, loose ten times of their weight and become brittle. The dried mushrooms can be packed in polythene packets of 200g, 250g, 400g, 500 kg, 1 kg, 2 kg, 4 kg, or 5 kg polythene packets.

Bulk Packing : Bulk packing is to be practiced in large units or big commercial mushroom farms. Under such conditions bulk packing can be done in 1 kg wooden boxes, 4 kg plastic crates, plastic baskets, plastic trays, expanded polystyrene containers, plastic cans. Packing containers prepared with paper base have the environmental advantages as they can be easily degraded and are not hazardous.

10.7. MARKETING

Oyster mushroom is to be marketed afresh to get maximum profit. As it is a perishable product it degrades quickly after harvest and become unfit for consumption.

Marketing is not organised for mushrooms like that of vegetables, fruits, grains etc., hence the absence of an established market channel forces the producer to have his own marketing which in turn will have an adverse effect on growing of mushrooms.

Hence there is a need to organise marketing through government or through cooperative agencies.

The growers are not able to form a cooperative collection centre and promote sales. Hence the middleman makes all the profit and dictate terms to the producer

by purchasing them from the producer at lower rates and selling at higher rates to the interested consumers.

Necessary incentives for export may be provided by the government to the interested cultivaters as there exists an ample scope for export. Besides this, mushroom receipes are to be improved and suggested from time to time to make it popular and improve the marketing of mushroom.

Check Your Progress - 2

List out the different techniques employed for processing and preservation of mushrooms.

Note : (a) Write your answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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10.8. SUMMARY

Mushrooms are now established as cash crop by the farmers and also by the urban elite especially the house wives, unemployed youth and students. But the short shelf life and absence of organised market posing a threat to the mushroom growing industry.

In order to have good mushrooms, care should be taken to harvest and pick them up. Mushrooms are to be picked up without any damage when the caps begin to fold, then they are to be graded according to international standards as size and weight. The mushrooms are either marketed afresh or processed by the processing techniques like freezing and drying, and then preserved for long term use. Similarly the marketing aspect is not to be neglected and it has to be organised by government or through farmer cooperatives to stablilize the prices otherwise the middle man in mushroom market will take the benefit. Hence marketing has to be properly organised for the benefit of the actual mushroom growers.

10.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Oyster mushroom is to be harvested when the cap has attained the diameter of 5-8 cm.

2. The different techniques employed for processing and preservation of oyster mushrooms are freezing, freeze drying, steeping preservation, dehydration and canning.

10.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe briefly the method of harvesting, processing, preservation and marketing of oyster mushroom.
2. Describe in detail the methods of preservation of oyster mushroom.

II. Answer the following questions in about 10 lines each.

1. Differentiate between freezing and freeze drying.
2. Write a brief note on canning of mushroom.
3. What is dehydration ? How are the oyster mushrooms dehydrated ?

Dr. H.A.K. Sarvar

UNIT - 11 : FACTORS INFLUENCING OYSTER MUSHROOM PRODUCTION

Contents

11.1. OBJECTIVES

By the end of this unit you will be able to :

- list out the abiotic and biotic disorders of oyster mushroom,
- explain the abiotic factors affecting oyster mushroom production like pH, temperature, relative humidity, light, oxygen and carbon dioxide.
- describe the symptoms caused by competitor moulds and other pathogens.

11.2. INTRODUCTION

The growth and development of oyster mushroom is controlled by various abiotic (environmental) factors like relative humidity, temperature, light, pH and carbon dioxide. The yield of oyster mushroom is also significantly affected by competitor or contaminant moulds (*Aspergillus, Mucor, Rhizopus, Trichoderma, Penicillium*) and pathogenic moulds (*Verticillium, Sibirina fungicola, Gliocladium*).

11.3. ABIOTIC FACTORS AFFECTING OYSTER MUSHROOM

Various physical (abiotic) factors that influence the growth and development of oyster mushroom are given below.

11.3.1. Hydrogen Ion Concentration (pH)

The optimum pH range for the growth of mycelium is about 6.0 to 7.0. The water used for spraying must be clean and should not be either acidic or alkaline. It should not be stored in rusted iron drums as the fruit body formation gets delayed in the presence of iron.

11.3.2. Temperature

Temperature is an important factor that influences the oyster mushroom production. Oyster mushroom (*Pleurotus* spp.) shows good mycelial growth at a temperature range of 20-30^{0}C. Fruit body formation takes place between a wide range of temperature i.e., 10 to 28^{0}C in various species. Species like *Pleurotus florida, P. ostreatus, P. sapidus, P. sajor-caju, P. flabellatus, P. eryngii* and *P. fossulatus* are high temperature species and require 20 to 30^{0}C for their growth (Table -11.1). While all these species yield a good amount of fruit bodies after a low temperature shock treatment (14 to 22^{0}C). The colour of the cap or pileus is light brown in *P. florida* when grown at a temperature range of 10 to 15^{0}C and white to pale yellowish at 20-25^{0}C. In case of *P. sajor-caju* the fruit bodies are dull white at 15 to 18^{0}C and brown at 25 to 30^{0}C.

Table - 11.1. Yield performance and temperature requirement of various *Pleurotus* spp.

S.No.	Species	Optimum temp. for mycelial run (^{0}C)	Optimum temp. for fruiting (^{0}C)	Temp. range it can grow (^{0}C)	No.of days required for substrate colonization at optimum temp.	No.of days for fruit at optimum temp.	Yield performance (Biological efficiency %)
Summer cultivated species							
1.	*P. flabellatus*	25-30	22 ± 2	16-28	12-14	18-22	60-90
2.	*P. sajor-caju*	25-30	24 ± 2	17-30	12-14	18-25	50-70
3.	*P. sapidus*	25-30	27 ± 2	20-30	7-9	8-12	40-70
5.	*P. citrinopileatus*	25-30	26 ± 2	20-30	12-14	20-28	30-60
6.	*P. eous*	25-30	24 ± 2	16-28	20-22	25-30	30-50
Winter cultivated species							
7.	*P. ostreatus*	25-30 strain-I	20-22	18-25	20-25	30-35	30-50
		strain-II	12-20	7-22	"	"	"
8.	*P. florida*	25-30	20 ± 2	12-22	16-18	25-30	50-90
9.	*P. cornucopiae*	25-30	20 ± 2	12-25	16-18	25-30	40-70
10.	*P. fossulatus*	18-22	18 ± 2	12-25	50-55	65-70	20-30
11.	*P. eryngii*	18-22	16 ± 2	12-24	55-60	70-75	20-30

* Source. R.C. Upadhyay, 1990 Technical Bulletin No.1, NCMRT, Solan, India.

The mushrooms grown at lower temperatures consist of high dry matter.

11.3.3. Relative Humidity

Various species of oyster mushrooms require a range of relative humidity between 70 to 85% for fruit body formation. The relative humidity of the cropping room may be adjusted by spraying water frequently or by using a humidifier. Bigger fruit bodies which contain less dry matter are produced at high relative humidity (85-90%) levels. At a relative humidity range of 65-70% the fruit bodies are small with high dry matter.

11.3.4. Light

Light is required for initiation of fruit bodies in oyster mushroom production. Light is essential to promote fruiting of oyster mushroom and it was first noticed by Kaufert (1935). The formation of mushroom primordia requires light of 200 lux intensity for 12 hours. The development of fruit body requires light of 50 to 500 lux intensity. Thus, over all, one to two hours diffused light per day during cropping period is sufficient. The colour of the pileus is influenced by the intensity of light. The pileus is dark brown, black or grey coloured in bright light where as in diffused light the fruit bodies are white coloured. When light is insufficient mushrooms give poor yield with long stipes and small caps (pileus).

11.3.5. Oxygen and Carbondioxide Content

During spawn run oyster mushroom can toletrate high carbon dioxide concentration (upto 20,000 ppm or 20%). The concentration of carbon dioxide should be less during cropping (600 ppm or 0.6%). Abnormal fruit bodies are formed due to poor ventilation. The stalk is very long with small, funnel shaped caps. High carbon dioxide content in the cropping room yields deformed fruit bodies with long stipe and profuse branching.

Check Your Progress - 1 & 2

1. What are the optimum pH and relative humidity required for oyster mushroom production ?

2. Which are the disorders that appear in oyster mushroom due to poor ventilation and high carbon dioxide content ?

Note : (a) Write the answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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11.4. BIOTIC FACTORS AFFECTING OYSTER MUSHROOM

Pasteurized and partially sterilised substrates are used for oyster mushroom cultivation. Non sterilized and incompletely sterilised substrates are usually associated with a variety of microorganisms. Of which, few organisms may be beneficial to the mushrooms as fermentors, nutrient suppliers etc. Many microbes that are associated with the substrates used for oyster mushroom cultivation affect the yield adversely.

11.4.1. Competitor moulds

Many fungi are present in the substrate and compete with the mushroom mycelium for nutrition, thus reducing the growth. These are called weed moulds or competitor moulds. Such moulds do not cause much damage once the mushroom mycelium is established in the bed used for production. Examples for such moulds are *Penicillium Gliocladium, Trichoderma, Aspergillus, Mucor, Rhizopus, Sclerotium, rolfsii, Coprinus, Fusarium, Peziza, Chaetomium, Cladosporium, Arthrobotrys, Stachybotry etc.*

11.4.2. Pathogens

Some fungi are also known to damage fruit bodies by directly attacking them. The diseased fruit bodies are deformed with slimy cap. White, green or purple coloured growth of the moulds are found in the beds. *Cladobotryum apiculatum, C.varium, Gliocladium virens, G.deliquescens, G.roseum, Verticillium fungicola, Sibirina fungicola* etc. are known to cause damage.

Pseudomonas infects the fruit bodies when proper ventilation is absent in the cropping room.

A virus affecting *P.florida* has been detected in India. Elongation of the stalk and premature spore shedding are the typical symptoms of the disease. Thus there are many pests and diseases reported on oyster mushroom.

11.4.3. Control

Prevention is better than cure for all the diseases. Bavistin spray (0.01%) is more effective. Spraying should be done only on the substrate. Incidence of flies can be controlled by spraying Nuvan @ 0.1% (1 ml in 1 litre of water). The mushrooms should be harvested before spraying.

Check Your Progress - 3

Name few competitor moulds that occur commonly in the substrate of oyster mushroom ?

Note : (a) Write the answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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11.5. SUMMARY

Oyster mushroom production is greatly influenced by abiotic factors like temperature, pH, light, relative humidity, gases etc., and biotic factors like competitor moulds and other pathogens. Optimum mycelial growth and fruit body formation requires a temperature range of 20-30^{0}C, pH between 6.0 - 7.0 and relative humidity of 70-85%. Formation and development of fruit bodies require diffused light. Poor ventilation results in the formation of abnormal fruit bodies. Competitor moulds like species of *Penicilium, Aspergillus, Trichoderma, Mucor, Rhizopus* etc., and pathogens like species of *Cladobotryum, Verticillium* are prevalent in the substrates. Bavistin and Nuvan are recommended for fungal attack and flies respectively.

11.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Oyster mushroom production requires an optimum pH of 6.0 - 7.0 and relative humidity of 70 to 85%.
2. Abnormal fruit bodies with large stipe and small, funnel shaped caps are formed due to poor ventilation. High carbon dioxide content results in deformed fruit bodies with long stipe and profuse branching.
3. Common competitor moulds seen during oyster mushroom cultivation are species of *Penicillium, Trichoderma, Gliocladium, Aspergillus, Mucor, Rhizopus* etc.,

11.7. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the abiotic factors influencing the production of oyster mushrooms.
2. Write an essay on factors influencing oyster mushroom production.

II. Answer the following questions in about 10 lines each.

1. Write a note on the effect of light and temperature on oyster mushroom.
2. Write a short note on competitor moulds.

Ms. K. Prasunamma

BLOCK - IV
PADDY STRAW AND OTHER MUSHROOMS

UNIT - 12 : CULTIVATION OF PADDY STRAW MUSHROOM

Contents

12.1. OBJECTIVES

After going through this unit you will be able to :

- list out the morphological characters of paddy straw mushroom,
- explain the growth requirements of paddy straw mushroom,
- describe the preparation of spawn and production of mushrooms,
- list out the harvesting methods, preservation techniques and marketing aspects of the mushroom,
- describe the symptoms of common diseases of paddy straw mushroom.

12.2. INTRODUCTION

Paddy straw mushroom (*Volvariella* sp.) belongs to the family Pluteaceae, order, Agaricales, subclass, Holobasidiomycetidae and class, Basidiomycetes. The genus *Volvariella* consists of about hundred species distributed all over the world. Many cultivated forms of *Volvariella* belong to *Volvariella volvaceae. V. esculenta* and *V. diplasia.* It is commonly known as Chinese mushroom, since it was first cultivated in China about 300 years ago. This mushroom is mainly grown in tropical and subtropical countries of Asia like China, Hongkong, Taiwan, Indonesia, Phillippines, India, Sri Lanka etc on paddy straw substrate. Hence it is referred to as tropical mushroom, warm mushroom or paddy straw mushroom. As early as 1822 it was cultivated by Buddhist monks of Nanhua temple of Choahsi in Northern Guangdong Province in China and hence also termed as "Nanhua Mushroom".

Paddy straw mushroom is a fast growing mushroom and requires only 8-10 days from spawning to harvesting. It grows at a temperature range of 28-35°C and relative humidity of 80-90%. In India, in between the period when oyster and white button mushrooms cannot be grown, paddy straw mushroom can be cultivated successfully as gap filling crop.

12.3. MORPHOLOGY

The fruit bodies of the genus *Volvariella* consists of thick volva, free gills and pink elliptic spores. The basidiocarp or the fruit body of paddy straw mushroom for the sake of convenience is divided into six stages. They are pinhead, tiny button, button, egg, elongation and mature stages (Fig. 12.1). The pin head and the tiny button stages are formed by the interwoven hyphae and are covered by a membrane which is called universal veil. the pin head stage is very small and made up of tiny knot of hyphal cells. The tiny button stage is round in shape. The button and the egg stages are ovoid in shape. At these stages, the mushrooms have great demand in the market. The button stage is covered by an universal veil. In the egg stage pileus protrudes out of the veil whereas stipe is hidden. At this stage, veil covering the stipe is called "volva". In the elongation stage upper part of the stipe elongates. From the lower part of the pileus one can see many lamellae hanging in the form of thin strands of tissue from the margin extending till the stalk.

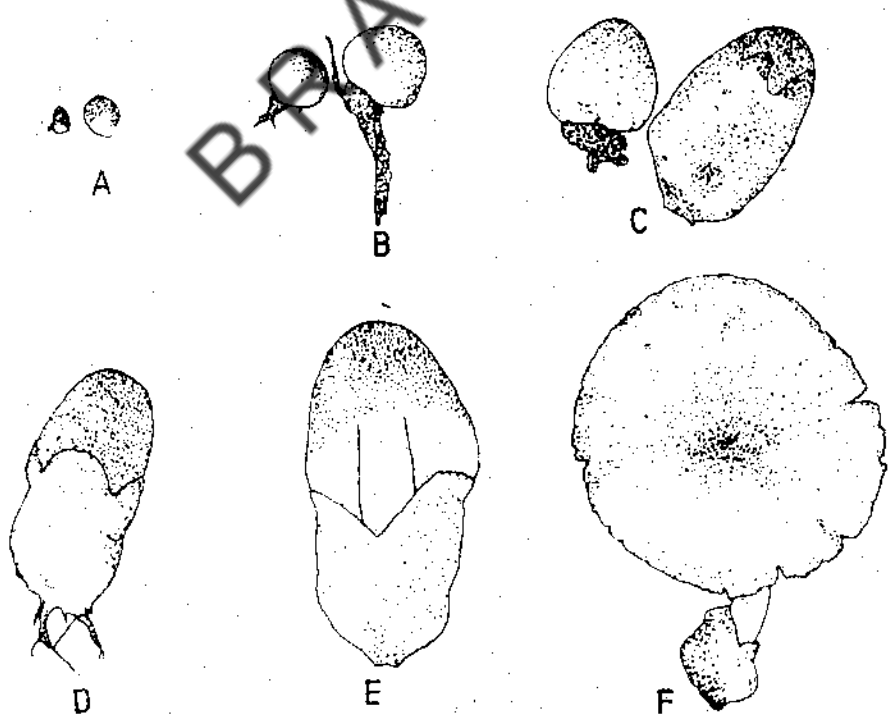

Fig. 12.1. Different stages of paddy straw mushroom. A. Pinhead. B. Tiny button. C. Button. D. Egg stage. E. Elongation. F. Maturation stage.

Check Your Progress - 1 & 2

1. List out the various stages in the development of paddy straw mushroom ?

2. What is meant by volva ?

Note : (a) Write your answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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12.4. GROWTH REQUIREMENTS

Paddy straw mushroom as its name indicates grows well on paddy straw. Many other agricultural wastes have been tested for its growth but resulted in poor yields. However, cotton waste compost gave an excellent yield in Hongkong. Substrates having glucose and polymers of glucose supported the growth of paddy straw mushroom to a great extent. In 1977, Chang, Ho and Yee reported that mannose and starch support the growth of this mushroom. Paddy straw mushroom is unable to utilize lignin. Organic nitrogen supports the growth of paddy straw mushroom. Hence it is necessary to supplement the straw, cotton or other cellulose substrates with organic nitrogen. Addition of vitamins like ascorbic acid, pyridoxine, riboflavin, thiamine, growth promoters like gibberellic acid and also L-amino benzoic acid gives significant yield.

The mushroom requires a temperature range of 30-35^{0}C for mycelial growth 28-30^{0}C for fruit body formation. The pH required is 6-7 and relative humidity is 80-90%. Light acts as a trigger for fruit body formation and hence diffused light for 8-10 h per day should be provided. Good ventilation which provides more O_2 and removes excess CO_2 are necessary during fruit body formation.

Check Your Progress - 3

Mention the optimum temperature required for the mycelial growth and fruit body formation ?

Note : a) Write your answer in the space given below.
b) Compare your answer with the one given at the end of this unit.

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12.5. CULTIVATION TECHNIQUE

The cultivation technology of paddy straw mushroom is simple and best suited to Indian conditions. The method of cultivation basically consists of two steps. They are preparation of spawn and mushroom production.

12.5.1. Preparation of Spawn

Spawn may be defined as a medium coated with mushroom mycelium that serves as the 'seed' for cultivating the mushrooms. Before producing the spawn for mushroom cultivation starting cultures are required. They can be obtained by two ways. They are tissue culture and spore culture methods. These cultures are to be grown on culture media under sterile conditions. Preparation of culture media and isolation of starting cultures of paddy straw mushroom are given below.

Culture media : A medium is the one which have all nutrients required for the growth of the fungus. There are various culture media on which mushroom cultures can be grown. Two commonly used media are given below.

A. PDA (Potato dextrose agar) Medium

Peeled and diced potato	-	250 g
Dextrose	-	20 g
Agar agar powder	-	20 g
Distilled water	-	1000 ml

Diced potatoes are boiled in distilled water for 15-20 min and the decoction is strained through cheese cloth. The liquid is collected in a graduated cylinder and the volume is made upto 1000 ml by adding fresh distilled water. To this solution dextrose and agar are added and boiled by stirring occassionally until the agar is completely dissolved. The medium is transferred to tubes and flasks and plugged with non-absorbant cotton. They are then sterilized in an autoclave at 15 lb pressure (121^{0}C) for 20 min.

B. Malt Extract Agar (MEA) Medium

Malt extract	-	25 g
Agar agar powder	-	20 g
Distilled water	-	1000 ml

Malt extract and agar powder are added to 1000 ml distilled water and boiled while stirring occasionally until the agar is dissolved. The medium is then poured in test tubes (10 ml per tube) and plugged with non-absorbant cotton wool. The tubes are then sterilized in an autoclave at 15 lb. pressure (121^{0}C) for 20 minutes.

Isolation of starting cultures : Starting cultures can be raised either through tissue culture or spore culture methods.

A. Tissue culture method : A mature unopened mushroom is washed thoroughly in water and dried gently with tissue paper. The fruit body is cleaned with a cotton swab and dipped in 0.1% mercuric chloride solution (100 mg Mercuric Chloride in 100 ml sterilized water) taken in a sterilized beaker for 30 seconds with the help of a sterilized forceps. The fruit body is then washed 4-5 times serially in sterile distilled water to remove excess chemical. The fruit body is dried superficially with sterile tissue paper and cut lengthwise. At the inner surface from the point of junction of pileus and stipe small bits of tissue are taken and placed on the agar surface of the test tube. The entire process should be carried out under sterile conditions. The instruments and the surrounding area should be sterile. The test tubes are then incubated at 30-35^{o}C for 6 to 7 days. White mycelium is seen coming out of the tissue. Contaminated tubes are to be discarded and healthy ones are to be used directly in spawn substrates.

Tissue culture method is the most widely used one for large scale production of spawn.

B. Spore culture method : Spores of the paddy straw mushroom are collected by taking spore prints. A spore print is nothing but a mass of spores collected from the mushroom on a clean surface. The technique of taking spore print is as follows :

1. A mature and opened mushroom is cut at the upper end of the stalk and placed it on a clean paper. After 10 minutes spore print is seen which is to be discarded, since microorganisms may be present in the first print.
2. The mushroom is again placed in a sterile petriplate and covered with a clean beaker. In about 20-30 minutes the spores are shed on the petriplate and are ready for inoculation.

Collection of spores through spore porint and inoculation are to be carried out under sterile conditions. The spore masses are lifted with the help of a sterilized inoculation needle and transferred on to an agar slant. The tubes are incuated at 30- 32^{o}C for 4 to 5 days for mycelial growth.

The cultures thus obtained are to be used directly for inoculating the spawn substrate.

Spawn substrates : A variety of substrates are used for the preparation of paddy straw mushroom spawn. They are grains like sorghum, wheat, rye, rice, straw cuttings, cotton waste, used tea leaves etc.

A. Cereal grains : Cereal grains like sorghum, wheat, rye etc are boiled for 20-30 minutes to increase the moisture content of the grains to 40-50%. The grains are dried for few hours. They are mixed with 2% calcium sulphate and 0.5% calcium carbonate on the dry weight basis of the grains to adjust the pH of the substrate to 7.5 and to keep the grains dry and separated.

B. Paddy straw substrate : The paddy straw is cut into 2.5 to 5 cm long bits, soaked in water for 2-4 hours. The excess water is drained out and mixed with 1% calcium carbonate and 1 to 2% rice bran.

C. Used tea leaves : Used tea leaves are collected and washed thoroughly with water to remove debris and drained. They are mixed with 2% calcium carbonate.

D. Cotton waste substrate : Card waste grade of cotton waste from textile industry is soaked in water for few hours and drained. Further, 2% calcium carbonate is added.

Any of the above spawn substrates are filled in bottles or polypropylene bags (300 g per bottle or bag) and plugged with non- absorbant cotton. In case of bags polypropylene rings are used to provide mouth for bags and plugged with cotton. They are then sterilized in an autoclave at 22 lb. p.s.i pressure (126.5^{o}C) for about 2 hours.

The substrate containers after sterilizing are cooled to room temperature and inoculated with paddy straw mushroom mycelium growing on culture medium in the test tubes under sterile conditions. These bottles or bags are incubated at 30 - 35^{o}C for about three weeks. Such a culture is called "master culture or master spawn". From these bottles spawn is inoculated into other bottles or bags to form commercial spawn which can be used directly by the grower. Spawn of 12-20 days old is most ideal for cultivating the paddy straw mushroom.

Check Your Progress - 4 & 5

4. Mention various methods of raising starting cultures ?

5. What is a master spawn ?

Note : (a) Write your answers in the space given below.
(b) Compare your answers with those given at the end of the unit.

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12.5.2. Production of Mushrooms

Though a variety of waste materials like paddy straw, cotton waste, oil palm bunch, water hyacinth, banana leaves, saw dust and sugarcane bagasse are used for cultivation. The most widely used are paddy straw and cotton waste. Common methods for growing paddy straw mushroom are (a) outdoor cultivation (b) cage culture (c) cotton waste compost method and (d) polybag technique.

A. Outdoor cultivation by using paddy straw : Clean fresh dried paddy straw is taken and 32 bundles (800 g -1 kg each) are made by tieing each of them at one or two places. The bundles are steeped in water for 24-48 hours. After draining

excess water the bundles are dipped in boiling water for about half-an hour. The straw bundles are spread on slope to drain off excess water. The beds are to be laid on raised (75-90cm) wooden or concrete platforms. Four bundles are to be kept length wise with butts on one end and loose ends on the other. Another four bundles are placed in line with first four bundles, but with butts on the otherside. This forms the first layer and consists of eight bundles. This layer is spawned at about 3-4 inches away from the edges. Another eight bundles of paddy straw are placed over the first layer in the same manner as the first layer and spawned. Thus third and fourth layers of straw and spawn are to be placed one after the other. The whole bed is pressed lightly and covered with a polythene sheet and supported by a bamboo frame work. The polythene sheet helps to increase both the temperature and humidity. Such beds are usually made in east-west direction under the shade created by trees or creepers. After four days the sheet is removed and slight watering is required on 6th day. However, when mushroom pinheads appear spraying of water is not necessary.

B. Cage culture of paddy straw mushroom (indoor cultivation) : In this method paddy straw bundles are arranged in wooden cages (1m x 50 cm x 25 cm). R N Verma et al (NCMRT, Solan) followed this method of cultivation and were successful. Fresh, dry paddy straw should be selected and 60 bundles (each 25cm long and 10cm thick) of paddy straw are made for each cage. The bundles are soaked in boiling water for 20-30 min and after cooling, excess water is drained out. The cage and polythene sheet are disinfected with 4% formalin. Ten straw bundles are arranged as the bottom layer and spawn is spread over the straw bundles. Again second layer of ten bundles and spawn are placed. Thus six layers of bundles and spawn are arranged one after the other to fill the cage. The beds are sprayed with the solutions of 0.1% malathion and 0.2% *Dithane Z-78*. The beds are then covered with polythene sheet and tied with a twine. The spawned cages are kept in a room or a shed for the mycelial growth. During this period, a warm temperature around 30^{0}C gives better growth of the mycelium. Pinheads start appearing after 10-15 days of spawning.

C. Cotton waste composting method: The method is widely used in Hongkong for commercial production of mushrooms. The yields are 25-40% higher in cotton waste compost than in paddy straw.

The compost is prepared by using cotton waste obtained from textile industry, rice or wheat bran(4%) and lime stone (1 to 3%) to adjust pH. The mixture is sprayed with water and a stack of 1.0-1.5m height is made. The stack is left for 2-4 days for fermentation to take place. One turning is to be given in between this period. The compost is filled in special beds made of iron frame lined with polythene sheets (4mm) and steam is sent through the compost raising the temperature to 65^{0}C for 2-4 hours. Then fresh air is let in and cooled to room temperature. The spawn is mixed with the compost and are incubated at 32-34^{0}C.

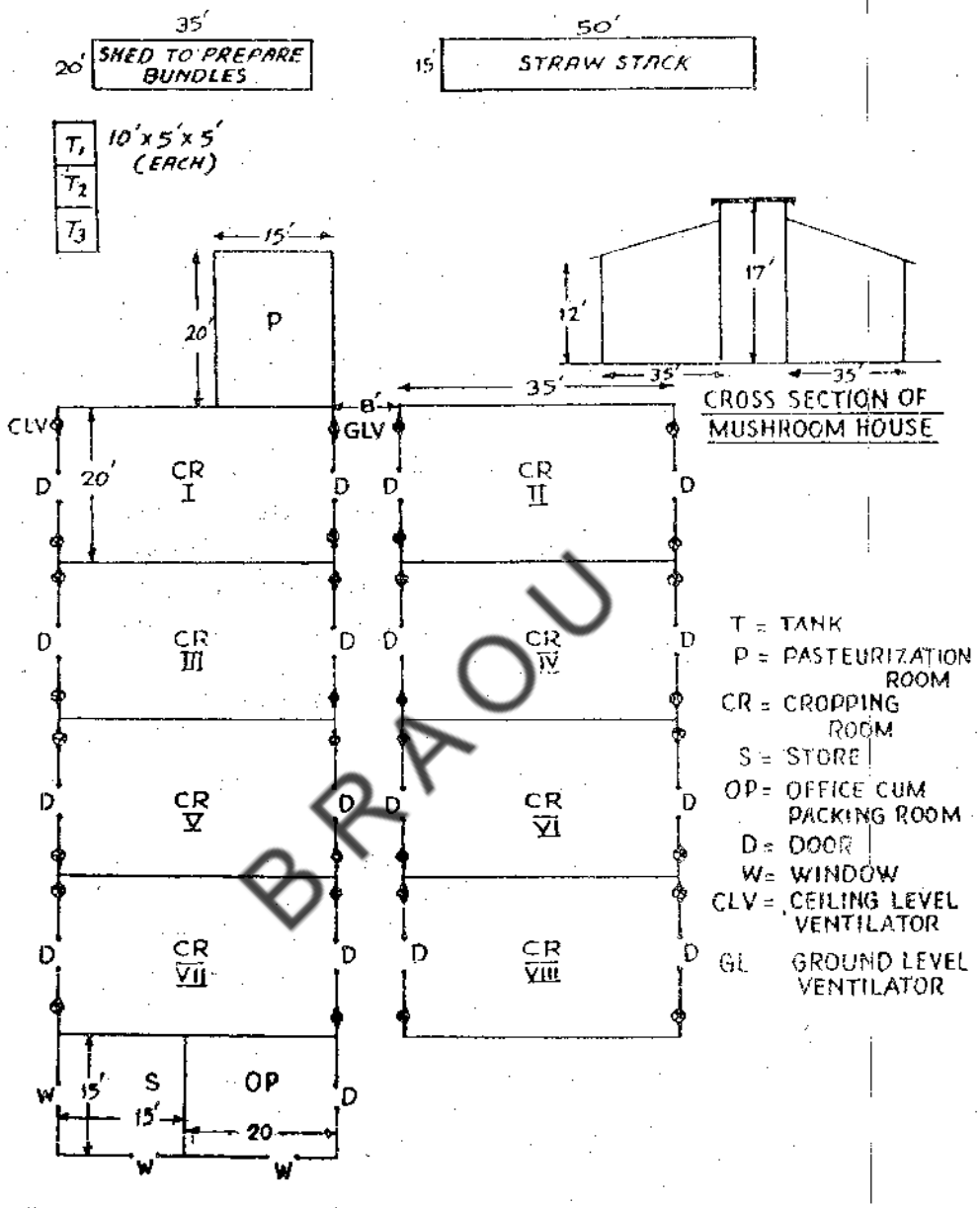

Fig.12.2. Farm layout of paddy straw mushroom.

D. Polybag method : Finely chopped paddy straw and small pieces of waste paper bits (1:1) are soaked separately in water containing formalin and bavistin (125 ml of 35-40% formalin and 7 g bavistin in 100 litres of water for 16-18 hours). The soaked straw bits and paper pieces are spread on a clean cemented floor or wire mesh for half an hour. They are then mixed throughly with spawn and filled in polypropylene bags of convenient size. Few holes are made in bags. The bags are tied with thread and incubated. After ten days the bags are cut open and incubated for mushrooms to appear. Regular spraying of water is necessary.

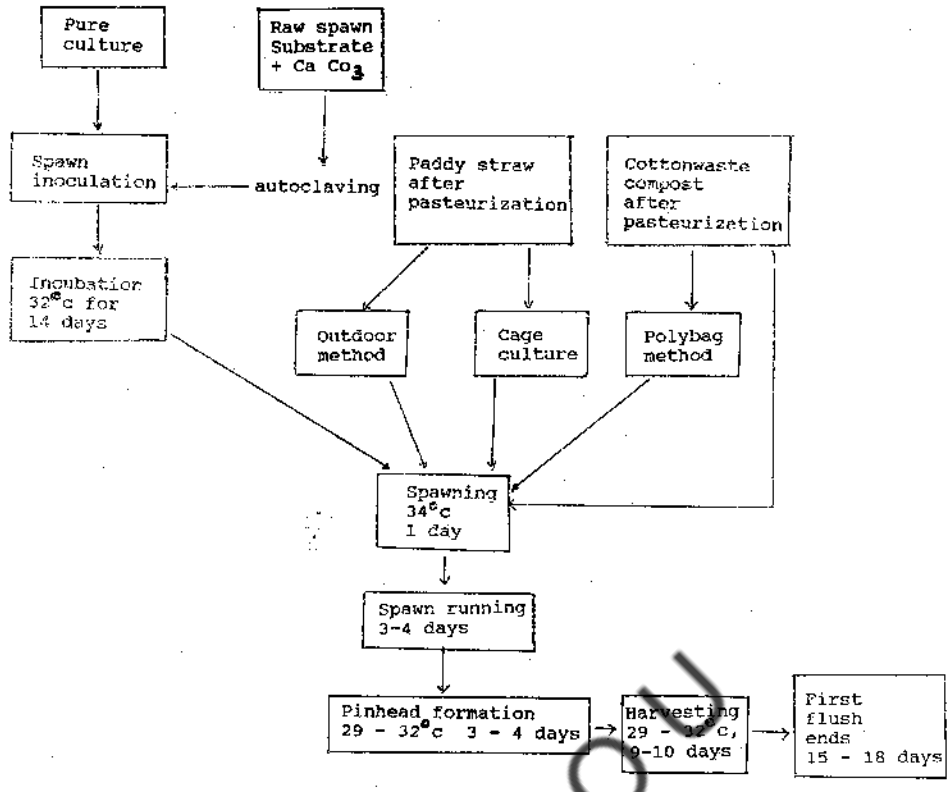

Fig.12.3. Flow chart for paddy straw mushroom production

Check Your Progress - 6

What are the common methods of growing paddy straw mushroom ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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12.6. HARVESTING, PRESERVATION AND MARKETING

Harvesting : In about 10 days paddy straw mushrooms appear in the beds. They are usually picked at egg stage only, before the volva breaks and are not allowed to grow to their maximum size. They should be carefully harvested by slight twisting at the base without damaging the growing mycelium. During cropping fresh air, diffused light and 80-90% relative humidity are to be provided. 70-90% of the expected yield is obtained from the first flush itself which appears in about 10 days after spawning. After 3 to 5 days second flush appears which gives only 10-30% of the total crop. In between flushes thorough watering is necessary. In a period of 15-20 days paddy straw mushrooms of about 2.4 to 7.3 kg/m are obtained.

Preservation : Fresh paddy straw mushrooms picked at button stage have shelf life of about 6-8 hours at room temperature. The fresh mushroom undergo autolysis (self digestion) at 4°C. They can be stored in perforated polythene bags for 4 days at a temperature of 10- 15°C. The straw mushrooms can be blanched by immersing them in 10% brine solution and by air drying can be stored upto a week. By sun drying or drying in a mechanical drier at 50-55°C for 5-6 hours the mushrooms can be preserved.

Marketing : The straw mushrooms packed in polybags are to be marketed in fresh form within 6-8 hours of packing. In China, fresh mushrooms are transported by boat or rail in wooden cases having three compartments. Mushrooms packed in the middle compartment and the other two compartments being packed with ice. They are packed in bamboo baskets and are transported by air frieght in Taiwan and Thailand. At the centre of the basket an aeration channel is provided and dry ice is wrapped in paper and placed on the top of the mushrooms.

Check Your Progress - 7

What is the shelf life of fresh paddy straw mushroom ?

Note : (a) Write the answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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12.7. COMMON DISEASES AND THEIR MANAGEMENT

Paddy straw mushroom is attacked by various weed moulds and insect pests. Competitor moulds like *Coprinus* spp., *Rhizopus stolonifer, Penicillium* spp., *Psathyrella* spp., *Trichoderma* spp., *Aspergillus* spp. and *Sclerotium* spp. *Sclerotium* spp. causes 'button rot' disease. Collembola infestation is found in some parts of South India. *Rhizoctonia solani* which reduces the formation of sporophores has been reported on the substrate of paddy straw mushroom. Bahl and Choudhary (1981) have reported that *Podosora faurelii* inhibits the growth of mushroom mycelium completely and is a serious competitor. Mites (*Scheloribates* spp) also damages the buttons of paddy straw mushroom.

The diseases of paddy straw mushroom are prevented by manipulating environmental factors like temperature, humidity and ventilation. Sanitation and hygiene gives a little chance for the incidence and spread of disease. Spraying with captan and zineb (0.2%) have been reported to reduce the diseases.

12.8. SUMMARY

Paddy straw mushroom (*Volvariella* sp.) is a tropical mushroom which grows at a temperature range of 28-35°C and produces mushrooms within 8-10 days from the day of spawning. The fruit body consists of six stages. They are pin head, tiny button, button, egg, elongation and mature stages. The fruit body or the basidiocarp at the young stages is covered by means of a membrane called "volva". The mushroom grows on many agricultural wastes but gives better yield on paddy straw and cotton waste compost. The starting cultures are raised either by tissue culture or spore culture method. However, tissue culture method is commonly followed by commercial producers. From the starting cultures master spawn can be grown on various spawn substrates like cereal grains, used tea leaves, paddy straw and cotton waste. Commercial spawn is prepared from the master spawn on any of the spawn substrates mentioned above. There are four common methods of cultivation. They are outdoor cultivation, cage culture, cotton waste compost and polybag technique. In about 10 days after spawning mushrooms can be harvested. The harvested mushrooms are packed in fresh form or dried and marketed. The fresh mushrooms have a shelf life of about 6 to 8 hours. The paddy straw mushroom is commonly attacked by many competitor moulds and insect pests. They can be prevented either by regulating environmental factors or maintaining strict hygiene or spraying with chemicals like zineb (0.2%) and captan.

12.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Pinhead, tiny button, button, egg, elongation and mature stages are the various stages that appear during the development of paddy straw mushroom.

2. A membrane covering the stipe is called volva.

3. The temperature required for mycelial growth is 30-35°C and for fruit body formation on 28-30°C

4. Tissue culture and spore culture are the two methods used for raising starting cultures.

5. A culture that is prepared directly from the starting culture which is used for the preparation of commercial spawn is called master spawn.

6. Outdoor cultivation, cage culture, cotton waste composting method and polybag technique are the common methods of growing paddy straw mushroom.

7. The shelf-life of paddy straw mushroom is 6-8 hours.

12.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe briefly various methods of preparation of spawn of paddy straw mushroom ?
2. Explain in detail the different methods of production of paddy straw mushrooms ?

II. Answer the following questions in about 10 lines each.

1. Write a note on growth requirements of paddy straw mushrooms ?
2. Give a brief note on diseases of paddy straw mushrooms and their management.

Ms. K. Prasunamma

UNIT - 13 : CULTIVATION OF *LENTINUS EDODES, AURICULARIA* Spp. *AND CALOCYBE INDICA*

Contents

13.1. OBJECTIVES

After going through this unit you will be able to :

- explain the importance of *Lentinus edodes, Auricularia spp* and *Calocybe indica,*
- list out the morphological characters and growth requirements of the three mushrooms,
- describe the methods of preparation of spawn and cultivation of the three mushrooms,

- list out the harvesting methods, preservation techniques and marketing aspects of the three mushrooms and
- describe the symptoms of common diseases.

13.2. INTRODUCTION

Shiitake mushroom *(Lentinus edodes),* Black ear mushroom (*Auricularia* spp.) and Milky white mushroom *(Calocybe indica)* are three other edible mushrooms whose production in India is increasing in recent times.

Lentinus edodes belongs to the family : Tricholomataceae; order: Agaricales; subclass : Holobasidiomycetidae and class : Basidiomycetes. It is commonly known as black forest mushroom, shiang-gu (Chinese name) or Shiitake mushroom (Japanese name). The name Shiitake mushroom has come from the 'Shii' tree *(Castanopsis cuspidata)* on which it was growing naturally in Japan. It occupies third place in the world's mushroom production after *Agaricus bisporus* (button mushroom) and *Pleurotus* sp (oyster mushroom). Annual production of this mushroom is about 3,93,000 tonnes. It is mostly cultivated in Japan, People's Republic of China, Taiwan, S.Korea and United States of America. Shiitake mushroom occupies first place in the export industry in Japan. It is popular for its unique taste, flavour and medicinal values. The specific flavour of the mushroom is due to the presence of guanidine 5 - monophosphate. Wu shu, a Chinese doctor (1368-1644) wrote about this mushroom that it cures cold, improves blood circulation and reduces plasma cholesterol level thus lowering hypertension.

Auricularia belongs to the family : Auriculariaceae; order : Auriculariales; subclass : Phragmobasidiomycetidae and class: Basidiomycetes. This was the first cultivated mushroom around 600 A.D. in China. The name *Auricularia* is derived from the Greek word *"Auricula"* meaning 'ear'. Hence it is called by different common names such as 'wood ear', 'Jew's ear', 'ear fungus' 'black ear mushroom etc'. Though there are nearly 10 species available world wide, the species that are commercially cultivated are *A. auricula, A. polytricha* and *A. fuscosuccinia.* In South East Asian Countries its cultivation now has become an occupation. About 90% of Taiwan's dried produce is being exported to Hongkong, Japan and U.S.A. Thailand is the major importer of this mushroom for local use. Its total annual production is 199.07x100 metric tonnes and occupies fifth position among the cultivated mushrooms (Chang, 1987). The mushroom grows under natural climates in North Eastern Hills of India. The cultivation of black ear mushroom in India has begun recently. Though the mushroom does not have any specific taste, it is popular due to its cartilaginous texture and medicinal value. It cures anaemia, sore throat and on regular intake also cures certain digestive disorders especially piles.

Calocybe indica belongs to the family; Tricholomataceae; order : Agaricales; subclass : Holobasidiomycetidae and class : Basidiomycetes. It is commonly called 'Milky White Mushroom' due to its attractive white colour. It is a wild edible fungus growing in the forests of West Bengal. It was first identified by

Purkayastha and Chandra (1974) in India. The mushroom grows on humus rich soil in forests. It is sold in village and city markets of West Bengal. Attempts to grow this mushroom artificially were made by many workers and were successful. Milky white mushroom is catching its attention by many growers due to its taste, long shelf-life and attractive white fruit bodies. Young pinheads consist of low protein (15% on dry wt. basis) while mature fruit bodies consist of high contents of protein (17.2% on dry wt. basis). This mushroom consists of 12 aminoacids of which glycine is in large amounts (10.8 g/100g protein).

Check Your Progress - 1

Name a mushroom that reduces plasma cholesterol level ?

Note : (a) Write your answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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13.3. *LENTINUS EDODES*

Shiitake mushroom *(Lentinus edodes)* usually grows on wood of deciduous trees like beech, Oak, Chestnut etc.

13.3.1. Morphology and Growth Requirements

The basidiocarps (fruiting bodies) are eccentric or centrally stipiate (Fig. 13.1). Pileus, the upper umbrella-like portion grows upto 11 cm in diameter, first convex, later on depressed and consists of darker scales in the centre. Gills are crowded, first white in colour later on changing to brown or grey. Stipe (3-4 x 0.8 - 1.5 cm. in size) is solid and consists of dark brown scales at the joints. A colourless ring called cortina is present on the stipe of young fruit bodies. The fruit bodies are fleshy when young and tough when mature. Spores are smooth, cylindrical and non-amyloid.

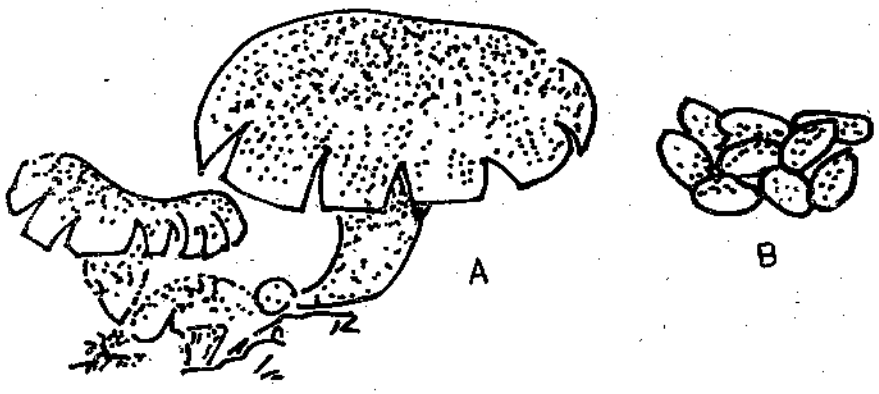

Fig.13.1. *Lentinus edodes* (Shiitake mushroom). A. Fruitbody. B. Spores.

Shiitake mushroom is a saprophytic (growing on dead organic matter), wood rotting fungus. It grows on the cambium of dried logs. The bark of the wood protects the growing mycelium and plays a major role in the formation of fruit bodies. The mushroom mainly grows on the broad leaved members of the family : Fagaceae, that includes many oak species. Wood from other trees are also used for growing the mushroom. List of trees on which the mushroom grows is given in the following table (Table - 13.1)

Table - 13.1. List of trees suitable for wood log method of cultivation of shiitake mushroom.

S.No.	Scientific name	Common name	Growth rating	Reference
1.	*Acer nigrum*	Black maple	Fair	Kuo & Kuo, 1983
2.	*A. pictum*	Japanese maple	Fair	Singer & Harris 1987
3.	*Alnus serrulata*	Hazel alder	Good	San Antinio, 1981
4.	*Betula lutea*	Sweet birch	Good	Kuo & Kuo, 1983
5.	*B. nigra*	Red birch	Good	Kuo & Kuo 1983
6.	*Carpinus laxiflora*	Horn bean	Excellent	Singer & Harris 1987
7.	*Castanea crenata*	Japanese chestnut	Excellent	Singer & Harris 1987
8.	*Castanopsis cuspidata*	Shii	Excellent	Singer & Harris 1987
9.	*C. sieboldii*	Shii	Excellent	Singer & Harris 1987
10.	*Osytria virginiana*	Iron wood	Excellent	Kuo & Kuo, 1983
11.	*Quercus alba*	White oak	Excellent	Singer & Harris, 1987
12.	*Quercus acutissima*	oak	Excellent	Singer & Harris, 1987
13.	*Quercus* sp.	oak	Excellent	Singer & Harris, 1987
14.	*Salix nigra*	Blackwillow	Excellent	San Antonia, 1981

* Source : S.R.Sharma, Cultivation of speciality mushroom, NCMRT, Solan.

Artificially this mushroom grows on various substrates mixed with sawdust and bran.

Optimum temperature for mycelial growth is 24-28^{0}C and for fruit body formation is 12-20^{0}C. The relative humidity should be between 85 and 90%. Medium light intensity (500-600 lux) stimulates to form fruit bodies more rapidly while low light intensity (120-200 lux) lengthens the cultivation period. pH range should be 5.5-6. Chemical substances like tannic acid (500- 1000ppm) and Caffeine (50-100ppm) have been reported to stimulate the fruit body formation.

Check Your Progress - 2

What are the optimum physical factors required for shiitake mushroom ?

Note : (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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13.3.2. Preparation of Spawn

The spawn culture (master culture) of shiitake mushroom is a dikaryotic mycelium. This may be obtained by tissue cultue method from a dikaryotic mycelium (secondary mycelium) or by spore culture method.

The stock cultures are grown on any suitable media like malt extract agar or potato dextrose agar, whose composition is given below :

Malt Extract Agar			**Potato Dextrose Agar**		
Malt extract	-	25 g.	Potatoes (Peeled & diced)	-	250 g.
Agar-Agar powder	-	20 g.	Dextose	-	20 g.
Distilled water	-	1000 ml.	Agar-Agar powder	-	20 g.
			Distilled water	-	1000 ml.

The medium is filled in test tubes (10ml/tube) plugged, and sterilised in an autoclave at 121^{0}C (15 lb. sq. inch pressure) for 20 min. The tubes are made into slants by keeping them in slanted position. The tubes are ready for inoculation when the medium is cooled.

Tissue culture method : As in the case of other mushrooms a mature fruit body should be chosen for the purpose. The fruit body is cleaned with cotton swab and dipped in 0.1% mercuric chloride solution for 30 seconds. The fruit body is further thoroughly washed in sterile distilled water for 4-5 times serially. The fruit body is cut lengthwise. From the point of junction of pileus and stipe small bits of tissue (2x2mm.) is taken and placed in the tubes containing medium. The test tubes are incubated at 25^{0}C. After 4-5 days the mycelium is seen growing out of the tissue. This method is the quick and widely followed one for commercial spawn production.

Spore culture : The spores are collected from the fruit bodies by taking spore prints. These spores are inoculated on petriplates. When they germinate the compatible monokaryotic (having uninucleate cells) mycelia are grown in a petriplate from which after mating dikaryotic mycelium is obtained. This method is lengthy, involves high technical skill and usually not carried out by a commercial grower.

The stock cultures thus obtained are inoculated on the spawn substrates to get master spawn and also ordinary spawn. There are mainly two types of spawn substrates used in case of shiitake mushroom. They are (i) saw dust and (ii) wood plugs.

(i) Saw dust substrate : Saw dust substrate is prepared by using any of the following different combinations.

(i) Saw dust - 78%
Sucrose - 1%
Wheat bran - 20%
Calcium carbonate -1%
Water - 65%

ii) Saw dust 65%
Used tea leaves - 20%
Wheat bran - 15%
Water - 65%

iii) Saw dust - 400g.
rice bran - 100g.
Surcose - 15g.
Potassium nitrate - 2g.
Calcium carbonate - 3g.
Water - 1000 ml.

Sawdust is thoroughly mixed with water and other ingredients and filled in empty glucose bottles or polypropylene bags. A hole for inoculation is made in the centre of the substrate with the help of a glass rod. The bottles or bags are plugged with non- absorbant cotton and covered with aluminium foil. They are autoclaved at 20 lb. p.s.i. for 2 hours. After cooling, the bottles are inoculated with the mycelium (10-15 days old culture) and incubated at 25^{0}C for 25-30 days.

(ii) Wood plug substrate : Small, wedge shaped or cylindrical pieces of wood are taken in the bottles or polypropylene bags and are autoclaved at 20 lb p.s.i. for 2 hours. The mycelium is inoculated into these wood pieces. After incubation, the mycelium grows on the wood pieces which will be used as spawn in future.

13.3.3. Cultivation Methods

Shiitake mushroom *(Lentinus edodes)* is usually cultivated by two methods. They are (i) log method and (ii) polybag method or Taiwan method.

(i) Log method : Logs of 9-18cm. diameter from 15-20 years old trees (listed in Table 13.1) are chosen. Autumn to spring is the most suitable period for cutting the tree for log making. During this time the logs contain high amounts of carbohydrates and other organic substances. The bark is intact and tightly attached with the wood. They contain optimum moisture content (45-55%) at this time. The logs after cutting are left for 25-45 days as such due to which the moisture content come down to 40-45%. With the help of drilling machine small holes of 1x1cm and 1.5-2cm. deep are made on the logs. The holes should be alternate in position and are at a distance of 20-30 cm (long axis) and 6cm. between each row. Saw dust spawn or wood plug spawn is inserted into these holes and the holes are sealed with cellophane tape or paraffin wax. The logs are kept in open place in piles. They are covered with gunny bags to prevent loss of moisture.

The mycelial growth is completed between 8-12 months. For fruit body formation, sudden drop in temperature, enough light and high humidity are required.

The logs are either immersed in cold water or sprayed with cold water. During summer the logs are immersed in cold water (15-28°C) for one day and during winter for 2-3 days at 10-15°C. The logs are then leaned against the supports. 15-20°C temperature and 80-90% humidity are maintained.

This method requires very long period (3-5 years) and the wood used for the purpose is costly and not easily available.

II) 'Polybag' or Taiwan method : Polybag method is the commercially followed one by using the saw dust of maple (*Acer* sp.) or oak (*Quercus* sp.). Following are the commonly used substrate formulations for polybag technique.

(a) Mori et al (1974)
Saw dust - 80%
Rice bran - 20.0%
Water content adjusted to - 65%

(b) Rom et.al (1981)
Hardwood sawdust - 89.8%
Rice bran - 10.0%
$CaCO_3$ 0.2%
Water content adjusted to - 60.0%

(c) Rouse et.al. (1985)
Saw dust -80%
(maple and birch 60:40)
Rice bran - 20%
Millet - 10%
Wheat bran - 10%

(d) Song (1986)
Hardwood Sawdust -
82.8-34.2% (100kg)
Rice bran - 2
.7-5.2% (8-15kg)
Corn powder - 1.4-2.6%
Millet or rice - 4.8kg.
$CaCO_3$ - 0.2-0.3% (0.6-1.0kg)
Water content - 59-62%

(e) Corn cobs - 40kg.
Sawdust - 10kg.
Wheat bran - 12.5kg.
Cane sugar - 1kg.
Pectin - 15g.
Urea - 20g.

(f) Sugarcane bagasse - 50kg.
Rice bran - 12.5kg.
Gypsum - 1.5kg.
Potassium sulphate - 15g.
Urea - 15g.
Magnesium sulphate - 10g.

(g) Rice straw - 50%
Wheat straw - 20%
Saw dust - 20%
Cane sugar - 1.3%
$CaCO_3$ - 1.5%
Citric acid - 0.2%
$CaSO_4$ - 0.5%

Saw dust should be soaked for two days and rice straw for 3 hours before use. Substances like sulphate, sugar and citric acid are to be dissolved in water before mixing. The water to the above formulations should be adjusted to 60-65% and pH at 5.5-7.0. by adding gypsum and lime.

Saw dust mixture (1.5 to 4kg) is filled in polypropylene bags of about 500x160mm size and pressed to form a cylindrical cake. The ends of the bags are

sealed or tied with a twine or may be fitted with an iron ring and plugged with non-absorbant cotton. Two holes of 15mm diameter and 20mm deep are punched on opposite sides with the help of an auger. The holes are covered with square (33mm) adhesive medical tape. The time period between mixing the substrate and sterilization should not be more than six hours. Otherwise, the substrate undergoes fermentation. The bags can be sterilized in an autoclave at 121°C for 1 hour or on a brick and cement lined-tower at 90-95°C for 5-7 hours. After cooling, the tapes are removed in a sterile area and the spawn should be pressed into the holes. The tapes are put back and the bags are incubated in the growing rooms. Spawn of about 750g. can be used to inoculate 25-30 bags. Mycelial growth in the bag takes place in about 18-100 days. During spawn run many changes occur in the substrate at different periods. (i). In about 2-4 weeks after inoculation thick mycelial coat forms on the substrate. (ii) Later on, clumps of mycelia called mycelial bumps are formed on the surface of many strains. Bumps are formed due to high CO_2 and fluctuating temperature. Hence proper aeration should be provided at this stage. (iii). Brown pigmentation is seen on the substrate. (iv) The mycelial coat turns hard and brown. At this stage the bags are removed partially (half or one third). The moisture content at this stage is about 80%. (v) Fruiting occurs. Factors like high humidity, temperature, soaking, less CO_2, physical shocks are to be induced to give better yield. During incubation the substrate does not require watering.

The polybag method is easy because the substrate is mainly saw dust and other agricultural wastes like corn cobs, sugarcane bagasse etc. The production period is less. But the quality of mushrooms on synthetic log (Polybag substrate) is poorer than natural logs.

Check Your Progress - 3

Name the easiest and commercially followed method for cultivating shiitake mushroom ?

Note : (a) Write your answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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13.3.4. Harvesting, Preservation and Marketing

Shiitake mushrooms should be harvested at an early stage. The yield from each log is 15-30% of the wet weight of the substrate.

Shiitake mushrooms are consumed in fresh or dried form, by canning or pickling in vinegar. They can be either sun dried or in a mechanical drier. When they are to be sundried, they should be exposed to sunlight for 2 to 4 days. In a mechanical drier, the drying should begin at 35°C for 5 hours during summer and 30°C for 7 hours during rainy season. Later on, the temperature can be raised to 40 to 60°C for 12 to 18 hours. The moisture content of the mushroom should be

10 to 13%. When the moisture content reaches to 20% the mushrooms are affected by moulds and insects. Hence they should be sealed in air tight containers and stored at 2 to 5^0C for long storage.

Marketing of these mushrooms can be either in fresh form or dried. The dried mushrooms are also marketed in powdered form.

Check Your Progress - 4

Mention the moisture content in a dried shiitake mushroom.

Note : (a) Write your answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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13.3.5. Common Diseases and Their Management

Trichoderma viride has been recorded from 15-25% in the supplemented bags and 5-10% in unsupplemented bags during shiitake mushroom cultivation (Thakur and Sharma, 1992). Benomyl (Benlate 50 wp) at the rate of 240g/200 litres/100m^2 should be sprayed during first watering to avoid the incidence of the above fungus. Two bacteria were reported from Japan on shiitake mushroom. They are *Pseudomonas fluorescence* causing immature browning (Komatsu and Croto, 1974) and RLO (Rickettsia Like Organisms) causing malformation. The conditions of the cropping room should be maintained properly. Chlorine water at the concentration of 150ppm may be sprayed at every watering.

In countries like Japan, China and U.S.A. viral diseases on this mushroom have been reported (Ushiyama & Nakai, 1975). They are either spherical, stiff or flexuous rods (20nm-1500nm.). The symptoms induced by the viruses are unspecific and not easily noticeable in the early stages. There may be early maturation of fruit bodies with elongated and slightly bent stipes. Strict hygiene should be maintained to prevent viral diseases.

Check Your Progress - 5

Name the common bacterial diseases that occur on shiitake mushroom ?

Note : (a) Write your answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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13.4. *AURICULARIA* Spp.

Black ear mushroom (*Auricularia* spp.) grows on decaying wood trunks in forests (Fig.13.2.).

13.4.1. Morphology and Growth Requirements

The fruiting bodies are leathery, waxy and are purplish brown to black in colour. They are first cup shaped which later on, expand. The optimum temperature for mycelial run is between 20°C to 34°C while for fruit body formation is 12 to 30°C and the relative humidity is around 85%.

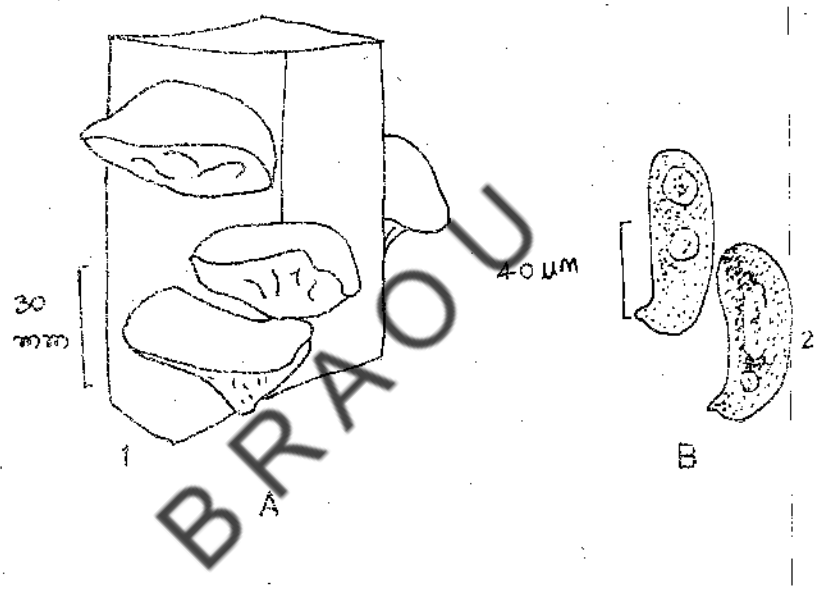

Fig.13.2. *Auricularia polytricha* (Black ear mushroom) A. Basidicarps. B. Spores.

Check Your Progress - 6

Mention the optimum temperature and relative humidity suitable for black ear mushroom ?

Note : (a) Write your answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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13.4.2. Preparation of Spawn

The starting cultures of black ear mushroom (*Auricularia polytricha*) are prepared in the same way as in shiitake mushroom. Spawn is prepared on the

substrate consisting of saw dust (100g), rice bran (25g), Potassium nitrate (5g), Calcium carbonate (7g) and sufficient water to make the medium wet. The substrate is filled in the glucose bottles or polypropylene bags and sterilised in an autoclave at 20 lb. p.s.i. for 2 hours. After cooling it is inoculated with pure culture and incubated at 25-28°C for 3 weeks.

13.4.3. Cultivation Methods

Black ear mushroom is cultivated by two methods. They are log method and polybag method.

(i) **Log method :** Logs of trees like *Acacia confusa, Bombax ceiba, Ficus retusa, Pongamia pinnata, Gardenia jasminoides* are commonly used. The trees selected for log preparation are to be filled before autumn when the nutrients are more. The cut logs (1m. length and 5-15cm. diam.) are placed in shade. Many small holes (1 to 15 cm. in depth and 1cm. in diam.) are made with an auger and the holes are filled with saw dust spawn. The holes are covered with wax and the logs are kept in slanted position under the shade. They are covered with plastic sheets. The logs are turned upside down once in 30 days. The period of spawn run varies from one to many months depending on the type of wood used. After the mycelial growth the logs are shifted to cropping sheds made of bamboo or straw on open shady places. The logs are placed at a distance of about 10cm. The fruit bodies are formed within 7-10 days after the formation of primordia.

ii) **Polybag method :** The substrate used is saw dust mixed with 2 to 20% bran and little calcium carbonate to adjust pH. Wheat straw supplemented with rice bran (4%) was found to enhance mycelial growth as well as yield at NCMRT, Solan. The substrate is filled in polypropylene bags (15-20cm length and 10-20cm. diam) and sterilized at 100°C for one and half an hour. After cooling, the bags are then inoculated with spawn and incubated at 25-28°C in small huts made with straw and bamboo. When the mycelial growth is complete both ends of the bag are cut open and are arranged on bamboo frames. Once or twice a day watering should be done. Few hours of aeration and light are required at this stage. Each bag yields about 300-500g.

The mushroom yields were good when grown on cotton hull (6-8 kg dry mushrooms per 100 kg Cotton seed hulls) (Yin and Nieu, 1988).

13.4.4. Harvesting, Preservation and Marketing

The mushrooms have thick edges when young and slowly thins out towards the margins. The mushrooms are usually harvested at this stage either by slight twisting or cutting with a knife.

The mushroom stays for 7-10 days on the substrate after maturity. It is less perishable. The fruit bodies can be sundried or in a mechanical drier and stored. They are marketed both in fresh and dried form.

13.4.5. Common Diseases and their Management

Auricularia polytricha (Goltapeh et.al. 1989) shows white fluffy growth both on the substrate and fruit bodies resulting in higher yield loss. This is due to

Cladobotryum verticillatum. Carbendazim (50ppm) spray is effective for controlling the disease. Apart from this, other competitors like *Trichoderma, Aspergillus* and *Fusarium* were also reported during the cultivation of black ear mushroom (Sharma and Thakur unpublished).

Check Your Progress - 7

Name the fungicide used against *Cladobotryum verticillatum* on *Auricularia* ?

Note : (a) Write your answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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13.5. *CALOCYBE INDICA*

Calocybe indica commonly known as milky white mushroom is grown on paddy straw supplemented with wheat bran or maize meal.

13.5.1. Morphology and Growth Requirements

The basidiocarps are solitary, the stipe is central, white or pale coloured, fleshy in nature (Fig. 13.3.), spores are hyaline, broadly ellipsoidal and nonamyloid.

The temperature required is 25-30^{0}C and relative humidity 90- 95%.

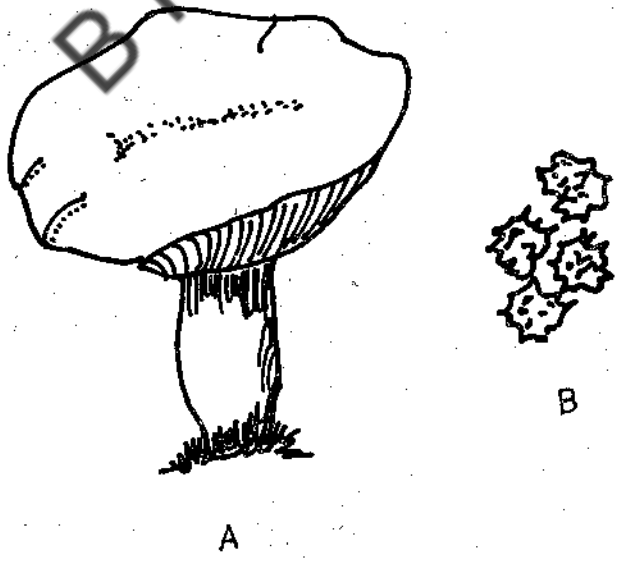

Fig.13.3. *Calocybe indica* (Milky white mushroom). A. Basidiocarp. B. Spores.

13.5.2. Preparation of Spawn

The pure cultures can be obtained in the same manner as in the case of shiitake mushroom and others. The spawn is prepared on cereal grains mostly wheat or Jowar grains. The grain bottles or polypropylene bags are sterilised at 20 lb. p.s.i. for 2 hours and after cooling inoculated with the pure culture. The inoculated bottles are incubated under light (6-7 hr/day) under a fluorescent lamp which is kept 30cm away for 3-4 weeks.

13.5.3. Cultivation Methods

Milky white mushroom is cultivated on paddy straw supplemented with maize meal or wheat bran (5% wet wt. of the straw). Paddy straw bits (1cm long) are soaked in water for 18-24 hours. Then they are immersed in boiling water for 2-3 hours. Maize meal or wheat bran is mixed with the treated straw. The substrate is mixed with spawn and filled in polybags or in small trays. 250g. of spawn is required for each tray of 2sq.ft. These trays are covered with sterile news papers (disinfected or autoclaved) for 2-3 days. On fourthday, the newspapers are removed and casing soil is applied over the growing mycelium. Casing soil is prepared by mixing dried loam soil or garden soil and sand (1:1) and 12% calcium carbonate of soil and sand mixture. Watering should be done periodically to keep the substrate wet. Pinheads develop in 3 weeks after casing and attain maturity in another 5-6 days. Thus the mushrooms appear within 3-4 weeks after casing. About 150-200g of fresh mushrooms are obtained from 1kg. of straw.

Check Your Progress - 8

Give the composition of casing soil used for milky white mushroom ?

Note : (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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13.5.4. Harvesting, Preservation and Marketing

The mushrooms are harvested by slight twisting at the base. They can be preserved in fresh form for 3-4 days at room temperature and 1 week in refrigerator. The mushroom has very less marketing problems due to its attractive colour and long shelf-life.

13.5.5. Common Diseases and their Management

Various competitor moulds like *Rhizopus, Mucor, Aspergillus, Coprinus, Sclerotium, Trichoderma* and *Fusarium* (Doshi et.al., 1991) have been reported from the substrate. Sharma and Thakur observed high incidence of *Cladobotryum* and *Oedocephalum* sp. in the casing mixture. Spraying with Benomyl (240g/200

litres/100m^2) and Bavistin (240g/200 liters/100m^2) reduces the incidence of disease.

Check Your Progress - 9

Name three common competitor moulds that occur on milky white mushroom ?

Note : (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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13.6. SUMMARY

Cultivation of *Lentinus edodes* (Shiitake mushroom), *Auricularia* spp (Black ear mushroom) and *Calocybe indica* (milky white mushroom) has been increasing in recent days due to their importance in human nutrition and medicine.

Shiitake mushroom consists of a substance that reduces plasma cholesterol level. Optimum temperature for mycelial growth is 24- 28^{0}C and 12-20^{0}C for fruit body formation. Relative humidity is 85-90%. Spawn is prepared on sawdust substrate and wood plug substrate. The cultivation of this mushroom is being carried out by two methods, log method and poly bag method. Yield of this mushroom is 15-13% of the wet weight of the substrate. Moulds like *Trichoderma viridae*, bacteria like *Pseudomonas fluorescence* and RLO and spherical, stiff or flexuous viruses affect this mushroom. Strict hygiene should be maintained in the growing area of the mushroom.

Black ear mushroom was the first cultivated mushroom in the world around 600 A.D. in China. Consumption of this mushroom cures anaemia, sore throat and other digestive disorders especially piles. The fungus requires 20-34^{0}C for mycelial growth and 12- 30^{0}C for fruitbody formation. Relative humidity is 85%. Saw dust substrate is used for spawn preparation. This has been cultivated by log method and polybag technique. It is a less perishable mushroom. Moulds like *Cladobotryum verticillatum, Trichoderma, Aspergillus* and *Fusarium* have been reported on the substrate of this mushroom.

Milky white mushroom consists of white fleshy attractive fruit bodies. Among the 12 amino acids that occur in this mushroom glycine is predominant. (10.8g/100g. protein). The fungus requires 25-35^{0}C temperature and 90-95% relative humidity for its growth. The spawn is prepared on any cereal grains but mostly wheat or Jowar grains are used. It is cultivated on paddy straw pieces supplemented with maize meal or wheat bran. Casing soil is required for

fruit body formation. The mushrooms appear in 3-4 weeks after casing. This mushroom has long shelf-life (3-4 days) at room temperature. Competitor moulds like *Mucor, Aspergillus, Coprinus, Sclerotium, Rhizopus, Trichoderma, Fusarium, Cladobotryum* have been observed on the substrates of the mushroom. Spraying with Benomyl and Bavistin reduces the incidence of disease.

13.7. CHECK YOUR PROGRESS : MODEL ANSWERS

1. *Lentinus edodes* (Shiitake mushroom) reduces plasma cholesterol level.
2. The optimum temperature required for mycelial growth is 24-28^{o}C and for fruit body formation is 12-20^{o}C and a relative humidity of 85-90%.
3. Polybag method is the easiest and commercially followed method for shiitake mushroom.
4. 10-13% should be the moisture content of a dried shiitake mushroom.
5. Immature browning and malformation are the common bacterial diseases of shiitake mushroom.
6. The optimum temperature required for black ear mushroom is 20-34^{o}C for mycelial growth and 12-30^{o}C for fruit body formation and relative humidity of 85%.
7. Carbendazim (50ppm) is used against *Cladobotryum veriticillatum* when it infects *Auricularia.*
8. Dried loam soil or garden soil and sand (1:1) and 12% calcium carbonate of soil-sand mixture.
9. *Coprinus, Trichoderma* and *Aspergillus* are the common competitor moulds that occur in the beds of milky white mushroom.

13.8. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe in detail the cultivation methods of shiitake mushroom ?
2. Describe the cultivation techniques of black ear mushroom ?
3. Give an account of spawn preparation and cultivation practice of milky white mushroom ?

II. Answer the following questions in about 10 lines each.

1. Write a note on the medicinal uses of Shiitake, black ear and milky white mushrooms.
2. Write a short note on diseases of shiitake mushroom and their management ?
3. Give briefly the important diseases on black ear mushroom and their management.
4. Write a brief note on competitor moulds of milky white mushroom and their management ?

Ms. K. Prasunamma

BLOCK - 5
PESTS, DISEASES AND ECONOMICS

UNIT-14: PESTS AND DISEASES OF EDIBLE MUSHROOMS

Contents

14.1. OBJECTIVES

By the end of this unit you will be able to:

- list out the fungal, bacterial, viral diseases of edible mushrooms,
- describe the characteristic symptoms, epidemiology and control of fungal, bacterial and viral diseases of mushrooms,
- describe the competitor moulds of edible mushrooms and give the control measures,
- list out the various pests that affect mushrooms and suggest their management,
- exilain abiotic disorders of edible mushrooms.

14.2. INTRODUCTION

Mushrooms are also attacked by several pests and diseases. Mushroom growing is an indoor activity, hence the productivity and qualities are affected by many

biotic and abiotic factors. The common biotic factors include parasitic and antagonistic fungi, bacteria, viruses, nematodes and insect pests. The abiotic factors are temperature, relative humidity, CO_2 concentration and excess of moisture. Mushrooms are grown on a specially prepared substrate. However if the process of substrate preparation is not carried out properly, weed moulds develop which reduce the yields significantly. The appearance of weed moulds indicate improper composting. Hence, they are also known as indicator moulds. Weed moulds compete with mushroom mycelium for nutrients and space and are called competitor moulds. The button mushrooms are often cultivated with out any environmental control and insulation in ordinary rooms, abandoned poultry sheds and thatched huts. In such cases poor hygienic conditions and lack of disposal facilities help in the spread of various pests and diseases (Sharma, 1991).

The mushroom cultivation in India is different from all the mushroom growing countries of the world with regard to substrate and system of cultivation and hence the occurrence of diseases is common. The cultivation of oyster mushroom is now picking up very fast in central and southern parts of India. The growers are using various substrates for the cultivation. They are grown under natural conditions in ordinary rooms or sheds without environmental control. Few competitor moulds are being observed during its cultivation which sometimes may result in total crop failures. Paddy straw mushroom is grown in states like Orissa, Tamilnadu, West Bengal, Karnataka and Kerala by small farmers. Now much work is being done on pests and diseases of this mushroom in our country. Abiotic factors, pests and diseases are mainly responsible for low productivity of mushrooms (Sohi, 1992, Sharma and Gupta, 1993).

14.3. DISEASES

The diseases to mushrooms are mainly caused by fungi, bacteria and viruses.

14.3.1. Fungal Diseases

Common fungal diseases of white button (Table-14.1.), oyster (Table-14.2.) and paddy straw mushrooms, symptoms and control measures are given below.

Table - 14.1. Fungal diseases of white button mushroom (*Agaricus* spp.)

	Disease	Causal organism	Symptoms	Morphological characters	Epidemiology	Control measures
1.	Wet bubble	*Mycogone perniciosa*	Swollen stipe and small cap at early stages of infection. The infected area becomes creamish brown due to chlamydospore formation. *Mycogone* shows white, fluffy growth. Pin heads show abnormal size with clear, brown coloured drops caused by putrifying bacteria. The bubble emits foul smell and measures 1/2 size of a golf-ball.	Mycelium white, felt-like and compact. One celled conidia (5-10x4-5μ) are produced on conidiophores, chlamydospores are two celled and measure 15-30x10-20μ.	Infection comes through spent compost, air, casing soil, infested trash etc. Spread of infection is through chlamydospores which can survive even upto 3 years.	Good hygiene, proper sterilisation of casing soil, spraying Dithane Z-78(0.3%) proper disposal of diseased mushrooms (sterilize the beds with 2% formalin before disposal) and treatment of infected areas with 0.2 per cent Dithane Z-78 and benlate 0.05 percent.
2.	Dry bubble	*Verticillium fungicola*	White mycelial growth which turns to greyish yellow appears on the substrate. The infection when takes place at early (pinhead) stages, onion-shaped pinheads appear. Stipe is thicker than cap. Light brown spots coalesce	Fungus produces one-celled, oblong to cylindrical, thin walled hyaline conidia (3.5x15.9% 1.5-5μ) on branched conidiophores. Clusters of conidia are surrounded by a sticky mucilage. Resting mycelium remain in	Initial source of infection is casing soil. The resting mycelium perpetuates through spent compost. Lack of proper air circulation, high humidity and temperature above 16^{o}C	Use of sterilised casing soil, proper disposal of spent compost, control of insects, nematodes, mites etc., proper hygiene avoids primary infection.

	Disease	Causal organism	Symptoms	Morphological characters	Epidemiology	Control measures
			to form irregular patches on the cap. Deformed mushrooms are formed at the later stages of infection.	dormant stage for long time.	favour the spread and development of disease	Spraying with Dithane Z-78 (0.2-0.5 percent) or Spergon at 1.5g per m^2. Nine days after casing are effective. Control of high temperature and proper ventilation during cropping are advisable. Control of local infections with 2% formalin.
3.	Cobweb disease	*Cladobotryum dendroides*	Fluffy, white, cobweb like mould grows over the casing soil which later changes to pink or red colour. Affected mushrooms turn brown, begin to rot and die-off. Severe attacks results in formation of dense, white mould over casing and mushrooms change from a fluffy cobweb to a dense mat of mycelium. Brown or pinkish brown spots appear	Sterile hypae form a turf and are prostrate branched, septate and hyaline with approximately opposite branches which divide above into three pointed branchlets. Elongated septate (2-3μ), pointed conidia (20-30x10-12.5μ)	The main source of infection are soil, air, wet surface, high humidity and butts of mushrooms left in the cropping trays. Temperature and relative humidity during picking beyond 65°F and 90 percent respecti-	Sterilizing the casing mixture with live steam or formalin or treatment with 150g benomyl per $10m^2$ upon casing or sterilizing the casing mixture at 50°C for 4 hours. Maintenance of temperature and humidity during picking

	Disease	Causal organism	Symptoms	Morphological characters	Epidemiology	Control measures
			on the cap.	appear on erect conidiophores	vely favours the disease	around 65°F and 90 percent respectively. Use of bavistin (0.6g/m^2) is also recommended. As a preventive measure, dust between flushes with zineb or manozeb 100g per 100m^2 once a week or spray the beds with formalin (0.2-0.3%). Proper sterilization of the room after the crop.
4.	Gill-mildew	*Cephalosporium* spp.	Stunting of the gills with a growth of white mycelium on their surface is the characteristic symptom.	-	-	The disease is never serious enough to warrant any control measures.
5.	Cap Spotting	*Aphanocladium album*	Brown spots appear on the caps. The pathogen affects the cap, producing light brown to dark brown roughly circular spots, which may be upto 10mm in diameter. Under conditions of high	-	-	Fungicides recommended for the control of dry bubble disease are likely to give control

	Disease	Causal organism	Symptoms	Morphological characters	Epidemiology	Control measures
			relative humidity white aerial mycelium is formed on the affected tissues.			
6.	Shaggy stipe	*Mortierella bainieri*	The most characteristic symptom is the peeling of the stalk of the affected mushrooms giving a shaggy appearance. The stalk and cap are usually discoloured, becoming dark brown as the disease progresses. The coarse grey-white mycelium of the pathogen can usually be seen growing over the affected mushroom tissue and also over the surrounding casing. It is superficially similar to cobweb but is then distinguishable from it by the colour of the mycelium and the symptoms shown by the affected mushrooms. The cap may also develop a brown blotch often surrounded by an yellow ring.	The pathogen produces masses of sporangia and sporagiospores that spread the disease	Spores are both air borne and water borne. The fungus is a common soil dweller and soil is likely to be the main initial source.	All diseased mushrooms should be carefully removed and the affected areas of beds are to be treated with zineb or common salt as recommended for the control of dry bubble.

Table - 14.2. Fungal diseases of oyster mushrooms (*Pleurotus* spp.)

	Causal organism	Symptom	Control
1.	*Cladobotryum apiculatum* *C. verticillatum* *C. variospermum*	White cottony growth on the substrate; small brown, irregular sunken spots or fluffy growth on fruit bodies; soft rot and decay of sporophores emitting foul smell.	Spray Bavistin 50 ppm.
2.	*Gliocladium virense* *G. deliquescens*	Fruit bodies covered by mycelium and green spots; and young pinheads become soft, brown, pale yellow and decay. Mature fruit bodies show brown spots enclosed by an yellow halo.	Spray 100 ppm bavistin or benomyl.
3.	*Arthrobotrys pleuroti*	Fluffy growth on substrate and fruit bodies; infected tissues turn yellow, water logged and rot.	Spray 50 ppm bavistin.
4.	*Sibirina ungicola*	Powdery white growth on stipe, gills and the primordia; promordia show brownish discolouration and soft rot; mature fruit bodies turn fragile.	Proper aeration and Relative humidity essential. Spray benomyl twice.

Check Your Progress - 1 & 2

1. List out the important fungal diseases of button mushroom.

2. List out the important fungal genera causing diseases to oyster mushroom.

Note : (a) Write your answers in the space given below.
(b) Compare your answers with those given at the end of this unit.

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Fungal Diseases of Paddy Straw Mushrooms *(Volvariella* spp.)

Paddy straw mushrooms are attacked by a number of diseases/competitor moulds like *Mycogone perniciosa, Scopulariopsis fimicola* and *Verticillium* sp. in other countries. In India, large number of competitor moulds *namely Coprinus, Psathyrella, Penicillium, Aspergillus, Rhizopus* and *Sclerotium* appear in the beds.

Bahl and Chowdary (1981) reported that *Podospora faurellii* is a competitor of *Volvariella* sp and it inhibits the growth of the mushroom. Bhavani Devi and Nair (1986) recorded *Rhizoctonia solani* on the substrate which reduces the sporophore formation and causes malformation of fruiting primordia.

For controlling these fungi, spraying with Captan or Zineb @ 0.2% suppresses the growth of the weed fungi/competitor moulds without affecting the crop of paddy straw mushroom.

14.3.2. Competitor Moulds

Competitor moulds are moulds which adversely affect the growth of the mushroom mycelium during the spawn run (colonization) of the substrate (compost and/or casing soil) through competition for 0_2, nutrients, water or space. Although parasitic moulds can also exhibit this competitive behaviour, they are different from competitive category of moulds in that they damage the mycelium or the fruit bodies of the mushrooms without necessarily being lethal.

Competitive moulds are also described as weed moulds to indicate that they are undesirable and can spread quickly on a massive scale, or they are known as indicator moulds. The main competitor moulds along with their symptoms and control measures are briefly given in Table - 14.3.

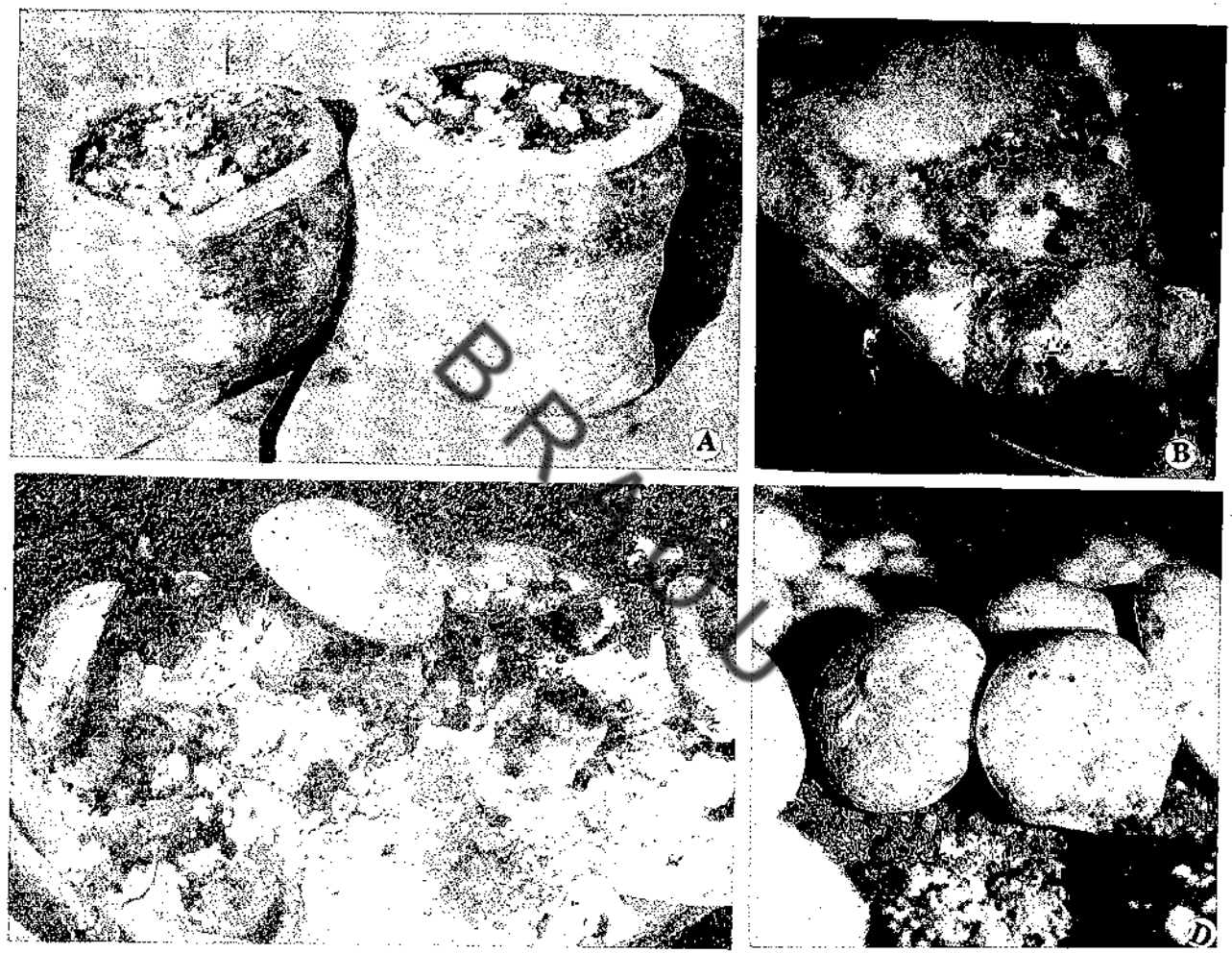

Fig. 14.1. Fungal diseases and competitor moulds of mushrooms. A. Dry bubble disease. B. Wet bubble disease. C. Cobweb disease. D. False truffle.

Table - 14.3. Commonly Occuring Competitor/Weed/Indicator Moulds.

Name of the mould	Causal organism	Symptoms	Control
Brown plaster mould	*Papulospora byssina*	Whitish patches on the casing/compost ultimately turning to rust colour.	Regulate moisture content of compost, treat patches with formalin (2%) spray or Bavistin (0.05%)
White plaster mould	*Scopulariopsis fimicola* *S.brovicaulis*	Dense white patches of mycelium on compost and casing soil giving flour like appearance.	Compost pH should be below 8, spray bavistin 0.05% or Thiram 0.1% at 10 days interval.
Inky cap	*Coprinus atramentarius* *C. lagopus* *C. comatus* *C. fimitarious*	Very rapid apperance of long slender stalks and thin caps disintegrate into black slimy mass of spores.	Eliminate ammonia properly. Remove the weed before opening of their caps and destory.
Olive green,	*Chaetomium olivaceum* *C. globosum* *C. indicum*	Greyish white mycelium on compost, later turning to olive green.	Proper pasteurization during peak heating, spray Dithane M-45 (0.2%) on the affected area.
Yellow mould	*Mycoliophthora lutea (mat disease)* *Chrysosporium merdarium* *Sepedonium chrysospermum* *S. maheswarianum*	Brown yellow patches with a white fluffy edge generally between compost and casing.	Hygienic conditions, proper pasteurization, spray calcium hypochlorite solution (15%)
Lipstick mould	*Sporendonema purpurescens*	White crystal-like colonies, whitish grey mouldy fluff with little white balls on straw. On spore formation colour changes to cherry red.	Hygienic conditions, proper pasteurization, maintain proper moisture content in the compost (68-70%).

Name of the mould	Causal organism	Symptoms	Control
False truffle	*Diehliomyces microsporus*	White fluffy mycelium later turning creamy yellow; prominent between compost and casing layers, turning into thick solid wrinkled mass resembling brain like structure.	Lower the temperature to 15-18°C and maintain hygiene. Destroy infected beds/bags. Treat the affected patches with 2% formaldehyde or 0.05% Bavistin.
Green moulds	*Trichoderma viride* *T.lignorum* *T.koningii* *Penicillium sp.* *Aspergillus sp.*	Small blue green cushions on spawned and cased trays. Also grows on dead stumps of mushrooms. Caps turn brown.	Good pasteurization of compost. Remove dead mushrooms, spray DM-45 (0.2%) or bavistin (0.05%) Hygiene is important.
Black or grey whisker mould	*Doratomyces stemonitis*	Mycelium dark and forms black or grey bristles upto 2mm long.	Proper fermentation, peak heating and hygiene conditions
Cinnamon brown mould	*Peziza Ostracoderma (Chromelosporium fulvum)*	Round white mycelial patches generally on casing layer, later turn yellow brown with thick fluffy white edge, saucer shaped, yellowish brown fruit bodies.	RH after casing should be below 95%. Use only recommended quantity of formalin for sterilization of the casing soil. Pasteurize casing with steam.
White mould	*Cephalotthecium roseum*	White mouldy growth turns pink in due course in compost or casing soil	Spray captan 0.4%-at 7-10 days intervals.

Check Your Progress - 3

What are the commonly occurring competitor moulds ?

Note : (a) Write your answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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14.3.3. Bacterial Diseases

A large number of bacterial diseases have been reported on different mushrooms. There are various diseases that are induced by bacteria in mushrooms which are as follows.

1. Bacterial blotch or brown blotch
2. Ginger blotch
3. Mummy disease
4. Pit disease
5. Drippy gill

1. Bacterial blotch : *(Pseudomonas tolaasii).* The most characteristic symptom of the disease is the occurrence of dark brown areas of blotches on the surface of the cap. Several affected mushrooms may be distorted and the caps may split where the blotch symptoms occur. The stalk may also be affected.

Disease development : On many forms the pathogen appears to be endemic, probably surviving between crops on surface, in debris, on tools and on various structures. The bacteria can be dispersed on debris, on mushroom spores, in water droplets by flies and the hands of pickers. In addition, once the disease has become established in a crop watering will disperse the bacteria very rapidly. Infection depends on the high population of the bacterium. The enlargement of the spots on the cap surface is dependent upon environmental conditions and is favoured by temperatures of atleast 20^0C together with the presence of water.

Control : None of the commercial strains is resistant to the disease, so following points should be taken in to account.

1. Avoid surface condensation on developing mushroom.
2. Store all casing materials, before and after mixing, in an area free from contamination.
3. Adjust the conditions within the cropping house so that, whenever possible, evaporation shall be taking place from the surface of the developing mushrooms.
4. When the disease is established, remove all affected mushrooms and apply measures to prevent the pathogen spreading by pickers hand and or by watering.
5. Add chlorine to the spraying water to give a concentration of 150 ppm at every watering.
6. Start the application of chlorinated water before symptoms develop.
7. Biological control can be possible with the use of antagonists.

2. Ginger blotch : This disease, caused by *Pseudomonas ginger* which is closely related to the organism which causes bacterial (brown) blotch *(Pseudomonas tolaasii)* has only recently been described. The ginger colour of the blotches, which do not change with age, distinguishes this disease from brown blotch. As far as is known the ecology of the organism is similar to that of *P. tolaasii* and the casing materials are probably the most important primary source. Control measures are identical to these recommended for bacterial blotch.

3. Mummy disease : Mummy disease is common although it seldom causes large crop losses. There is considerable doubt about the cause of this disease. A bacterium, *Pseudomonas,* possibly related to *Pseudomonas tolaasii* may be responsible.

Symptoms : The symptoms of the diseases overlap with those attributed to virus diseases. The most characteristic feature of the disease is its fast rate of spread, which is quoted as being 10-25 cm bed length per day. Affected mushrooms die and become very dry with the internal tissue discoloured, often with brown streaks. When cut across, the affected stipes sometimes show small pin head - sized dark brown spots. The cap may sometimes be distorted and is commonly tilted. At the base of the stalk the mycelium is very stringy and there is often a basal swelling together with a growth of fluffy white mycelium. However, another feature of mummy disease affected crops is the almost complete failure of subsequent flushes. In this respect mummy disease is very similar to severe virus attack.

Disease development : The only way in which the disease has been produced consistently is by placing compost or casing from an affected bed into clean compost at the time of spawn running; there is no evidence of spread in any other way.

Control : 1. Mark affected boxes or areas of beds by digging 20 cm wide channel and treat them with 0.5% formalin. 2. Cook out at the end of cropping. 3. Follow strict hygienic measures. 4. Examine peak-heat to make sure that some compost is not becoming excessively wet.

4. Pit disease : Although this disease is fairly common, it rarely causes large crop losses. The cause of pit has not been established although it is thought to result from attack by a bacterial pathogen: mites and nematodes have also been implicated.

Some dark (often black) and slimy pits appear on the cap surface of an otherwise healthy mushroom. There is no particular distribution pattern for the pits and their number varied from one to ten or more per mushroom. Generally, pit does not appear until fairly later in the crop and most frequently is seen in the third or later flushes. Same control measures as recommended for bacterial blotch may reduce the incidence and spread of the disease.

Control : Check peak-heat temperatures to make sure that these are high enough to kill pests such as mites or nematodes.

Check hygiene during cropping and also the cleanliness of areas used for storing and mixing casing ingredients.

If the problem persists, apply a chlorine preparation at 150 ppm from the first watering after casing.

5. Drippy gill : This disease is caused by the bacterium, *Pseudomonas agarici* and is of sporadic occurrence, although some farms have a persistent problem.

Symptoms : Affected gills are often underdeveloped, showing small brown decaying areas with creamy-white bacterial ooze on them; hence the name, drippy gill. Little is known about the conditions which favour this disease. However, it is likely that flies, pickers and water splash spread the organism within the crop. Because the gills are affected before the viel breaks. More likely the bacteria are systemic within the mushroom. Little is know about the disease and there are no specific control measures. Those recommended for bacterial blotch are usually employed.

Several bacterial diseases have been reported on oyster mushrooms caused by *Pseudomonas tolaasii, P. agarici, P. fluorescens* and other *Pseudomonas* spp.

Bacterial diseases of oyster mushroom reported from India are as follows.

1. Bacterial rot : The disease has been reported from west bengal inducing water soak areas and yellow brown discolouration of young spores. Rotting of grown up fruit bodies starts from the centre towards periphery. The gills on the lower surface turn yellow and caps get wrinkled and rolled upwards and inwards.

2. Brown spot : *Pseudomonas stutzeri* has been reported responsible for the disease. The bacterium is a common soil saprophyte, that induce brown spots in the substrate in 27-37% bags causing a reduction in the yield of *P. sajor-caju* from 27-61%. Streptomycin dip beyond 100 ppm and formalin dip beyond 25 ppm controlled the bacterium.

3. Yellow blotch (*Pseudomonas agarici*) : The disease appears as yellow hazel-brown or orange coloured blotch on pile us. The infected fruit bodies rot and emit foul smell under high temperature and humid conditions. The slimy appearance on infected fruit bodies is very characteristic symptom of the disease. Oxytetracyclins, streptocycline and sodium hypochlorite (400 ppm each) have been reported effective for the management of the disease both under *in vitro* and mushroom house conditions.

Check Your Progress - 4

List out the important bacterial diseases of mushrooms ?

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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14.3.4. Viral Diseases

Virus and virus - like particles have been commonly observed in *Agaricus bisporus* and few reports are available in *Pleurotus* spp. and *Lentinus edodes.*

Various mushroom viruses (MV) are recognised and these are differentiated according to the size and shape of the particles. From the literature it is evident that the following types of viruses have been reported on mushrooms.

MV 1	:	Spherical particles, diameter 25 nm
MV 2	:	Spherical particles, diameter 29 nm
MV 3	:	Bacilliform particles, 50 x 19 nm
MV 4	:	Spherical particles, diameter 35 nm
MV 5	:	Spherical particles, diameter 50 nm

In addition, particles of different shapes and sizes have been described in other countries, including club shaped particles in France. Mushrooms are often affected simultaneously with more than one virus. It is not known exactly to what extent, each virus combination affects mushroom growth and yeild. MV 1 and MV 2 can cause severe loss and MV 2 has been associated with the die back symptoms of mushroom mycelium. MV 4 and MV 1 are now the most common viruses in U.K. Significant yield reduction is often associated with high concentrations of MV 4. The significance of MV 3 and MV 5 is unknown.

Symptoms : The viral infection shows following symptoms.

i) Distortion of the sporophores, elongation of the stalks, tilting of the caps and very small caps on normal stalks.

ii) Crop shows a patchy appearance and sometimes associated with death of the mushroom mycelium.

iii) Early maturity (premature opening) of sporophores or slight discolouration of mushrooms.

iv) Delayed appearance of pin heads of the first flush or formation of fruiting primordia below the surface of casing layer can be an important indication of the disease.

v) Watery, spongy, thickened, barrel shaped stipes.

vi) A specific musty smell in diseased mushroom.

Epidemiology : Due to the wide variation in the symptomatology the economic impact of viruses on mushrooms is also variable. Various factors like time of infection, cultural conditions and strain of the spawn used, greatly affect the yiled. In artificial inoculation the extent of loss varied from 27.5 to 95.6% over the control.

Spread : Mushroom viruses can be spread from crop to crop in two basic ways.

- infected mycelium

- infected spores

The spread of viruses through infected spores or mycelium can spread in a number of ways such as :

a) Air flow (ventilation air or wind),

b) Phorid and sciarid flies,

c) Dirty containers,

d) Means of transport which have not been disinfected,

e) People (dirty clothing, foot wear etc.),

f) Inadequate or no cooking out,

g) Poor or no disinfection of wooden floor, and or side parts after harvesting.

Management of virus problems

a) Strict attention to hygiene at all phases of crop production.

b) Use of filtered air during peak heat and spawn running.

c) Change to *A. bitorquis* for some period to enable the inoculum level on the farm to reduce.

d) Whenever possible, pick all mushrooms before they have opened, in order to prevent the dispersal of spores.

e) For preventive measures spray the wood with 2% sodium pentachlorophenate to which 0.5 - 1% $Na_2 CO_3$ has been added. After drying, for about 5 hours spray with a large amount of water.

f) After the appearance of the disease the concentration of sodium pentachlorophenate should be increased to 4% instead of 2%.

g) Just before spawning and thereafter twice a week, disinfect the working corridor with a 2% solution of commercial formaldehyde.

h) The entire farm and its surroundings should be clean.

Check Your Progress - 5

List out the ways by which viruses can spread.

Note : (a) Write the answer in the space given below.

(b) Compare your answer with the one given at the end of this unit.

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14.4. PESTS

14.4.1. Insect Pests

Mushrooms like other crops are attacked by a number of insect and mite pests. Sciarid flies, phorid flies, cecid flies, springtails, staphylinid beetle and mushroom mites infest cultivated mushrooms in India. When conditions are favourable for their development, they increase in number and damage the mushroom crop causing economic loss to the mushroom growers. Brief discussion on their identification, life history, damage and management is given below.

Sciarid flies : Three species of these flies have been recorded in India. They are primarily pests of white button mushroom, however, in some cases they also attack oyster mushroom. The adults are greyish black, delicate, two-winged insects, 2.5-3.0 mm long with conspicuous bead like antennae. The larvae are dirty white with black head and 6-8 mm long. The female flies lay eggs on compost, casing or mushrooms. The larvae feed on mycelial strands, pinheads, mature mushrooms and organic matter. Larvae pupate in loose cocoons in the casing soil. The life cycle is completed in 14-27 days.

The most obvious damage is the tunneling of the mushrooms by the larvae. The most serious damage is, however, to the pinheads and small buttons. With the warming of the season from the second half of February, the number of infested buttons increases, 11 larvae per 100 cm^2 of casing area produce more than 30 per cent infested buttons.

Phorid flies : The flies have been recorded as pest of mushrooms in Himachal Pradesh, Punjab and Tamil Nadu. The adults are two winged, light to dark brown

flies with a humped thorax measuring 2mm long. The larvae (Maggots) are dirty white, 3.5mm long with a narrow head and visible black mouth hooks. Female flies prefer spawned compost for egg laying. At 25°C, the development period from egg to adult emergence is 15 days. In severe winter, the fly population declines due to prolonged pupal period. The flies mate outside the mushroom house in the open and fly back to the mushroom house for egg laying.

Larvae damage both white button and oyster mushroom. In white button mushroom, the larvae feed gregariously on mushroom tissues and move upward in the stem and enter into the cap forming tunnels in the stem and honey-comb like holes in the cap. Mushrooms when attacked at pinhead stage do not grow further. In white button mushroom, maximum damage is caused in the beginning and at the end of the winter season. In case of oyster mushroom, flies lay eggs through the vents of the culture bags, larvae feed on mycelium and form a clean wet zone around the vent.

Management of Sciarid and Phorid Flies : The following measures should be adopted for their management :

1. Checking the source of fly infestation : The spent compost and casing soil thrown at moist and shady places become ideal substratum for breeding of the flies. These materials should be put in the compost pit and covered with 10cm thick layer of manure. Mushroom flies are attracted to mushroom and spawn odour. For checking their entry into the mushroom house, the doors and ventilating openings of the mushroom house should be covered with wire or nylon nets of not less than 14 mesh/cm.

2. Preventive measures : Incorporation of safe insecticide in the compost and casing reduces larval population in the mushroom beds. For this purpose 20 ml of linden 20 EC after dilution with water should be thoroughly mixed by spraying in the compost prepared from 100kg of wheat straw at its last turning. If the mushroom flies are present in the mushroom house before casing, then 15 ml of lindane 20 EC should be thoroughly mixed in 100 kg of ready to use casing soil after dilution in water. After these treatments, the residues of linden in the first flush mushrooms were found to be less than 0.1 ppm, which is less than the maximum residue limit of 10 ppm.

Recently, diflubenzuron (a chitin synthesis inhibitor) was evaluated for the control of sciarid fly by incorporating it in compost and casing soil. Diflubenzuron at 0.005 per cent in compost or at 0.01 per cent in casing soil proved more effective than the already recommended linden treatment. Its residues in mushrooms were less than maximum residue limit of 0.1 ppm in the first flush mushrooms.

3. Curative measures : Presence of mushroom flies in the mushroom house helps in further build-up of the fly population resulting in high infestation of mushrooms. The flies should be killed with non-persistent and comparatively safe chemicals. For this, the flies should be controlled by spraying 30 ml of Nuvan 76 EC per 100 m^3 of space in fine spray droplets. After spraying, the mushroom house should be closed for 2 hours and direct spraying of the beds should be avoided. Interval of 48 hours between spraying and picking of mushrooms must be observed. Twenty four hours after treatment, the residue of nuvan in the mushrooms was 0.28 ppm which is less than the maximum residue limit of 0.5 ppm.

Cecid flies : Occurrence of cecid larvae on oyster mushroom was recorded at Jind (Haryana) and Chandigarh. The larvae are white, spindle shaped and 1.5-2.35 mm long. Larvae feed on mycelium. The mother larva produces about 12 young ones and it takes 5-7 days to complete one generation. The winged adults are rarely formed.

So far there is no report of any serious damage to mushroom crop by this pest in India. However, general cleanliness and disposal of spent compost and casing materials or their cook-out will help in checking the infestation by this pest.

Springtails : Three species of springtails damaging mushrooms have been recorded in Himachal Pradesh, Delhi, Rajasthan and Punjab. These are tiny wingless insects of ground colour measuring 1.5 mm long. They move by jumping and rarely by walking. At 30°C, egg and nymphal periods are completed in about 20 days. Under moist conditions, adults can survive for more than 2 months. Population declines during severe winter and dry summer.

Adults and nymphs damage all types of cultivated mushrooms. They feed on mycelium by scraping it from the spawn grains and cutting the mycelial strands resulting in arrested spawn-run. They produce pits on sporophores which turn brown. In oyster mushroom, the damage is more serious because of its preferred host. Springtails congregate at the base of the stem resulting in arrested growth of young primordia showing withered look and small pits.

Management of springtails : Springtails have no wings, their entry into the mushroom house is along with the organic matter.

Following measures are helpful in minimizing their damage.

(i) Cleaning of the surroundings and inside of the mushroom house.

(ii) Disposal of the spent compost and casing soil as given under mushroom flies.

(iii) Raising the crop above the floor level.

(iv) Efficient pasteurization of the compost.

(v) Spraying of the infested places with 0.05 per cent malathion emulsion.

(vi) In case of springtail infested compost, mixing of diazinon at 30 ppm dosage (15 ml of diazinon 20 EC after dilution in 100 kg of compost) at the time of filling kills the springtails present in the compost.

Staphylinid beetle : The only report of staphylinid beetle damaging oyster mushroom is from Kerala. The larvae of this beetle are white, long, campodeiform with tubular terminal segment. The adults have short elytra and large folded-membranous hind wings. The females lay eggs in over matured pileus and discarded mushroom debris. The grubs feed on soft gills and crawl over the beds. The life cycle is completed in about 3 weeks. The adults predate on mites and springtails.

Grub is the only damaging stage of this insect. They inhabit the gills and make small irregular holes in the hymenium and stipe in the initial stages and later on damage the developing mushrooms.

Management

(i) Removal of the mushroom debris from the mushroom house and surrounding areas prevents the adults from egg laying and checks further build up of the population.

(ii) Over matured mushrooms should not be left unharvested.

(iii) Bleaching powder repels the adults, its application in the mushroom house and premises helps in preventing the adults from egg laying.

Mushroom mites : Mites are quite abundant in the compost during composting and later during spawn-run and cropping. All of them are not the pests of mushrooms. Only a few of them are mycophagous, others are saprophagous having secondary pest status. Other than these, are the predatory mites which feed on mushroom pests.

Occurrence of this type of mites belonging to mycophagous group on white button mushroom have been reported from Himachal Pradesh and Punjab. They are also known as red pepper mites and generally feed on weed moulds. They often swarm in vast number on the surface of the casing soil and mushrooms. They annoy the pickers by crawling over their bodies and contaminate the mushroom buttons creating difficulties in canning of mushrooms.

Mites of saprophagous group have been reported to be damaging mushrooms in Himachal Pradesh, adjoining states and West Bengal. These mites are translucent white having long hairs on their body. They are 0.3-0.5 mm long and much slower in their movements than the red pepper and predatory mites. These mites feed on mycelium and damage sporophores by causing shrunk caps and brown rusted spots on buttons. They cause complete destruction of young buttons of button and tropical mushrooms. These mites can be introduced into the compost by the mushroom flies, on whose bodies the migratory stage cling by means of suckers. The migratory stage is produced when there is overcrowding.

Management of mite pests : Improperly pasteurized compost and casing soil, older infested beds, spent compost, contaminated implements and mushroom flies are the main sources of mite infestation in the new beds. Following measures are helpful in minimizing their damage :

(i) Efficient composting and peak heating of fresh compost.

(ii) Fungal and bacterial contaminants are commonly found at the end of the cropping period and saprophagous mites breed readily on such substrates. An efficient cook-out (at 71°C for 2 hours), safe disposal of the spent compost, cleaning of mushroom house and disposal of all organic debris are essential for avoiding saprophagous mites.

(iii) Disinfest the mushroom house by spraying floor, walls and premises with dicofol 0.1 per cent as prophylactic measure.

(iv) If mites are present in the compost, spray the compost with diazinon emulsion (15 ml of diazinon 20 EC in 100 kg compost after dilution).

Predatory mites : These mites, often called gamasid mites, are frequently encountered in mushroom houses. They feed on eggs and larvae of mushroom pests. These mites are beneficial and should not be regarded as pests. Two species of the genus *Parasitus* have been recorded from Himachal pradesh and Punjab. These mites are heavily sclerotized, oval in shape and 0.90 to 0.95 mm long. They move very fast on the mushroom beds in search of their prey. They cause irrigation to the pickers when present in large number.

14.4.2. Nematode Diseases

During mushroom cultivation number of nematodes are also encountered in mushroom beds along with insects like flies, springtails and mites. The nematodes are the small, microscopic (up to 1mm length) and thread like organisms and found easily where slight soil and moisture is present. These small organisms may sometime cause complete failure of the crop..

Generally, five types of nematode species are found in the mushroom beds. These can be myceliophagous, saprophytic, predatory, plant parasitic and animal parasitic nematodes. The myceliophagous nematodes are no doubt the plant parasitic ones and they can feed on fungal mycelium only. These are known to be most serious pests of mushrooms sometimes causing complete failure of the crop. The saprophagous nematodes are also harmful to the crops. The predatory nematodes are not harmful but play beneficial role as biocontrol agents. The plant parasitic and animal parasitic nematodes are not harmful to the crop and are found as chance contaminants.

a) Myceliophagous Nematodes : Some myceliphagous nematodes such as species of *Ditylenchus myceliophagus, Aphelenchoides composticola, A. sacchari;, A. saprophilus, A. agarici* have been found to be highly pathogenic.

Nature of damage : The myceliophagus nematodes are having a needle like structure (stylet) in their mouth parts with the help of which they puncture the hyphal cell and suck the contents resulting in destabilization of the mycelium. The nematodes are capable of rapid multiplication (50-100 times a week) hence their easy infestation may result in an epidemic form at a later stage causing complete failure of the crop. The flushes may be delayed or their number can be reduced causing loss of yield.

b) Saprophagous Nematodes : Some saprophagous nematodes such as species of *Rhabditis, Caenorhabditis, Panagrolaimus, Diplogaster,* and *Acroboloids* have been observed to be commonly present in all types of mushroom beds. These nematodes create unhygienic conditions in the compost, or sometimes these may produce toxins and carry harmful or pathogenic bacteria in their body parts.

c) Predatory nematodes : Predatory nematodes (*Monochus* spp) are the friendly nematodes as they feed upon other harmful nematodes.

Symptomatology : The early infection/infestation due to nematodes may result in one or all the following types of symptoms in mushroom beds.

- spawn run very slow
- whiteness of spawn run slowly changes to brown and disappears.
- poor and delayed mushroom flushes
- surface of compost sinks
- browning of pin heads, decline in yields
- complete crop failure

Check Your Progress - 6

Name the common nematodes that occur in mushroom beds ?

Note : (a) Write the answer in the space given below.
(b) Compare your answer with the one given at the end of this unit.

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Source of Nematode Infestation : Improperly pasteurized/prepared compost and casing ingredients are known to be the main source of infestation. Spent compost, uncleaned wooden trays, dirty spray water, contaminated implements and compost components may be the sources of nematode contamination from time to time. Sometimes mushroom flies and mites may also carry nematodes in their heavy body parts.

Favourable environmental conditions : The environmental conditions favourable to the development of mushrooms (14-28^{o}C temperature, 70-90% relative humidity, 6.5-8.0 pH and free flow of fresh air) have also been found to be suitable for the development and multiplication of these nematodes. Once they escape from the heat (60-61^{o}C) of composting/pasteurization of compost and casing, due to negligence or faulty pasteurization process and enter into the mushroom compost, then these nematodes multiply at a rapid rate and start damaging the mycelium/mushroom sporophores.

Management of Mushroom Nematodes

There is no curative method once these nematodes are able to make their entry in the mushroom beds. Hence only the preventive measures of control with the following integrated pest management strategy should be adopted for controlling these nematodes.

i) Strict hygiene should be maintained.

ii) It is to be ensured that proper bed temperature during peak heat stage of compost pasteurization at 60 $\pm$ 1^{o}C for 3-4 hours and sterilization of casing mixture (65 $\pm$ 1^{o}C for 3-4 hours) are maintained uniformly and satisfactorily.

iii) The composting ingredients should always be stored in a dry but covered store room.

iv) Mix, pasteurize and store the casing mixture in a clean area and to be packed in polythene bags.

v) The spray water should be fly proof and insecticides should be sprayed (DDVP, Thiodan) from time to time to kill the insects.

viii) The wooden trays should be cleaned and disinfected before use or grow mushrooms in polythene bags.

viii) Mix furadan -3G (1/2 g/kg straw) or neem cake on the final compost turning.

ix) At the end of the cropping period cook out the compost *in situ* (70°C for 10-12 hours), remove the spent compost and burry distantly in a pit.

14.4.3. Environmental/Abiotic Disorders

There are a large number of abiotic agents which create unfavourable environment for the proper growth of mushrooms resulting in the quantitative as well as qualitative loss. These abiotic agents include low or high moisture in the substrate, pH, temperature, CO_2 concentration in the room, wind velocity, fumes and relative humidity. Many of these agents make the substrate non selective for mushroom mycelium and encourage other moulds and pests while some interfere with the normal mushroom production.

Management of environment is of great significance in mushroom cultivation and any deviation from the optimum requirements may lead to various kinds of abnormalities. Since a major proportion of button mushrooms is being produced under natural climatic conditions in India, the following abiotic disorders are quite frequently observed.

a) Distortion : Many forms of distortion can occur; many are probably induced by fluctuation or unsatisfactory environmental factors. They may also be strain linked. The following symptoms have been seen.

i) Hollow stems : The mushrooms tend to be of poor quality but on the bed they appear to be normal. When they are cut for market, they are found to have partially hollow stem, often with a circular cavity surrounding a solid core. The cut surface of the stipe then may split and curl backwards, giving the mushroom an unattractive appearance.

ii) Split stipes : This is probably an extreme expression of the previous disorders. The stipe begins to split at cutting or even before. The vertical splits are sometimes associated with horizontal ones which enable stipe to curl upwards, downwards or both. These symptoms are associated with periodic water stress on fluctuating watering regimes.

iii) Swollen stems : Sometimes mushroom stems have swellings either at the base of the stem, in the middle or at the top. Only in the later case the marketing of mushrooms is affected.

iv) Hard gill : The affected open mushrooms, when viewed from below, have a pale colour and the gills are very shallow or even non-existent. If the cap is broken it often seems unusually thick and it is then apparent that there is little or no gill tissue. Hard gill is known to occur in all strains but some strains are affected more than others.

b) Misshapen mushroom : The symptoms range from rather knobby lumps to recognizable mushrooms with rather misshappen caps. Fusing of individual mushrooms can also occur. Incorrect environmental conditions are atleast part of the cause. The problem does not affect a large proportion of the crop.

c) Water logging : Symptoms include clear water soaked areas, particularly in the stems; the exudation of water from the mushrooms when squeezed; and in extreme cases, a spontaneous release of large quantities of clear or colour liquid from mature mushrooms which subsequently collapse.

d) Pinning disorders : These problems are more common and often more devastating disorders as they affect both the management or harvesting and often the total yield.

i) Mass pinning : In this disorder unusually large number of pin heads are formed. Mass pinning occurs when the environment has over conducive temperature, humidity or water regimes.

ii) Clumping : It refers to the occurrence of large mounds of mushrooms, which cause havoc to picking rates and mushroom quality. Some strains are more prone to the disorder than others. The periodic low temperatures at pinning causes the problem.

iii) Stroma : When the mycelium grows through the casing and appears on the surface to form a mat, it is called 'stroma'. Mycelial cap formed on the casing surface is impervious to water, causing water logging to the casing surface and gradual drying of the lower layers where it occurs, thus preventing the cropping. The cause is probably a combination of high CO_2 concentration, high relative humidity and sometimes high temperature. Apart from rectifying the environmental conditions, the only resource is to ruffle and lightly recase as soon as the problem begins to develop.

iv) Pin death : Pin heads may die even though the casing is well colonized, giving rise to non cropping patches. The symptom is usually seen in later flushes and is often caused by water logging of the surface due to the presence of an impervious mycelial layer on the casing. This is attributed to under watering in the early life of the crop; enabling dense mycelial colonization of the drying casing. Similar symptoms can be caused by very high temperatures, pests and pathogens (e.g., mummy disease, virus, and sciarid larvae.)

e) Carbon-dioxide damage : The main symptom is the considerable elongation of the stipes caused by build up of CO_2. As a disorder it is now rare because of the universal adoption of forced air ventilation.

f) Rose comb : The pink gill tissue, often with a porous appearance, develops on the surface of the mushroom cap. It may be in warts or in comb-like structure, or may appear to have spread over the side of the cap from the gills. The contaminated casing is often the primary cause of the trouble. The cause has been attributed to contaminations by hydrocarbon, phenols and over dosing with

certain pesticides. The source of the distorting material must be identified and eliminated.

g) Browning : When the staining of mushroom caps is light in colour and diffuse, the cause is taken as chemical instead of bacterial blotch. It appears due to the combination of high humidity and the frequent use of stuong sodium pentachlorophenate for tray or bed-board treatments.

h) Scaling : This is the natural reaction of the mushroom cap to dry air. The effect is strain related. Air with low relative humidities moving over the mushrooms causes scaling. The relative humidities concerned are over 80% but generally below 95%. The problem arises when the speed is out of ratio with the humidity. A further cause is sodium pentacholorphenate fumes from trays. In this case the scaling is differentiated by brown edges of the scales, which do not normally occur in case of simple over-drying.

If scaling is a persistent problem, the strains grown, the air distribution, humidification systems and the possibility of pesticide damage must all be considered.

i) Crypto-mummy disease : The main cause of the disease is chronic overwatering. Drastic reduction in the application of water, while not bringing about a complete recovery often results in the reappearance of healthy sporophores.

As compared to white button mushroom, there are few physiological disorders recorded in oyster mushrooms. Reduced light in the cropping room results in longer and thicker stipes and pileus is partly reduced. Insufficient ventilation (1-2% carbondioxide) and low light exposure induce bunched growth regeneration.

14.5. SUMMARY

Like all other crops, mushrooms are also affected adversely by a large number of biotic and abiotic factors. Among the biotic agents fungi, bacteria, viruses, nematodes, insects and mites cause damage to mushrooms directly or indirectly. A number of harmful fungi are encountered in compost, casing soil and substrates during the cultivation of edible mushrooms. Many of the fungi and competitor moulds attack the spawn run and fruit bodies at various stages of crop producing distinct disease symptoms. Different symptoms induced by the bacterial pathogens are brown blotch, black spotting, yellowing and mottled fruit bodies. Viruses can cause considerable reduction in yield. Distortion and growth abnormalities in the sporophore giving elongated stipes, early opening of caps, and angled caps are all symptoms that have been attributed to virus disease. The main abiotic factors are temperature, relative humidity, carbondioxide and excess moisture. Either alone or in combination all these factors may deviate from the optimum, resulting in poor mycelial growth. Therefore, poor cropping or distortion of the developing or developed sporophore give symptoms such as hard gill, rose comb or mass pinning. When conditions are favourable insects damage the mushroom crop causing economic loss to the growers. During mushroom cultivation a number

of nematodes are also encountered in mushroom beds along with insects like springtails and mites.

14.6. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The important fungal diseases of button mushroom are wet bubble, dry bubble and cobweb diseases.

2. The fungal genera causing diseases to oyster mushroom are *Cladobotryum, Gliodaclium, Arthrobotrys & Sibirina.*

3. Commonly occurring competitor moulds are inky caps, green moulds, black or grey moulds, white moulds, yellow moulds and false truffle.

4. The important bacterial diseases of mushrooms are bacterial blotch, ginger blotch, mummy disease, pit disease and drippy gill.

5. The spread of viruses through infected spores or mycelium occur in a number of ways such as - air flow, phorid and sciarid flies, through dirty containers, people, inadequate or no cooking out of the substrate and poor or no disinfection of wooden floor and or side parts after harvesting.

6. Common nematodes that occur in mushroom beds are *Ditylenchus, Aphelenchoides, Rhabditis, Panogrolaimus* and *Diplogaster.*

14.7. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Mention different fungal diseases of mushrooms, describe the specific symptoms and suggest suitable control measures ?

2. Discuss about the symptomatology, epidemiology and management of mushroom viruses.

3. List out the bacterial diseases of mushrooms and their control measures.

4. Mention the important pests and diseases and their causal organisms of edible mushrooms.

5. Write briefly about the competitor moulds of edible mushrooms and their management.

II. Answer the following in about 10 lines each.

1. Describe the morphological characters and epidemiology of wet bubble disease.
2. Describe the nature of damage caused by phorid flies and their control measures.
3. Write a brief account on abiotic disorders of edible mushrooms.
4. Write a brief note on nematode disease management.
5. Discribe the nature of damage caused by sciarid flies and suggest suitable measures.

Dr. K.V.S. Meena Kumari

UNIT - 15 : ECONOMICS OF MUSHROOM CULTIVATION

Contents

15.1. OBJECTIVES

After going through this unit you will be able to :

- estimate the expenditure of spawn production,
- estimate the expenditure for small and big size white button mushroom farms,
- estimate the expenditure of oyster mushroom and paddy straw mushroom cultivation and
- describe the formulation of project report.

15.2. INTRODUCTION

In recent years mushroom cultivation has become popular in many parts of the country. Growers are doing mushroom production on small, medium and large scale depending upon their capacity. However, it is important to note that cultivation is profitable, hence one must know the economics of mushroom cultivation. The economics of mushroom cultivation depends on various factors viz., materials used and their local cost, labour cost, production level, selling price, market demand etc. It differs from place to place. In this unit details have been given which will provide guideline to work out the economics of spawn and mushroom production keeping in view the local cost factor as mentioned above.

15.3. ECONOMICS OF SPAWN PRODUCTION

Mushroom spawn production is skill oriented technical work and involves rather higher investments for the establishment of spawn lab. In order to reduce the

investment small and medium sized mushroom units need not have a spawn lab. They can procure spawn from government spawn laboratories and reliable spawn laboratories from private sector. The preliminary requirement for making spawn is to have pure culture of the desired mushroom species on a suitable medium which is further used to make spawn bottles. The cultures may be either raised from mushrooms (spores/tissue) or procured from a reliable source. An account of the facilities required along with an approximate estimate of cost for spawn production which may vary from place to place due to local cost factor is given below.

Spawn Production (30,000 spawn bottles/annum)

A. Non-recurring **expenditure**

Sl.No.	Item	Value (Rs.)
1.	Autoclave room (10'x10'x10')	
2.	Kitchen (for boiling grains and filling bottles with working table) (12'x10'x10')	
3.	Office (8'x10'x10')	1,80,000
4.	Store room (8'x10'x10')	
5.	Spawn multiplication room (10'x10'x10')	
6.	Inoculation chamber (5'x6'x7') (Glass and plywood fitting and UV tube 3', table and double door entrance)	14,000
7.	Autoclave - 1 No.	25,000
8.	Hot plate - 2 Nos.	2,500
9.	Grain boiling container - 2 Nos.	150
10.	Spirit lamp - 2 Nos.	20
11.	Forcepes 12" - 2 Nos.	75
12.	Inoculation needle - 2 Nos.	90
13.	Pressure cooker - 12 Ltrs.	1,200
14.	Refrigerator	10,000
15.	Air conditioner (1 ton)	40,000
	Total :	2,73,035
	Interest @ 16.5% on Rs.2,73,035.00	45,051
	Depreciation @ 5% on Building (Rs.1,80,000)	9,000
	Depreciation @ 10% on temporary structure and equipments (Rs.90,200)	9,020
	Depreciation @ 20% on Misc. items (Rs.2,835)	567
		63,638

B. Recurring expenditure

1.	Empty glucose bottle (to be recycled) - 3,000 Nos.	3,000
2.	Non-absorbant cotton roll @ 40/roll (500 gms each) - 200 Nos.	8,000
3.	Jowar grain 40 q @ Rs.500/-per quintal	20,000
4.	Gypsum 100 Kg @ 0.40/Kg	40
5.	Chalk powder 800 Kg @ Rs.1.2/Kg	960
6.	Media - 1Kg	1,000
7.	Culture tube - 100 Nos. @ Rs.5/- per tube	500
8.	Water charges	100
9.	Electricity charges	6,000
10.	Permanent labourer - 1 No.	10,000
11.	Casual labourer - 1 No.	6,000
		55,600
	Interest @ 16.5% on working capital (Rs.55,600)	9,174
	Total :	64,774

Cost of spawn production = Interest and depreciation on non-recurring expenditure + Recurring expenditure and interest on it 1,28,412 Annual production of spawn bottles = 30,000

Cost of spawn production/ bottle Rs.1,28,412 ÷ 30,000 = 4.28 or 4.3

15.4. ECONOMICS OF SMALL SIZE WHITE BUTTON MUSHROOM FARM

Economics of small size white button mushroom farm of 720 trays taking 6 crops/annum is given below :

A. Non-recurring expenditure

Sl.No.	Items	Value (Rs.)
1.	Compost platform (40'x50'x3') - one	30,000
2.	Pasteurization room (15'x17'x12') - One	
3.	Spawn running room (15'x17'x12') - Two	
4.	Cropping room (15'x17'x12') - Six	
5.	Pasteurization room for casings oil (10'x15'x12) - One	6,00,000
6.	Boiler room (7'x15'x12') - One	
7.	Store room (7'x15'x12') - One	
8.	Office-cum-packing room (10'x15'x12') - One	
9.	Corridor (112'x8'x12') - One	

10.	Boiler (steam output 50 Kg/hr at 75-100 lb p.s.i.) - One	40,000
11.	Air conditioner (2 tonnes) - Six	3,00,000
12.	Humidity and air handling system	1,00,000
13.	Water pipe, sprayer, fan, etc.	5,000
14.	Trolley (hydraulic) - One	15,000
15.	Wooden tray (3'x2'x8") - 900 Nos.	1,80,000
	Total :	12,70,000
	Interest @ 16.5% on Rs.12,70,000	2,09,550
	Depreciation @ 5% on building (Rs.6,30,000)	31,500
	Depreciation @ 10% on equipment (Rs.4,55,000)	45,500
	Depreciation @ 20% on wooden tray, sprayer, fan etc (Rs.1,85,000)	37,000
	Total :	3,23,550

B. Recurring expenditure

1.	Paddy straw - 90 tonnes.	63,000
2.	Urea - 1.5 tonnes.	4,500
3.	Rice bran - 15 tonnes.	33,000
4.	Cotton sed - 1.8 tonnes.	12,600
5.	Gypsum - 3.6 tonnes.	1,440
6.	Chalk powder - 3.0 tonnes.	1,500
7.	Chemicals & fungicides	6,000
8.	Spawn (excluding cost of bottle) @ Rs.4/- per bottle - 4320 bottles.	17,280
9.	Casing soil	6,000
10.	Permanent labourer - 2 Nos.	12,000
11.	Casual labourer - 8 Nos.	58,400
12.	Electricity, water and fuel charges.	1,00,000
13.	Transport charges.	60,000
14.	Misc. expenditure.	10,000
		3,85,720
	Interest @ 16.5% on working capital Rs.3,85,720	63,644
	Total :	4,49,364

Cost of cultivation = Interest and depreciation on non-recurring expenditure
+ Recurring expenditure.

and interest on it. 3,23,550 + 4,49,364 = 7,72,914

C. Profit

profit = (Anticipated yield x selling price) - (cost of cultivation)

Table - 15.1. Profit at Different levels of yield.

Sl. No.	Yield/ tray (Kg)	Total yield/ annum 36 crops x120 trays (Kg)	Selling price/ Kg(Rs.)	Gross return (Rs.)	Cost of culti-vation (Rs.)	Net Profit (Rs.)
1.	5	21,600	40	8,64,000	7,72,914	91,086
2.	5.5	23,760	40	9,50,400	7,72,914	1,77,486
3.	6	25,920	40	10,36,800	7,72,914	2,63,886
4.	6.5	28,080	40	11,23,200	7,72,914	3,50,286
5.	7	30,240	40	12,09,600	7,72,914	4,36,686

Check Your Progress - 1 & 2

1. What is the approximate non-recurring and recurring expenditure for establishing a spawn production unit ?
2. What is the approximate non-recurring and recurring expenditure for a small size white button farm ?

Note : (a) Write the answers in the spae given below.
(b) Compare your answers with those given at the end of this unit.

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15.5. ECONOMICS OF BIG SIZE WHITE BUTTON MUSHROOM PLANT

Economics of White button mushroom farm yielding about 3,000 tonnes production per annum a 100% E.O.U. (Source : N.C.M.R.T. Solan, H.P., India), is given below (Table : 15.2)

Table - 15.2. Economics of White Button Mushroom Farm of about 3,000 T.P.A. (tonnes per annum)

Sl. No.	Facility	Unit	Size (ft)	Total area	Cost of Constn. (Rs/Sft)	Total Cost (Rs)
1.	2.	3.	4.	5.	6.	7.
A.	**Land procurement & Development**	1	–	6 Hectares	--	45,00,000.00
B.	**Compost Unit**					
1.	Pre-wetting area	1	150x 100	15,500 (Sq.ft)	50	7,50,000.00
2.	Composting yard	1	300x 120x 14	36,000 (Sq.ft)	125	45,00,000.00
3.	Pasteurization tunnels	9	70x12 x13	7,560 (Sq.ft)	300	22,68,000.00
4.	Casing soil pasteurization rooms	4	35x12 x10	1,680 (Sq.ft)	300	5,04,000.00
5.	Underground service room	1	120x9 x9	1,080 (Sq.ft)	200	2,16,000.00
6.	Spawning area	1	120x20 x13	2,400 (Sq.ft)	200	4,80,000.00
7.	Boiler room	1	18x15 x12	270 (Sq.ft)	200	54,000.00
8.	Paddystraw and Poultry manure shed	2	–	30,000 (Sq.ft)	50	15,00,000.00
				Total Rs. :		1,02,72,000.00
C.	**Production & Canning facility**					
1.	Cropping room	60	75x27 x13	1,21,500	300	3,64,50,000.00
2.	Canning hall	1	75x54 x13	2,025	250	8,10,000.00
3.	A/C Room/Shed	1	75x27 x13	2,025	200	4,05,000.00
4.	Cold room	1	37x27 x13	1,000	400	4,00,000.00
5.	Can store room	1	75x27 x13	2,025	200	4,05,000.00
6.	Corridor in the Cropping unit	1	864x25 x13	21,600	50	10,80,000.00

1.	2.	3.	4.	5.	6.	7.
D.	**Spawn laboratory**					
1.	Spawn lab	5	20x18 x12	1,800	250	4,50,000.00
E.	**Miscellaneous**					
	Store/Tool room Office/Canteen	4	18x15 x13	1,080	200	4,32,000.00

GRAND TOTAL = A+B+C+D+E = Rs.5,52,04,000.00

The following plant and machinery are required for the unit :

A.	**Composting Unit**	Unit rate
i)	Imported equipment (turners, soil mixers, computer control units, O_2, NH_3 measuring equipments etc).	1.75,00,000.00
ii)	Indigenous equipment	50,00,000.00
	Total Rs.	2,25,00,000.00
B.	**Growing rooms**	
i)	Imported machinery (CO_2 control, central computers, air handling units etc)	3,50,00,000.00
ii)	Indigenous machinery (racks, electrical panels, water chilling plant, ducting for Air handling unit etc)	2,50,00,000.00
	Total Rs.	6,00,00,000.00
C.	**Canning and Spawn Lab.** (Canning line, boiler, quality control equipments, spawn lab)	1,50,00,000.00
D.	**Misc. equipments and expenses** (Transformer, freight and insurance, erection of machinery etc)	1,00,00,000.00
	Total cost of the machinery	**Amount (Rs.)**
A.	Compost unit	2,25,00,000.00
B.	Growing rooms	6,00,00,000.00
C.	Canning and Spawn Lab.	1,50,00,000.00
D.	Miscellaneous	1,00,00,000.00
	Total Rs.	10,75,00,000.00

	Total cost of the Project	Amount (Rs.)
A & B)	Land and Infrastructure	5,52,04,000.00
C)	Machinery	10,75,00,000.00
	Total : A+B+C = Rs.	16,27,04,000.00
i)	Wages for Manpower	70,00,000.00
ii)	Expenses on Raw materials (paddy straw, manure, chemicals, repair and maintenance etc)	2,10,50,000.00
iii)	Interest and Depreciation (Rs.)	

On land	Cost	Interest & Depreciation. (Rs.)
15% interest	45,00,000.00	6,75,000.00
On building		
5% depreciation		
15% interest	5,07,00,000.00	1,01,40,000.00
On machinery		
10% depreciation	10,70,00,000.00	2,67,50,000.00
15% interest		
		Total Rs. 3,75,65,000.00

COST OF PRODUCTION

1.	Raw materials	2,00,00,000.00
2.	Wages for Manpower	70,00,000.00
3.	Interest and Depreciation	3,75,00,000.00
	Total Rs.	6,45,00,000.00

Total production at 18% conversion - 2,700 tons

Total production at 20% conversion - 3,000 tons

Cost of production per Kg - Rs. 24/- at 18% conversion

Cost of production per Kg - Rs. 21.50 at 20% conversion

CANNING OPERATION

	Rs.
Cost of A-10 can	20.00
Cost of Canning and Brine solution	12.00
Cost of mushrooms 2 Kg drained Wt. (3 Kg fresh mushrooms)	64.50
Total Rs. :	96.50

Sale price of One case containing six A - 10 size cans

@ $ 28.80
1 $ = Rs.32/-
(or)
$ 28.80 = Rs.921.60

Total A-10 cans produced from 9,75,000 Cans (or)

3,000 tons mushrooms 1,62,500 cases

Sales price of 1,62,500 cases

@ Rs.921.60 per case = Rs.14,97,60,000.00

Total production cost of 1,62,500 cases = Rs.9,40,87,500.00

Net Profit at 20% conversion = Rs.5,56,72,500.00

15.6. ECONOMICS OF OYSTER MUSHROOM CULTIVATION

Oyster mushroom can be grown both in temporary structures like polyhouses, thatched huts or in permanent structures. However, farm should be rat proof. Polythene/Polypropylene bag is preferred as it retains moisture and protects from contaminants and diseases. Economics of a medium size mushroom farm taking 72 crops/annum using 800 kg straw/crop i.e. 800 bags/crop is given below.

A. Non-recurring expenditure

Sl. No.	Items	Value (Rs.)
1.	Straw chopping shed (20'x35') - 1 No.	30,000
2.	Straw soaking tank (10'x5'x5') - 3 Nos.	30,000
3.	Pasteurization (15'x20'x12') Chamber/tank - 1 No.	
4.	Bag filling and spawning room (20'x20'x12') - 1 No.	
5.	Spawn running room (35'x20'x12') - 3 Nos.	
6.	Cropping room (35'x20'x12) - 6 Nos.	13,68,864
7.	Store room (15'x15'x12') - 1 No.	
8.	Office-cum-packing room (20'x15'x12') - 1 No.	
9.	Corridor (122'x10'x12') - 1No.	
10.	Chaff cutter with 1/2 HP motor - 1 No.	5,000
11.	Table for bag filling and spawning - 4 Nos.	1,000
12.	Wire mesh frame - 4 Nos.	1,000
13.	Rack (Bamboo/Casuarina) - 27 Nos.	30,000
14.	Sprayer with 1/2 HP motor.	3,000

Sl. No.	Items	Value (Rs.)
15.	Water boiling container with heating coil - 5 Nos.	4,000
16.	Trolley - 4 Nos.	8,000
	Total	14,80,864
	Interest @ 16.5% on Rs.14,80,864	2,44,343
	Depreciation @ 5% on building structures (Rs.14,80,864)	71,443
	Depreciation @ 10% on equipments (Chaff cutter trolley) (Rs.13,000)	1,300
	Depreciation @ 20% on table, rack, water boiling container, sprayer and wiremesh (Rs.39,000)	7,800
	Total :	3,24,886
B. Recurring expenditure		
1.	Paddy straw - 58 tonnes	40,600
2.	Spawn bottles 19,200 @ Rs.3/- (excluding cost of bottle)	57,600
3.	Chemicals and fungicides	6,000
4.	Polythene bags	40,320
5.	Permanent labourer - 2 Nos.	12,000
6.	Casual labourer - 8 Nos.	58,400
7.	Electricity, water and fuel charges	50,000
8.	Transport charges	50,000
9.	Misc. expenditure	10,000
		3,24,920
	Interest @ 16.5% on working capital (3,24,920)	53,612
	Total :	3,78,532

Cost of cultivation = Interest and depreciation on non-recurring expenditure
+ Recurring expenditure and interest on it 3,24,886
+ 3,78,532 = 7,03,418

C. Profit

Profit = (Anticipated yield x selling price) – (Cost of cultivation)

Table - 15.3. Profit at Different Levels of Yield

Sl. No.	Yield/ Kg straw (gm)	Total yield (Paddy straw 58 tonnes) (Kg)	Selling price/ Kg (Rs.)	Gross return (Rs.)	Cost of culti-vation (Rs.)	Net profit (Rs.)
1.	500	29,000	25	7,25,000	7,03,418	21,582
2.	600	34,800	25	8,70,000	7,03,418	1,66,582
3.	700	40,600	25	10,15,000	7,03,418	3,11,582
4.	800	46,400	25	11,60,000	7,03,418	4,56,582
5.	900	52,200	25	13,05,000	7,03,418	6,01,582
6.	1,000	58,000	25	14,50,000	7,03,418	7,46,582

15.7. ECONOMICS OF PADDY STRAW MUSHROOM CULTIVATION

Paddy straw mushroom is grown on paddy straw and yields 10-20% of the substrate on dry weight basis. It can be grown in thatched huts/polyhouses and brick stone rooms with proper provision of ventilation and light. Economics of cultivation has been given for a farm of thatched hut with 8 rooms, 3 rows of rack with 3 shelves accommodating 90 beds (20 Kg each) for spawn running and cropping.

A. Non-recurring expenditure

Sl. No.	Items	Value (Rs.)
1.	Shed (thatched) to prepare bundles (20'x35') - 1 No.	7,000
2.	Straw soaking tank (10'x5'x5') - 3 Nos.	30,000
3.	Pasteurization (15'x20'x12') - 1 No.	85,000
4.	Cropping room (20'x35'x17'x12') - 8 Nos.	
5.	Store room (15'x15'x15'x12') - 1 No.	
6.	Office-cum-packing room (20'x15'x17'x15') - 1 No.	
7.	Wire mesh frame with stand - 4 Nos.	1,000
8.	Rack (bamboo/casuarina) - 24 Nos.	26,700
9.	Sprayer with 1/2 HP motor - 1 No.	3,000

Sl. No.	Items	Value (Rs.)
10.	Water boiling container with heating coil - 5 Nos.	4,000
11.	Trolley - 4 Nos.	8,000
	Total :	1,64,700
	Interest @ 16.5% on Rs.1,64,700	27,176.00
	Depreciation @ 5% on permanent structure (water tank) Rs.30,000	1,500.00
	Depreciation @ 20% on temporary structure (sheds, cropping room, wiremesh, rack sprayer) (Rs.1,26,700)	25,340.00
	Depreciation @ 10% on trolley (Rs.8,000)	800.00
	Total :	54,816.00
B.	**Recurring expenditure**	
1.	Paddy straw - 210 tones	1,47,000
2.	Supplement (like chicken manure/ cotton seed husk 5%)	2,100
3.	Spawn bottles excluding the cost of bottle @ Rs.3/- per bottle, two bottles for each bed - 21,024 Nos.	63,027
4.	Chemicals and fungicides	6,000
5.	Polythene sheet	24,528
6.	Permanent labourer - 1 No.	6,000
7.	Casual labourer - 4 Nos.	29,200
8.	Electricity, water and fuel charges	50,000
9.	Transport charges	1,20,000
10.	Misc. expenditure	10,000
		4,57,900
	Interest @ 16.5% on working capital (Rs.4,57,900)	75,554
	Total	5,33,454

Cost of cultivation = Interest and depreciation on non-recurring expenditure + Recurring expenditure and interest on it 54,816 + 5,33,454 = 5,88,270

C. Profit

Profit = (Anticipated yield x selling price) - (Cost of cultivation)

Table - 15.4. Profit at Different Levels of Yield

Sl. No.	Yield/ bed (20 Kg) Kg	Total yield (Kg)	Selling price/ Kg (Rs.)	Gross return (Rs.)	Cost of cultivation (Rs.)	Net profit (Rs.)
1.	2.5	26,280	25	6,57,000	5,88,270	68,730
2.	3	31,536	25	7,88,400	5,88,270	2,00,130
3.	3.5	36,792	25	8,19,800	5,88,270	3,31,530
4.	4	42,048	25	10,51,200	5,88,270	4,62,930

15.8. FORMULATION OF PROJECT REPORT

A full fledged Project report is to be prepared for getting finance for Mushroom cultivation from funding agencies like - NABARD, DRDA, NHB (National Horticulture Board), Nationalised Banks, other State and Central Government Organisations. The Project report is to be prepared in the following way :.

i) INTRODUCTION

ii) OBJECTIVES

iii) ELIGIBILITY

iv) AREA OF OPERATION

v) TECHNICAL ASPECTS OF THE SCHEME

vi) ECONOMICS (FULL DETAILS OF INCOME, EXPENDITURE AND REPAYMENT SCHEDULE)

vii) REFINANCE ASSISTANCE (FROM NABARD)

viii) MARKET AND DEMAND

ix) CONCLUSION

15.9. SUMMARY

Cultivation of Mushrooms has become very popular in our Country. The economics of mushroom cultivation differs from place to place due to the difference in the local cost of raw materials, labour cost, market and demand etc. Economics of cultivation of white button mushroom, oyster mushroom and paddy straw mushroom are given in the unit. Funding agencies like NABARD, Nationalised Banks, DRDA and other State and Central government organisations provide financial assistance to eligible growers.

15.10. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The non-recurring expenditure for the construction of spawn production unit is Rs.2,73,035/- (approx.) and the recurring expenditure is Rs.64,774/- (approx.).
2. The approximate non-recurring and recurring expenditures for a small size white button mushroom farm are Rs.3,23,550/- and Rs.4,49,364/-.

15.11. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write in detail about the economics of white button mushroom cultivation.
2. Describe in detail about the economics of oyster mushroom cultivation.
3. Give an account of the economics of paddy straw mushroom cultivation.

II. Answer the following question in about 10 lines each.

1. What are the different aspects to be covered while preparing a project report for mushroom cultivation ?
2. Write briefly about the economics of spawn production.
3. Write briefly about the non-recurring expenditure of a small size white button mushroom cultivation.
4. Briefly write about non-recurring expenditure of oyster mushroom cultivation.

Dr. R.P. Tewari
Ms. K. Prasunamma

UNIT - 16 : PRECAUTIONS IN MUSHROOM CULTIVATION

Contents

16.1. OBJECTIVES

After going through this unit you will be able to :

- list out the precautions to be taken while selecting the area,
- list out the precautions to be taken during spawn preparation,
- list out the precautions to be taken during spawning, spawn run, cropping and harvesting.

16.2. INTRODUCTION

Mushrooms, since long time have been collected from nature for human consumption. Later on, the method of indoor cultivation of mushrooms through scientific way have been fully understood. Being a cash crop, mushrooms received much attention from growers of different regions of the world. Indoor cultivation of mushrooms was started in 1630 in France. In India, in 1943, one species of *Volvariella* was cultivated in Coimbatore for the first time.

Mushroom cultivation requires technical expertise and caution. Any disparities in the factors involved may lead to yield loss. Hence, precautions at different stages of cultivation are detailed in this unit.

16.3. PRECAUTIONS TO BE TAKEN IN MUSHROOM CULTIVATION

Though the technology for growing mushrooms is perfect, some precautions are inevitable to avoid loss of crop.

16.3.1. Selection of Area

The following points should be kept in mind while selecting the area for mushroom cultivation.

i. The ground should be firm to hold RCC structures.

ii. Plenty of greenery at the land site is essential to make the environment clean.

iii. Availability of clean water at the site.

iv. The area should have drainage arrangement, to maintain hygiene in the growing area.

v. Uninterrupted electric power supply with 3 phase facility should be provided.

vi. The site should be accessible to rail or road ways.

vii. In case of button mushroom cultivation, the composting platform should be closer to the main road for the sake of convenience of discharging raw materials. Close to the composting yard the bulk chambers should be placed for operational convenience. At the back of these chambers cropping rooms are to be built.

viii. Provision for future expansion of the Unit is to be left.

16.3.2. Spawn Preparation

The word spawn (San Antonio, 1984) is derived from an old French verb, 'espandre' meaning to expand. Quality spawn is one which consists of vigorous mycelical growth and free from all contaminants. Preparation of spawn involves sophisticated technology and infrastructure. Hence, small growers can depend on spawn laboratories run by government, voluntary and private organisations for spawn. However, the following precautions are to be taken while preparing spawn.

i. Glassware and instruments used for preparing cultures should be clean.

ii. Composition of culture media and spawn substrate as per the text should be followed strictly while preparing them.

iii. Proper pH (7-7.8) should be maintained.

iv. Culture media and spawn substrates should be sterilised according to the recommended procedures.

v. Inoculation should be carried out under aseptic conditions.

vi. Incubation of the inoculated tubes and bottles should be carried out at specified temperatures only (35^{o}C for paddy straw mushroom and 25^{o}C for others).

vii. Always it is advisable to use fresh spawn. However, after complete growth the culture tubes can be stored in refrigerator at 5^{o}C for all other types of mushroom spawn except for *Volvariella* which is to be stored at 15^{o}C for a maximum period of six months. Cultures and spawn stored for longer durations result in decline in the yield of mushrooms.

viii. Refrigerated cultures or spawn should not be used immediately after taking out of the refrigerator. They should be brought to room temperature and used.

ix. Transportation of spawn from spawn labs to growing area should be carried out either in refrigerated vans or during night time when the temperature is low.

x. Contaminated cultures and spawn bottles should be disposed properly. Prior to disposal they should be autoclaved to kill the contaminants (at 15 lb. p.s.i. for 20 minutes).

xi. Good strains should be selected for use depending upon the yield performance and quality.

xii. During the process of inoculation strict hygiene should be followed.

16.3.3. Spawning

The process of mixing spawn in the substrate for growing mushrooms is called spawning. The following precautions are to be taken during spawning.

i. Spawn should be uniformly distributed throughout the substrate.

ii. Rate of spawning is an important factor in determining the spread of mycelium. In case of White button mushroom, the recommended dose is 0.5 - 0.75 per cent i.e., 500 - 750 g for 100 Kg compost. In case of oyster mushroom it is 6.75 - 7.5 per cent i.e., 270 - 300g for 4 Kg dry substrate.

About 3 percent spawn (800 g spawn for 26 kg dry substrate) is necessary in case of paddy straw mushroom.

iii. Strict hygiene should be maintained at the area of spawning.

Check Your Progress - 1 & 2

1. Write any three precautions to be taken while selecting the area for mushroom cultivation.

2. What is the rate of spawning for white button mushroom and oyster mushroom ?

Note : (a) Write the answers in the space given below.

(b) Compare your answers with those given at the end of this Unit.

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16.3.4. Spawn Run

Spread of the mycelium from the grain spawn into the substrate is called 'spawn run'. The following things are to be kept in mind during spawn run.

i. The temperature of the spawn running room should be maintained. Optimum temperatures for spawn run of white button mushroom is 25 $\pm$ 2^{o}C, oyster mushroom 21-28^{o}C and paddy straw mushroom, 35- 40^{o}C.

ii. Relative humidity is to be maintained between 90 and 95 per cent in case of white button mushroom and 70-90 per cent in case of oyster and paddy straw mushrooms.

iii. Proper care should be taken to avoid the incidence of competitor moulds, parasitic moulds, bacteria, viruses, pests and nematodes.

16.3.5. Cropping

The following precautions are to be taken during cropping period.

i. The recommended temperature is to be maintained (23 - 25^{o}C for *Agaricus bisporus,* 28-30^{o}C for *A.bitorquis,* 20-30^{o}C for oyster mushroom and 34-37^{o}C in case of paddy straw mushroom).

ii. Relative humidity at 80-90 per cent in case of button mushroom, 65-85 per cent in case of oyster mushroom and 85-95 per cent in case of paddy straw mushroom.

iii. Spraying of water should be done gently.

iv. The cropping rooms should be fumigated quite often to check the unwanted organisms.

16.3.6. Harvesting

i. Proper care should be taken while harvesting mushrooms.

ii. The correct stage of harvesting should be judged on the basis of shape and size of the fruit body of different genera.

iii. They should be picked by gently holding them between the thumb and fingers by twisting slightly and pulling out gently.

iv. Lower part of the fruit body where the substrate is adhered to be cut and removed.

v. As far as possible smaller stipes are to be kept.

vi. Sufficient ventilation and light during the period yields mushrooms with shorter stipes.

16.4. SUMMARY

Mushroom cultivation requires technical expertise and caution. Proper care is inevitable at every step of the cultivation to yield good results. Selection of area is the foremost important factor. The area selected for mushroom cultivation should be accessible to rail or road, have uninterrupted power supply, availability of clean water with provision for future expansion. Every precaution is to be taken while preparing spawn. Contaminated cultures are to be disposed in a proper way. Spawning plays a major role in the spread of mycelium over the substrate. The optimum temperature and relative humidity are to be maintained during spawn run and cropping. Harvesting of mushrooms should be done with care and skill.

16.5. CHECK YOUR PROGRESS : MODEL ANSWERS

1. The area selected for mushroom cultivation should have rail or road accessibility, plenty of water and uninterrupted power supply.

2. The rate of spawning for white button mushroom is 0.5 - 0.75 per cent and 6.75 - 7.5 per cent for oyster mushroom.

16.6. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Write an essay on the precautions to be taken during mushroom cultivation.

2. Write an account on precautions to be taken during selection of site and spawn preparation.

II. Answer the following questions in about 10 lines each.

1. Write a note on the precautions to be taken during spawning.

2. What are the precautions taken during cropping and harvesting.

Ms. K. Prasunamma

UNIT - 17 : MUSHROOM RECIPES

Contents

17.1. OBJECTIVES

By the end of this unit you will be able to :

- list out the various recipes of Indian and western,
- describe the method of preparation of Indian recipes and western recipes,
- describe the preparation of pickles, powders and jam.

17.2. INTRODUCTION

Mushrooms are highly nutritious, easy to cook, subtle in flavour, characteristic of their texture and attractive in appearance. Mushrooms land themselves to several dishes like salad, sandwiches, omelette, curries souffle, soups, vegetable stuffings, rice pulao, pakoras, pickles and jam.

Mushrooms being a new vegetable has often led to various misconceptions in the consumers mind. The mushrooms cultivated commercially are neither poisonous nor they turn on storage. Besides, open mushrooms with exposed brown coloured gills are also consumable. However, care should be taken to purchase fresh and healthy mushrooms which can be ascertained by the absence of rotten smell. Insect larvae also damage the mushroom by boring tunnels into it which can be clearly seen by cutting open the mushroom. These are very simple tips which become clear with little experience.

Before cooking, mushrooms should be cleaned gently with running tap water to remove sticking debris. Mushrooms are never peeled; instead, are cut, preferably vertically, into 2 to 4 pieces. Mushrooms unlike other vegetables, retain their shape and do not dissolve into the curry while cooking. Hence a single steam pressure is enough to retain the nutrients as well. By following ones own style of working the mushrooms can be blended as per an individual's taste. A few of mushroom recipes are given below.

17.3. WESTERN RECIPES

1. Mushrooms Stuffed Chicken Breasts

Chicken breasts	: 600 g
Onions chopped fine	: 200 g
Mushrooms	: 100 g
Spinach leaves	: 4
Tomato sauce	: 2 table spoons (tbsp)
Sprouted moong	: 2 tbsp
Groundnut	: 15 g
Coriander leaves	: handful
Eggs	: 2
(Beaten, bead, crumbs as required)	
Green chillies	: 2
Ginger garlic paste	: 2 tbsp
Oil	: 6 tbsp.

Slice the chicken breasts into half without separating the two pieces. Flatten the chicken breasts with a meat mallet on a wooden board. Apply salt, ginger garlic paste and pepper powder to the chicken pieces. Parboil the spinach, drain and spread over the chicken breasts. Heat two table spoons of oil and saute the finely chopped onion till light brown. Add the mushrooms, sprouted moong, groundnuts, tomato sauce and the finely chopped green chillies. Stir well, cook till brown and dry. Add the finely chopped coriander leaves. Spread a little of this mixture over the spinach leaves and fold the chicken breasts. Fasten the edges with toothpicks or tie with a string. Dip in beaten egg and then roll in bread crumbs and shallow fry till done. Serve hot. Remove the toothpicks or string before serving

2. Mexicana Mutton Mince with Mushrooms

Mutton Mince	: 250 g
Medium sized tomatoes	: 150 g
Blanched and chopped mushrooms	: 1/2 cup (100 g)
Capsicum chopped	: 1/2 cup (100 g)
Medium sized onions	: 100 g
Coriander leaves chopped	: 50 g
Chilli powder	: 5 g
Lemon juice	: 1 tsp
Cumin	: 2 g
Salt to taste	
Oil	: 2 tbsp.

Chop the mushrooms into fairly big pieces. Heat two tablespoons of oil and saute the onions till soft. Add the mince meat and fry for sometime. Add the finely chopped blanched tomatoes, capsicums, chilli powder and cumin powder and cook till almost dry. Add the mushrooms and salt and stir well. Add the coriander leaves just before you remove from heat. Remove and serve hot, sprinkled with lime juice.

3. Indonesian Style Stuffed Chillies

For this adaptable recipe you can substitute pine nuts or peanuts if you don't have cashews.

Olive oil	: 30 ml/2 tbsp
Medium onion, peeled and chopped	: 1
Clove, garlic, crushed	: 1
Turmeric	: 2 tbsp
Crushed coriander seed	: 1 tbsp
Dessicated coconut	: 2 tbsp
Mushrooms chopped	: 100 g
Bulgar wheat	: 75 g
Raisins	: 50 g
Cleaned coconut	: 25 g
Stock or water	: 2380 ml
Tomatoes, skinned and chopped	: 200 g
Cashew nuts	: 50 g
Small green chillies deseeded and cut in half lengthways	: 4
Lemon juice	: 2 tbsp

Preparation :

1. Heat the oil and fry the onion and garlic until lightly browned.
2. Add the turmeric, coriander and dessicated coconut and cook gently for about 2 minutes.
3. Add the mushrooms and bulgar wheat and cook for a further 2 minutes.
4. Add the rest of ingredients except the nuts, lemon juice, chillies, and cooking stock and simmer gently for 15-20 minutes until the bulgar wheat is cooked.
5. Toast the cashew nuts in a dry frying pan until golden brown.
6. Blanch the chillies in boiling water for 3 minutes.
7. Mix the nuts and lemon juice with the rest of ingredients and fill the chillies with the mixture.
8. Place the filled peppers on the bottom of a large casserole dish and pour stock around the peppers.

9. Cook 180°C/350°F/gas mark 4 for 20 minutes.

10. Drain peppers and place on a hot plate to serve.

Time : Preparation takes 20 minutes, cooking takes 45 minutes.

Freezing : The cooked chillies will freeze well for upto 3 months.

4. Mushroom and Tofu in Garlic Butter

button mushrooms	: 225 g
Root ginger	: 2.5 cm piece
smoked tofu	: 225 g
butter	: 100 g
Cloves, garlic, crushed	: 1 tbsp
Chopped parsley	: 2 tbsp

Preparation

1. Wipe the mushrooms with a damp cloth.
2. Peel and grate the ginger.
3. Cut the smoked tofu into small 1.2 cm or 1/2 inch squares.
4. Melt the butter in a frying pan.
5. Add the crushed garlic and ginger and fry gently for two minutes.
6. Add the smoked tofu and heat through finally.
7. Add the mushrooms and cook gently for 4-5 minutes until the mushrooms are softened.
8. Divide between 4 individually hot dishes, sprinkle with chopped parsley and serve at once.

Time : Takes 10 minutes, cooking 12 minutes.

5. Tofu Burgers

Serve these delicious burgers with mustard and pickles and accompany with a salad.

bulgar wheat	: 50 g
boiling water	: 100 ml
Small onion, very finely chopped	: 1
carrot, grated	: 20 g
mushrooms, very finely chopped	: 50 g
packet tofu	: 250 g
Basil	: 1/2 tsp
Oregano	: 1/2 tsp

Tomato puree	: 2 tbsp
Black pepper	: $\frac{1}{2}$ tbsp
Whole wheat flour	: 100 g
Oil for deep frying.	: Sufficient

Preparation

1. Put the bulgar wheat into a bowl and pour boiling water over it. Leave it aside for 15 minutes until all the water is absorbed.
2. Add the onion, carrot and mushrooms to the bulgar wheat and mix well.
3. Drain the tofu and crumble into the bowl.
4. Add the basil, oregano, shoyu, tomato puree, a little black pepper and 1 table spoon of whole wheat flour. Mix together well.
5. With wet hands, take heaped table spoonful of the mixture, sqeeze together well and shape into burgers.
6. Coat the burgers with whole wheat flour.
7. Heat the oil until very hot and fry the burgers 3 or 4 at a time until golden brown.
8. Remove and drain on absorbent kitchen paper.

Time : Preparation takes 15 minutes & cooking takes 5 minutes per batch.
Watch point : The oil must be very hot otherwise the burgers will disintegrate.
Freezing : Freeze for/up to 3 minutes. Reheat by grilling or warming in the oven.

6. Savoury Rice Cake

An excellent way to use left over rice.

Medium onion, finely chopped	: 1
Clove garlic, crushed	: 1
Olive oil	: 2 tbsp
Fresh thyme chopped	: 12 tbsp
Red chilly, thinly sliced	: 1
Green chilly, thinly sliced	: 1
Eggs beaten	: 4
Salt and pepper	: Sufficient
Cooked rice	: 6 tbsps
Natural yogurt	: 3 tbsp
Cheddar cheese, grated	: 75 g
Mushrooms chopped	: 200 g

Preparation :

1. Fry the onion and garlic in the olive oil until soft.
2. Add the thyme and peppers and fry gently for 4-5 minutes.
3. Add mushrooms and fry till soft brown.
4. Beat the eggs with the salt and pepper.
5. Add the cooked rice to the thyme and peppers followed by the eggs.
6. Cook over a moderate heat; stirring from time to time until the eggs are cooked underneath.
7. Spoon the yogurt on top of the part-set egg and sprinkle the cheese over the top.
8. Put under moderate grill and cook until puffed and golden
9. Serve immediately.

Time : Preparation takes about 15 minutes, cooking takes 15 minutes.
Serving Idea : Garnish with fresh thyme and serve with green salad.

7. Mushroom and Apple Chutney

Onion	: 1
Apples	: 500 g
Mushrooms	: 500 g
Red chillies	: 125 g
Green tomatoes	: 375 g
Garlic	: 2 flakes
White vinegar	: 1200 ml
Brown sugar	: 375 g

1. Put the onion into a sauce pan, just cover with water and cook until tender, when most of the water will have evaporated.
2. Add apples, mushrooms, pepper and tomatoes and half of the vinegar.
3. Crush the garlic, put it into muslin and add to the pan.
4. Simmer the mixture until it thickens and then add the remaining vinegar gradually. When of a thick consistency, add the sugar and continue to cook until there is almost no liquid. Stir the mixture occassionally.
5. Remove the garlic, pour the chutney into clean, dry jars and cover. Yield approx. 1 kg.

Check Your Progress - 1

Describe the preparation of mushrooms and tofu in garlic butter.

Note : (a) Write the answer in the space given below

(b) Compare your answer with the one given at the end of this unit.

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17.4. INDIAN RECIPES

The Indian recipes of the mushroom viz., soups, curries, masala paneer, Bhujia, Kofta, Pulao, stuffed mushroom etc., are given below.

1. Mushroom Soup

Mushrooms	50 g	Onions	1 small
Ginger	10 g	Garlic	5 flakes
Refined flour	1 tbsp	Milk	1 cup
Butter	1 tbsp	Salt, pepper and sugar to taste.	

Method : Boil cut mushrooms, chopped onions, grated ginger and garlic in 750 ml water. Slightly fry refined flour in melted butter and add milk. Add sieved decoction of boiled mixture. Boil for 5-10 minutes. Add spices to taste.

2. Onion Pepper Mushroom Soup

Mushroom	100 g	Water	500 ml
Capsicum	2 no	Chopped Coriander	1 tbsp.
Onions	3 no	Grated cheese	75 g
Garlic	7 flakes	Refined flour	2 tsp
Tomatoes	2 tbsp.		

Method : Chop capsicum into thin strips, chop tomatoes, slice mushroom and onions. Coarsely grate garlic. Gently heat butter. Add refined flour. Add water and bring it to a boil. Add tomatoes and sliced mushrooms. Cook till tender. Add salt and pepper to taste. Serve hot with chopped coriander leaves.

3. Lentil Mushroom Soup

Lentils	50 g
Onions Sliced and chopped	10 g
Mushrooms	150 g
Celery stalks (chopped)	5 g

Carrots (sliced)	15 g
Tomatoes	30 g
Salt	2 g
Pepper	1 cup
Stock or water	1 cup
Vinegar	1 tsp
Oil	1 tsp

Method : Bring the stock to a boil and slowly add the lentils. Reduce to a simmer and cook for half an hour. Meanwhile saute the onions and mushrooms in oil and set aside. Combine all ingredients except vinegar and cook for half an hour. add vinegar before serving, add salt and pepper and serve hot.

4. Mushroom Corn Soup

Mushrooms	50 g
Corn	10 g
Onion	1 small
Ginger	10 gm
Corn flour	1 tbsp
Garlic	5 cloves
Butter	20 g

Salt, pepper and sugar to taste

Method : Boil cut mushrooms, corn grains, chopped onions, ground ginger and garlic in 1 litre water for 15 min. sieve the decoction. Heat butter and fry corn flour. Add decoction and spices for taste.

5. Mushroom Curry

Mushrooms	200 g	Turmeric	1/2 tbsp
Onions	2 no	Cumin	1/2 tbsp
Garlic	6 flakes	Curd/milk	1 cup
Ginger	1 piece	Ghee	1 tbsp
Tomatoes	2 large	Chillies & salt to taste.	

Method : Wash and cut mushrooms and tomatoes. Chop onions, grind garlic and ginger. Heat ghee. Add cumin seeds to crackle. Fry garlic, ginger and onion to golden brown. Add spices and salt to taste followed by chopped tomatoes. Leave to simmer. Add curd or milk. Add mushrooms. Simmer and water if desired.

6. Mushroom Peas Curry

Mushrooms	20 g	Tomato	2 large
Peas	500 g	Turmeric	1/2 tsp
Onions	2 no	Cinnamon	2 g
Garlic	6 flakes	Chillies & salt to taste	
Ginger	10 g		

Method : Wash and cut mushrooms. Shell peas. Chop onions, garlic and ginger. Heat ghee. Add cumin seeds to crackle. Fry all spices. Add tomatoes and simmer. Add mushrooms and peas and cook till peas become tender. Add water if desired.

7. Mushroom Theeyal

Mushrooms	250 g	Turmeric	1/2 tsp
Coconut	2 cups	Onions	10
Red chillies	3	Green chillies	2 Nos
Coriander seeds	1 tbsp	Garlic	2 cloves
Fenugreek	a pinch	Coconut oil	2 tsp
Pepper coms	4	Salt to taste	

A few curry leaves
One marble size dump of tamarind.

Method : Clean the mushrooms and slice into two. Roast chillies, coriander seeds, fenugreek and pepper along with finely grated coconut on a slow fire till coconut turns golden brown, Grind to a fine paste without adding water. Heat oil and saute onions, split green chillies and mushrooms. Add two cups water, salt and cook. When cooked, add ground coconut paste, cover and cook. Mix in tamarind juice and boil. Remove from fire and season with spluttered mustard seeds and curry leaves.

8. Mushroom Yakni

Fresh mushrooms	200 g	Cloves	2
Fennel powder	5 g	Salt to taste	
Aromatic Ginger	5 g	Oil	25 g
White cumin seeds	5 g	Curds	250 g
Asafoetida powder	a pinch		

Method : Wash and cut mushrooms into two halves. Heat oil and deep fry the mushrooms. Take out mushrooms when golden in colour. Put asafoetida, cloves and cumin in the same oil, when cumin crackles put fennel and aromatic ginger and stir slowly. Add curds to this mixture and keep on stirring for few seconds and then add the deep fried mushrooms and cook until the mushrooms are soft.

9. Makki Khumb Masala

Corn	250 g	Green chillies	4
Mushroom	450 g	Ginger paste	25 g
Ghee	150 g	Garlic paste	25 g
Onions	250 g	Red chilli powder	10 g
Ginger	30 g	Tomatoes	450 g

Method : Soak the corn in a pan full of water for 3-4 hours. Then boil until tender. Wash and cut mushrooms. Peel, wash and chop onions and green chillies.

Wash and chop tomatoes. Heat ghee in a Kadhai, add onions, and saute over medium heat till golden brown, add ginger paste, garlic paste and green chillies and stir for 15-20 seconds. Now add red chillies and stir for a minute. Add tomatoes and stir until the fat leaves the masala, add corn and mushrooms, bring to a boil and simmer until the liquid has evaporated. Sprinkle garam masala and stir.

10. Laziz Khimbi

Mushrooms	600 g	Tomatoes	750 g
Ghee	150 g	Green chillies	4
Cabbage	100 g	Ginger	30 g
Garlic paste	20 g	Onion	100 g
Whole Red chillies	4	Capsicum	40 g
Coriander seeds	5 g	Salt, Garam Masala	sufficient

Coriander leaves a few to taste.

Method : Heat 20 gms ghee in a pan and saute sliced mushrooms over medium heat for 4-5 minutes. Drain and keep aside. Shred cabbage and saute over medium heat in 20 gms of ghee. Heat the 50 gms of ghee in a kadhai and add garlic paste and stir over medium heat for 20 seconds. Add the pounded red chillies and coriander seeds; stir over medium heat for 3 seconds add chopped tomatoes and stir until the fat leaves the masala. Then add chopped green chillies and grated ginger stir. heat the remaining ghee in a separate kadhai, and sliced onions and saute over medium heat. Add cut capsicum and saute for 2, minutes. Transfer the masala from the first kadhai, add mushrooms and cabbage, stir constantly for 3-4 minutes. Adjust the salt and chilli powder. Sprinkle garam masala and fresh coriander leaves and serve hot.

11. Mushroom Paneer

Mushrooms	200 g
Paneer	100 g
Onions	3 No
Garlic	8 cloves
Cumin	8 cloves
Turmeric	1/2 tbsp
Coriander powder	1/2 tbsp
Garamasala	1/2 tbsp
Tomatoes	1 or 2 Nos.
Ghee	2 tbsp

Salt and chillies to taste

Method : Wash and cut mushrooms. Warm ghee. Add cumin to crackle. Fry ground garlic, chopped onions and ginger to golden brown. Add other spices

followed by chopped tomatoes and leave to simmer. Add fried paneer and mushrooms. Cook for 10 minutes Add water if necessary.

12. Mushroom Bhujia

Mushrooms	250 g
Potato	1 large
Onion	2 large
Tomatoes	2 large
Asafoetida	pinch
Garamasala	1 tbsp
Ghee	1 tbsp

Salt and chillies to taste

Method : Cut mushrooms. Boil potato and wash. Warm ghee. Add asafoetida. Fry chopped onions. Add spices and tomatoes for simmering. Add washed potatoes and mushrooms. Cook for 5 minutes. Add water if required.

13. Tomato Mushroom Bhujia

Tomatoes	100 g
Mushrooms	150 g
Onions	40 g
Green chillies	2 g
Garlic	5 g
Ginger	2 g
Turmeric	2 g
Chilli powder	2 g
Salt	2 g
Oil	20 g

Method : Take a flat bottom vessel and add oil. When oil is hot add onions and dry till light brown. Then add all the other ingredients and cook till gravy thickens. The mushrooms may or may not be chopped.

14. Palak Mushroom

Spinach	150 g
Mushrooms	150 g
Onions	50 g
Garlic	1 g
Potato	80 g
Red chilli	1 g
Turmeric	1 g
Cloves	1 g
Fat	10 g
Ginger	1 g

Method : Wash and chop spinach, onions and coriander leaves. Boil and Mash potatoes. Grind cloves, red chillies, garlic and ginger to a fine paste. Heat fat, add to it the spice paste and add mushrooms. Heat on low flame. Cook spinach and grind well along with mashed potatoes in an electric blender. Now add the spinach potato mixture to the coriander and chopped mushrooms. Add salt turmeric and cook for 2 minutes. Serve with lime.

15. Mushroom Kofta

Dhingri mushroom	200 g
Red chillies powder	1 tbsp
Turmeric powder	1 tbsp
Ground anardana	10 g
Gram flour	4 tbsp
Salt to taste	

Method : Clean dhingri. Take dry gram flour. Add all spices and mash dhingri with hand into this mixture. Add little water if needed. Make small balls and deep fry. A gravy preparation or cutlets can also be prepared from this kofta.

16. Creamy Mushrooms

Mushrooms	400 g
Chopped onions	15 g
Fresh cream	60 g
Chopped coriander	15 g
Butter	5 g
Salt and Pepper according to taste	

Method : Heat the butter and fry the onion for 1/2 minute. Add the prepared mushrooms and fry for a further 1 minute. Add the cream, chopped coriander leaves, salt and pepper and mix well. Serve hot with tooth picks.

17. Mushroom Pulao

Mushrooms	150 g
Rice	75 g
Onion	40 g
Ghee	30 g
Paneer	40 g
Salt	1 g
Peas	3 cups
Green chillies	
Water	

Method : Fry onions in ghee till golden brown. Stir in the drained rice. Mushrooms, paneer and salt are fried for 5 mins. Add shelled peas, chillies, hot water and cover and simmer till cooked. Serve hot.

18. Mushroom Pizza

For the Dough	Refined flour	60 g
	Fresh yeast	5 g
	Salt	1/2 tsp
For the topping	Mushrooms	50 g
	Tomatoes	75 g
	Onion	20 g
	Cheese	20 g
	Butter	1 tsp
	Garlic	1 flake
	Chilli powder	a pinch

Method : Sieve the flour with salt ; mix the yeast in the flour and add enough water to make a dough. Cover the dough with a wet cloth until it is double in size. Knead the dough roll out the dough. Cover the dough with a wet cloth until it is double in size. Knead the dough and roll out the dough to 1 cm thickness. Grease the pizza tray and place the rolled out dough in the tray. Chop the onion, tomatoes and mushrooms. Saute the onions, garlic, tomatoes and the mushrooms. Add chilli powder and salt. Cook for 5-10 minutes. Spread the mixture over the rolled dough and sprinkle with grated cheese. Bake in a very hot oven for 20 minutes.

19. Marinated Mushroom Salad

Mushrooms	500 g	Sugar	30 g
Water	1.5 litre	Onions sliced	4 in number
Vinegar	300 ml	Olive oil to taste	
All spices	2 tsp	Salt to taste	

Method : Place washed mushrooms in water (1.5 litre) and salt and boil for 5 minutes. Drain the mushrooms. Prepare marianade by bringing to boil vinegar, all spices, and sugar. Stir till sugar dissolves. Slice the mushrooms or leave them whole. Pack them into a jar alternating with a layer of onion rings. When marinade is ready pour into the jar. Press down the mushrooms to ensure all air has been expelled. Store in fridge to serve as salad, drain of marianade, toss mushrooms and onions with pepper and add a little oil to taste.

20. Mushroom Stuffed Capsicums

Capsicums	6 large size	Fresh chillies	25 g
Mushrooms	250 g	Garlic	2 flakes
Onions	2 large	Curry powder	5 g

Potato	1 large boiled	Cinnamon	2 g
Butter/oil	150 g	Turmeric powder	1/2 tsp.
Fresh ginger	25 g,		
		Fresh coriander	

Method : Wash capsicum and cut around the stalk. Drain out the stalks along with the seeds. Cut mushrooms and potato into small pieces and mince seperately onions, ginger, chillies, garlic and coriander. Fry onions in fat till onions become light brown. Add ginger, freshly cut chillies and garlic to it. Fry these for a minute. Add a small amount of water to prevent sticking. Add cut mushrooms and boiled potatoes along with spices. Stir till mixture is dry but not cooked fully. Take the mixture off the fire. Stuff capsicums with it and replace the cap of the stalk with a little force so that it gets well fitted in the stuffing inside. A small piece of sewing thread may be tied to keep the cap in position while frying. Deep fry the capsicums gently on slow heat. Make sure that capsicum does not lose its shape or get burnt. Arrange fried stuffed capsicums on a plate and garnish with remainder of the stuffing.

21. Stuffed Mushroom

Large sized mushroom	10 no
Onions	1 no
Bread	4 piece
Grated cheese	1 tbsp
Salt and pepper to taste	

Method : Wash mushrooms, remove gills and the longer portion of stem. Fry ground onions and finely chopped mushroom stems. Add bread crumbs, cheese, salt and pepper. Stuff this into the inner portion of mushroom cap. Bake for 10 minutes. Serve hot.

22. Stuffed Omelette

Mushrooms	50 g
Eggs	2
Onion	1
Ghee	1 tbsp
Green coriander leaves	1/2 tbsp
Green chillies	1/2 tbsp
Cumin	1/2 tbsp
Salt and pepper to taste	

Method : Chop mushrooms and onions finely, fry in small amount of ghee and put aside. Beat eggs and add salt, pepper and chillies. Heat ghee in teflon coated frying pan. Add cumin to crackle. Pour beaten eggs and spread mushroom mixture and other spices. Hold omelette till golden brown.

23. Marinated Mushrooms

Mushrooms	200 g
Green chillies	6 no
Garlic	6 flakes
Gram flour	2 tbsp
Ghee	for frying
Salt	to taste
Curd	1 cup
Vinegar	1 tbsp
Red colour	trace

Method : Add salt to whole mushroom and leave for 1-2 h to remove excess water. Dip in mixture of curd, vinegar and colour. Store in fridge for 48 h. Prepare a thin paste of gram flour. Add ground garlic and chopped chillies. Dip mushrooms into this mixture and deep fry.

24. Mushroom Fritters

Mushrooms	500 g	Egg yolk	1 tbsp
Flour	1/2 cup	Milk	1 cup
Salt	1/2 tsp	Soda water	1 cup
Pepper	1/4 tsp	Stiffy beaten	
Oil	1 tsp	egg white	1

Method : Sprinkle the whole mushrooms with lemon juice. Mix all ingredients from flour to egg yolk, gradually beat in liquid. Make sure there are no lumps left. Let this mixture rest, covered in the fridge for a couple of hours. Just before frying mix in the stiffy beaten egg.

Heat oil in a kadhai, dip the mushroom in the butter and fry till golden brown.

25. Mushroom Pancakes

Mushrooms	- 200 g
Milk	- 500 ml
Eggs	- 3
flour	- 140 g
Butter	- 100 g
Onion	- 1 (medium size)

Black pepper, salt and fresh parsley

Method : Chop the onion and fry lightly until the onion turns tender. Parboil the mushrooms, chop finely and mix them with onion. Season to taste. Keep this mixture warm while you make the pancakes. For the pancakes, separate the eggs and beat the yolk with half the milk, add flour and mix to a smooth paste; add the remaining milk. Whip the whites until stiff and pour into the mixture. Make

thin pancakes cooked on both sides. Put a spoonful of the mushroom mixture on each pancake and roll it up.

26. Mushroom Soufle

Mushrooms	150 g
Flour	5 g
Butter	5 g
Onions	30 g
Milk	60 g
Cheese 50 g	
Salt	1 g
Pepper	2 g
Egg	2 nos

Method : In a large saucepan melt butter and add onion. Cook until onion is soft and not brown. Remove pan from heat and blend in flour Stir in sliced mushrooms and milk. Return pan to heat and stir until mixture boils and thickens. Cool a little, then beat in egg yoks, cheese, salt and pepper. Beat egg whites until stiff and stir in one tablespoon egg white into the mushroom mixture. Fold in beaten egg whites quickly and lightly ; pour mixture into an ungreased soufle dish and bake till golden brown. serve hot.

27. Mushroom Pakorah

Mushrooms	250 g
Onions	2 small
Green chillies	4
Bread pieces	6 pieces
Shelled peas	2 tbsp
Ginger	1 small piece
Gram flour	2 large spoons
Ghee	for frying

Raw manago powder and salt to taste.

Method : Cut mushrooms into vertical halves. Grate onions and ginger. Dip the bread in water and squeeze water. Mix mushrooms with bread crumbs, onion and ginger; dip these in gram flour and fry in hot oil.

28. Mushroom Samosa

For dough

Maida	40 g
Fat	10 g
Salt	2 g

For stuffing

Mushrooms	100 g
Potatoes	20 g
Peas	20 g
Onions	20 g
Green chillies	2 Nos
Coriander powder	2 tbsp
Amchur	1 tsp
Chilli powder	1 tsp
Salt	2 tsp

Method : Sieve flour, melt fat and mix the flour and salt. Add water and knead to a stiff dough and leave aside for 1/2 hour. Boil potatoes and peas. Saute the chopped onions and green chillies and season. Add mashed mushrooms, peas and potatoes. Make small balls of dough and roll out into very thin rounds. Cut the rounds into half, form into a cone and pour in the stuffing. Seal the two edges together and deep fry till crisp and medium brown in colour.

29. Mushroom Snacks

Mushrooms without stem	6	Baking powder	a pinch
		Salt and pepper	According to taste
Egg	1	Fine white bread crumbs,	
Flour	10 g	oil to fry	

Method : Beat the egg and add flour, baking powder, salt and pepper and make a batter. Add little water if needed. Dip mushrooms in the batter and roll in bread crumbs. Heat the oil and fry the prepared mushrooms like pakoras, a few at a time, till they become golden brown.

30. Mushroom Sandwiches

Mushrooms	50 g	Bread	two slices
Onion	20 g	Oil/ghee	30 g
Tomatoes	Half	Salt and	According
Lemon juice	1/2 lemon	pepper powder	to taste

Method : Fry the small bits of onion in ghee. Take a small pan with little water. To that add cut tomatoes, salt, pepper powder and little lemon juice. Put the onions and cut mushrooms into the pan and boil it till the water is evaporated and nicely toast it with ghee. Now the mushroom curry is ready for stuffing the bread. Take bread slices and keep the mushroom preparation between two slices and toast it on a pan with ghee. Ready to serve hot, with tomato sauce or mint chutney.

31. Mushroom Kheer

Mushrooms	50 g
Milk	2 kg
Refined flour	1 tbsp
Sugar to taste	
Dry fruits for garnish	

Method : Slice mushrooms into thin slices. Cook in milk and refined flour till the milk concentrates into thick gravy. Add sugar. Add dry fruits to garnish.

32. Mushroom Ketchup

Fresh mushrooms	500 g	Cinnamon	1 g
Salt	12 g	Dry ginger	2 g
Cardamom	2 g	Red chillies	2 g
Pepper	2 g	Vinegar or glacial	500 ml
Cloves	2 g	Acetic acid	
Mace	2 g		

Method : Wipe off the mushroom caps with a damp cloth. Keep them in a porcelain or an enamelled bowl for 12 hours after sprinkling with salt. Store the mushrooms in vinegar for several days and blend the soaked or salted mushrooms to a fine slurry and add spices. Heat the mass till it thickens to consistency of ketchup; small quantity of meat extract or monosodium glutamate can also be added to enhance the flour. While still hot the ketchup bottles are sealed with corks and sterilised for 30 minutes in boiling water. The bottles are cooled and kept in a cool dry place. Use it as such or for sandwiches and omelette.

33. Mushroom Sauce

Mushrooms	: 100 g
Butter	: 3 spoons
Maida	: 2 spoons
Milk	: 1 cup
Salt and pepper powder for taste	

Method : Clean the mushrooms and cut into pieces. Add ghee, boil for sometime and keep it aside. Take another vessel and 2 spoons of butter, maida and milk and then boil with constant stirring. Add the mushroom and butter to the above. Add salt and pepper powder. Remove from fire.

34. Sweet Mushroom Chutney

Mushrooms	1 kg	Garlic	10 g
Sugar	550 g	Ginger	100 g

Salt	2 1/2 tsp	Onions	50 g
Mixed spices (Cardamom Cinnamon Cumin in equal amount)	30 g	Green chillies	10 g
		Vinegar	80 ml
		Sesamum oil	50 ml
		Pepper corn	1 tsp

Method : Wash mushrooms, slice them lengthwise. Chop onion, green chilli, garlic and ginger finely. Heat oil in a pan. Add onion and saute for 2 minutes. Add ginger, garlic, green chilli and cook for about 2 minutes. Add sliced mushrooms and water (1/2 cup) and cook till tender. Add sugar and cook till sugar leaves water. Add salt, red chilli powder and vinegar and cook for 5 to 7 minutes. Lastly, add roasted, powdered spices and cook for a minute or so . Cool and store in sterilised bottles.

Check Your Progress - 2

How to prepare mushroom pulao ?

Note : (a) Write your answer in the space given below.
(b) Compare your answer with the one given at the end of the unit.

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17.5. MUSHROOM PICKLES

1. Mushroom Pickle

Mushrooms	1 kg	Mustard seeds	20 g
Cumin seeds	15 g	Green chillies	12 Nos
Fenugreek seeds	15 g	Vinegar	350 g
Coriander seeds	25 g	Salt	50 g
Turmeric powder	20 g	Sesamum oil	350 ml

Method : Cook the prepared mushrooms in 150 ml sesamum oil with salt sprinkled over it in a covered stainless steel pan on simmering flame for 20-30 minutes and keep aside. Roast the cumin, fenugreek and coriander seeds in an open pan. Powder it and mix with ground mustard seeds and turmeric powder and it is now called spice mixture. Slit the green chillies longitudinally and lightly fry in about 100 ml oil. Add the cooked mushrooms and the whole mass should be thoroughly mixed. Finally add vinegar, heat to boiling and fill hot in bottles after removing from the flame. Heat the rest of the oil and pour the cooled oil in each bottle to cover the pickle completely. Screw the caps of the bottle.

Note : Don't use groundnut oil and mustard oil in the preparation of the pickle as groundnut oil is found to impart a little off flavour after a months storage and the mustard oil masks mushroom flavour completely.

2. Mushroom Sweet & Sour Pickle

Mushrooms	500 g
Ginger	25 g
Garlic	10 flakes
Red chilly powder	1 tbsp
Turmeric powder	2 tbsp
Jaggery	150 g
Mustard oil	200 g
Vinegar	1 tsp
Salt to taste	

Method : Fry cut mushrooms and remove from oil. In the same oil fry ground ginger, garlic and add spices. Prepare jaggery syrup along with vinegar and add to the spices. Add mushrooms. Keep in sun for 2-3 days after filling in clean jar.

17.6. MUSHROOM POWDER

Dry Mushrooms	: 1/4 kg
Red chillies	: 100 g
Coriander	: 10 g
Cumin	: 1 spoon
Curry leaves	: 10 leaves
Garlic	: 25 g
Tamarind	: 40 g
Oil	: 100 g

Method : Fry the mushrooms in oil like chips. Fry the red chillies, coriander, curry leaves, cumins with a little bit of oil separately and grind all of them in a mixer. Later, add tamarind, salt, garlic and grind.

17.7. MUSHROOM JAM

Mushrooms	: 1 kg
Sugar	: 1 1/4 kg
Water	: 1/4 litre
Mixed fruit essence	: 10 drops
Grape colour	: 2 g

Wash and cut the fresh mushrooms into small pieces. Tie them in a soft cloth. Dip them in boiling water for 2 minutes. Remove from the boiling water. Allow to drain off the water from the mushrooms. Add 2 g of grape colour. Boil the

mushrooms for 15 mins, then add sugar (1 1/4 kg). Again boil for 20 mins with constant and continuous stirring, so that it will not stick to the bottom. Remove from the fire. Allow it to cool. Then add mixed fruit essence (10 drops). Bottle the jam in a sterilised bottle. This can be eaten along with bread.

17.8. SUMMARY

Mushrooms like vegetables are purely vegetarian diet. They are highly nutritious, i.e., having good source of protein, vitamins and minerals. They are easy to cook and with excellent culinary qualities besides being valued for aroma. In India, we have diverse taste in different regions, so the thumb rule for cooking mushrooms is to follow in one's own style of cooking. These can be cooked in a variety of ways like sandwich, omelette, soup, salad, pulao and curries in combination with other vegetables.

17.9. CHECK YOUR PROGRESS : MODEL ANSWERS

1. Melt the butter in a frying pan and add crushed ginger, garlic and fry for 2 mins. Add the smoked tofu and heat it. Add into mushrooms, cook gently for 5 mts. Divide between 4 dishes and heat. Sprinkle with chopped parsley and serve hot.
2. Fry onions in ghee till golden brown. Add rice, mushrooms, paneer and salt, fry it for 5 min and then add shelled peas, chillies, add hot water, cover it and simmer till cooked. Serve hot.

17.10. MODEL EXAMINATION QUESTIONS

I. Answer the following questions in about 30 lines each.

1. Describe the preparation of mushroom stuffed capsicums.
2. Describe the preparation of Indonesian style stuffed peppers.
3. Describe the preparation of mushrooms soufle and mushroom pancakes.
4. List out the types of soups and give their preparations.

II. Answer the following questions in about 10 lines each

1. Write briefly about the preparation of mushroom pickle.
2. Write a brief account on mushroom ketchup.
3. Mention the preparation of mushroom Jam.
4. Describe the preparation of mushroom and apple chutney.
5. Describe the preparation of mushroom pizza.

Dr. K.V.S. Meena Kumari

DR. B.R. AMBEDKAR OPEN UNIVERSITY

FACULTY OF SCIENCE

CERTIFICATE PROGRAMME IN MUSHROOM CULTIVATION

COURSE - 2 : CULTIVATION OF MUSHROOMS

MODEL EXAMINATION PAPER

Time : 3 Hours

Max. Marks : 100
Min. Marks : 35

SECTION 'A'

Marks : 4x15=60

Answer any four questions.
Each question carries 15 marks.
Answer the following questions in about 30 lines each.

1. Write briefly the historical account of cultivated mushrooms and add a note on their distribution.
2. Explain in detail about the short method of compost preparation for growing button mushrooms.
3. Describe in detail the method of cultivation of button mushrooms.
4. Write an essay on various cultivation systems for oyster mushroom production.
5. Write an essay on the method of spawn preparation of paddy straw mushroom.
6. Describe in detail about the various bacterial diseases of mushrooms.
7. Write an essay on the economics of small scale button mushroom production.
8. Give an account of Indian recipes of mushrooms.

SECTION 'B'

Marks : 5x8=40

Answer any five questions.
Each question carries 8 marks.
Answer the following questions in about 10 lines each.

9. List out the precautions to be taken in maintaining the quality of button mushroom spawn.
10. Write a note on the growing requirements of *Agaricus bitorquis*.
11. What is casing ? List out the casing materials.
12. Write a short note on model mushroom house of oyster mushroom.
13. Write a brief note on the cropping room maintenance for oyster mushroom cultivation.
14. What is canning ?
15. What are the growth requirements of milky white mushroom ?
16. Write a short note on dry bubble disease.
17. Write a brief note on formulation of project report for Financial Assistance for mushroom cultivation.
18. How are mushroom pickles prepared ?

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CERTIFICATE PROGRAMME IN MUSHROOM CULTIVATION
COURSE - 2 : CULTIVATION OF MUSHROOMS

ASSIGNMENT - 1

Time : 2 Hours

Note :

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote any source, give the correct reference.
4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margin for the comments of the evaluators.
6. Completion of this assignment normally should not take more than two hours time.

I. Answer the following questions in about 30 lines each.

1. Write an essay on farm designing of white button mushroom.
2. Give a brief account on the morphology of various species of *Pleurotus* (oyster mushroom).
3. Write an essay on the method of spawn preparation of oyster mushroom.

II. Answer the following questions in about 10 lines each.

1. Write a short note on button mushroom production in developed and developing countries.
2. Write briefly about abiotic disorders of button mushroom.
3. What are the prospects and potentialities of oyster mushroom cultivation.

DR. B.R.AMBEDKAR OPEN UNIVERSITY

FACULTY OF SCIENCE

CERTIFICATE PROGRAMME IN MUSHROOM CULTIVATION

COURSE - 2 : CULTIVATION OF MUSHROOMS

ASSIGNMENT-2

Time: 2 Hours

Note :

1. Do not copy the answer directly from any of the books.
2. As far as possible try to answer the questions independently in your own words.
3. If it is necessary to quote from any source, give the correct reference.
4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margin for the comments of the evaluators.
6. Completion of this assignment normally should not take more than two hours time.

I. Answer the following questions in about 30 lines each.

1. Explain the method of cultivation of paddy straw mushroom.
2. Give an account of different cultivation methods, mode of harvest and preservation of black ear mushroom.
3. Write an essay on the competitor moulds of mushrooms.

II. Answer the following questions in about 10 lines each.

1. Explain polybag method of cultivation of shiitake mushroom.
2. What is wet bubble disease?
3. What is dehydration? How are oyster mushrooms dehydrated?

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ASSIGNMENT-3

Time: 2 Hours

Note :

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4. Use your own foolscap pages for writing the assignment.
5. Leave sufficient margin for the comments of the evaluators.
6. Completion of this assignment normally should not take more than two hours time.

I. Answer the following questions in about 30 lines each.

1. Give a brief account on the fungal diseases of white button mushrooms.
2. Describe briefly the pests & diseases of mushrooms and their control measures.
3. Write an account on the economics of oyster mushroom production.

II. Answer the following questions in about 10 lines each.

1. Write a note on viral diseases of mushrooms.
2. Write briefly about the method of preparation of mushroom jam.
3. Explain the preparation of Mexican mutton mince with mushrooms.