



1

INTRODUCTION TO MUSHROOM

There is decline in income of farmers in traditional agriculture. To ensure that the farmer gets assured income year after year, there is a need for diversification in agriculture, that is, needs to cultivate different type of crops. One of the options is to grow mushrooms which can be grown on straws and other agricultural wastes.

Unlike plants, mushroom cultivation is an indoor activity. It is possible to grow mushrooms in a particular season under natural conditions. It is possible to grow mushrooms throughout the year under controlled conditions. An additional advantage is that very less land is required for growing mushrooms.

You must have seen that after rains many mushrooms appear from nowhere, especially in grassland, near manure heap, dung or rotting straws/ wood. We must be aware that all mushroom occurring in the nature are not edible. At present there is no simple method to differentiate an edible mushroom from non-edible type. Some mushrooms have medicinal value. A few of these are poisonous and thus it is important to cultivate edible mushrooms. In the subsequent chapters we will discuss about the cultivation of some of the common edible and medicinal mushrooms.

Firstly, let us try to understand what are mushrooms and from where they come. How many types of mushrooms are there in the world, why to grow and eat mushrooms? What mushrooms are cultivated in our country and what are the basic steps in their cultivation.



OBJECTIVES

After reading this lesson you will be able to:

- explain that what are mushrooms and how many species of mushrooms are there in the world;



Notes

- learn that whether mushrooms are plants or animals and how these survive in nature;
- understand the history of mushroom cultivation and the benefits of growing of mushrooms to the farmers and environment;
- state the advantages of consuming mushrooms as a health food;
- summerise basic steps in mushroom cultivation.

1.1 WHAT ARE MUSHROOMS?

When we say mushroom, many people think of only button mushroom (Fig. 1.1). This is more so in West as the mushroom industry in the UK and other western countries is nearly 100% dominated by button mushroom. This could mislead you that this is the only species considered as mushroom. Actually, there are thousands of different species of mushrooms in nature.



Fig. 1.1: Button mushroom

Unlike higher plants, mushrooms do not have chlorophyll (green part in leaves) which helps the plants to use water, carbon dioxide and energy from the sun to synthesize their own food. In the absence of chlorophyll, mushrooms cannot produce their own food and depend on higher plants for food. Mushrooms obtain nutrients from organic materials like straw, dead wood, manure, dung, etc.

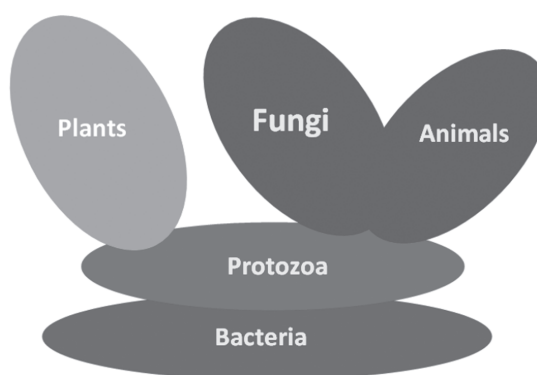


Fig. 1.2: Evolution of five kingdoms of organisms on Earth

Earlier workers considered mushrooms as plants. Now we know that these are neither plants nor animals. In evolution plants evolved from lower organisms.

Introduction to Mushroom

Soon after that the fungi and animals also got separated (Fig. 1.2). Plants make their own food. Fungi and animals depend upon other organisms for food. Mushrooms have cell wall that is different from plants. Animals do not have cell wall. Because of these characters and also the method of their nutrition, growth and reproduction, etc, scientists have grouped all fungi into a separate kingdom.



Notes



INTEXT QUESTIONS 1.1

State true or false

- (i) Mushrooms are plants.
- (ii) Mushrooms synthesize their own food.
- (iii) Mushrooms are fungi.
- (iv) Mushrooms have chlorophyll.

1.2 HOW MANY SPECIES OF MUSHROOMS EXIST?

Fungi are the 2nd largest group of organisms after insects. We know only about some of these. According to an estimate, there are about 15 lakhs fungi in the world (Fig. 1.3). However, we have not been able to study all and scientists have studied only 1.1 lakh fungi out of which 14000 are considered as mushrooms (Actual number of mushrooms in nature may be 10 times of this). All mushrooms are not edible. Some are even poisonous. Out of these, only 3000 have been considered to be truly edible. However, it is not possible to cultivate all of these. Despite all the efforts we succeeded to cultivate only about 200 species experimentally out of which 60-70 are cultivated commercially and about 10 are cultivated on industrial scale.

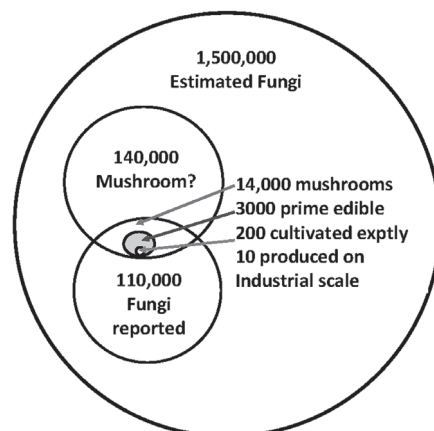


Fig.1.3: Estimated and actually reported fungi and mushrooms



INTEXT QUESTIONS 1.2

Answer the following questions

- (i) What is the estimated number of fungi on Earth?
- (ii) How many have been cultivated experimentally?
- (iii) How many species are cultivated on industrial scale?

1.3 HOW MUSHROOMS SURVIVE IN NATURE?

Mushrooms are the fruiting bodies of fungi. But major part of the life of mushrooms is in the form of microscopic thread like structure in the soil, wood, etc (Fig. 1.4). These microscopic threads are called mycelium. One cubic centimetre of soil can have up to 13 km long mycelium. These threads unite to form small structures (pinheads) that grow into mushroom. These fruiting bodies produce spores that help in spread of the fungus. You might have seen black spots on old bread pieces. These are nothing but spores of fungi.

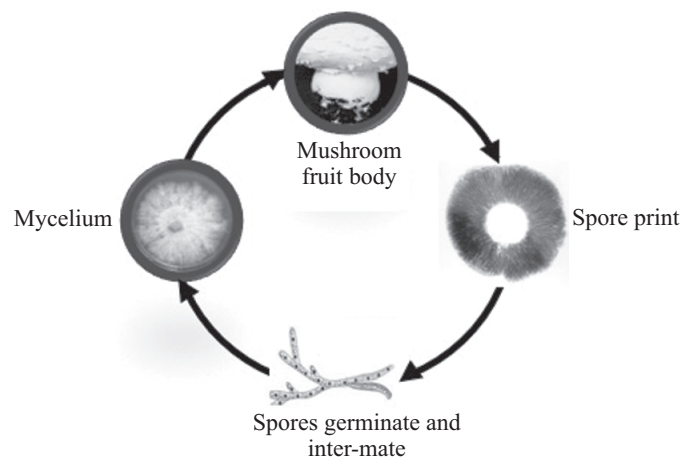


Fig. 1.4: Life cycle of Mushroom: The Mushroom produces spores; these germinate, inter-mate and the mycelium spread in the soil or wood, etc. During proper season the mycelium turns into fruiting bodies, that is mushroom

But keep in mind that all fungi are not mushrooms. There are numerous other fungi that are source of medicine, help trees to grow in forest, help farmers by converting waste into compost. There are also numerous fungi that cause diseases in plants and animals. As mentioned earlier, all mushrooms cannot be eaten. Some of the mushrooms are not good as food, but have medicinal value. In this book we will discuss about some edible and medicinal mushrooms.



INTEXT QUESTIONS 1.3

State True or False

- (i) Fungi exist as microscopic threads in soil or on wood.
- (ii) Mushrooms are fruiting body of fungi.
- (iii) All fungi are mushrooms.
- (iv) All fungi are useful.



Notes

1.4 HISTORY OF MUSHROOM CULTIVATION AND PRESENT STATUS

Mushrooms like wood ear, winter mushroom and shiitake were cultivated in China on wood logs more than a thousand year ago while button mushroom was cultivated in France about four centuries ago. But the scientific cultivation of mushrooms started in the beginning of 20th century and in the initial years button mushroom was the most commonly cultivated mushroom. Subsequently, numbers of other mushrooms were brought under cultivation. In 1960, when mushroom production was low, white button mushroom cultivation was about 80 percent of world mushroom production, shiitake contributed 15 % and others were only 5%.

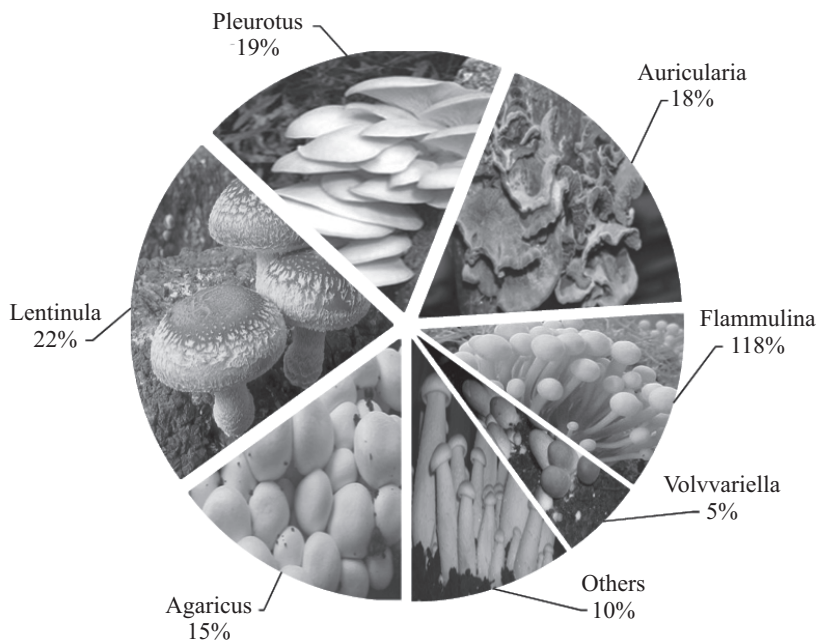


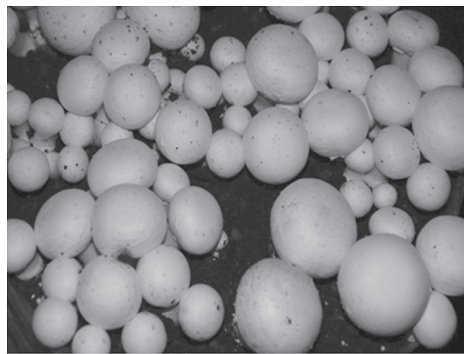
Fig. 1.5: Relative contribution of different mushrooms to world mushroom production of 34 million tonne in 2014



Notes

Over decades there has been increase in production of button, but the production of other mushrooms has increased much more as a result of which at present the relative contribution of button in world production is only 15% and it is no more world's number one mushroom. At present shiitake is number one cultivated mushroom (Fig. 1.5). Six mushrooms, namely shiitake (*Lentinula*), oyster (*Pleurotus*), wood ear (*Auricularia*), button (*Agaricus*), winter mushroom (*Flammulina*) and paddy straw mushroom (*Volvariella*) account for 90% of the total world mushroom production. Today China cultivates around 60 different types of mushrooms and produces around 85% of the total of 40 million tonne mushrooms of the world.

In India, we cultivate mainly four types of mushrooms viz., button, oyster, paddy straw and milky mushroom (Fig. 1.6). The total estimated mushroom production in India in 2016 was around 1.3 lakh tonnes, of which button accounted for 3/4th of the production (Fig 1.7). Some of the mushrooms like morels are still collected from forests and we have not succeeded in cultivating these in our country.



Button mushroom



Milky mushroom



Oyster mushroom



Paddy straw mushroom

Fig. 1.6: Mushrooms under cultivation in India



Notes

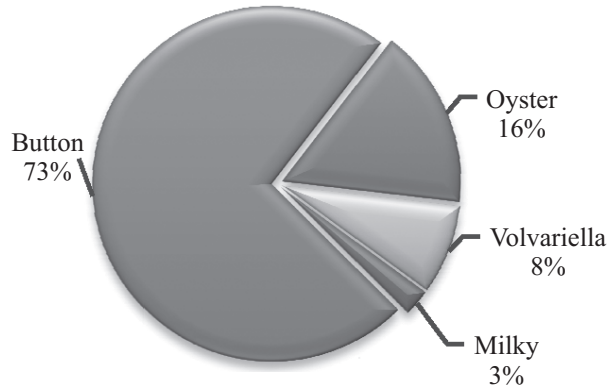


Fig. 1.7: Contribution of different species in total mushroom production in India

Button mushroom is an introduced crop in India. You must have listened about other crops like apple, potato that were introduced from other countries to India. Cultivation of button mushroom in India started in mid 60s in hilly region of Himachal and J&K as the low temperature required was naturally available in these regions. Later on, its cultivation started under controlled conditions in other regions. At present the mushroom production systems in our country are mixed

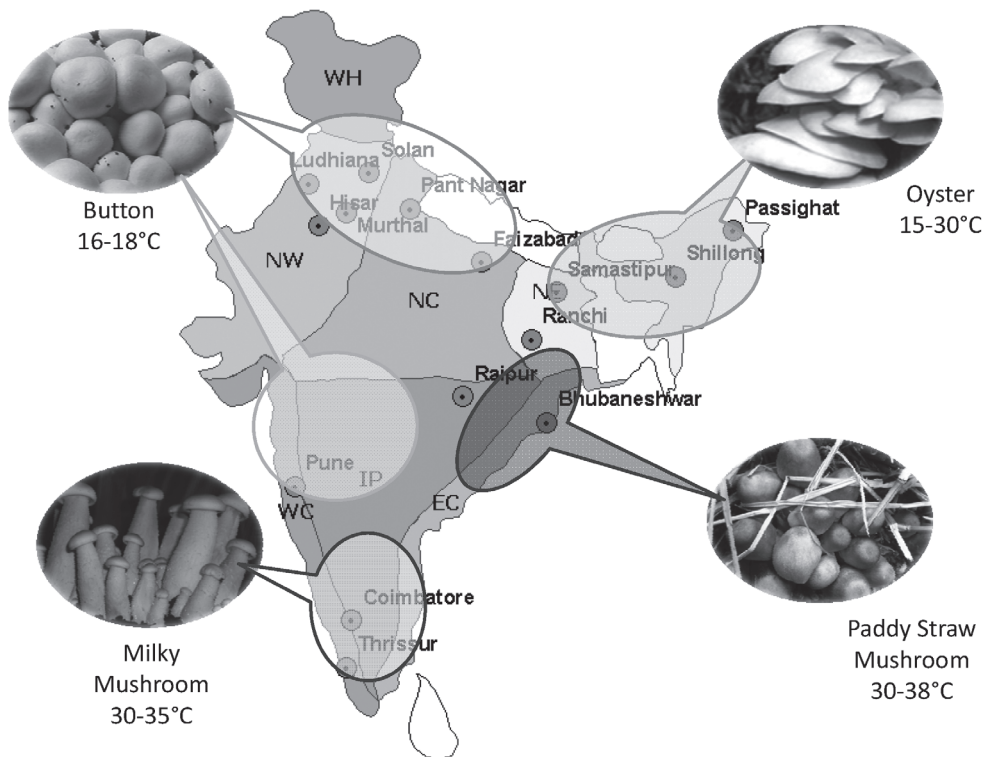


Fig. 1.8: Major areas of cultivation of different mushrooms in India



type i.e. both seasonal farming as well as high-tech industry. Mushroom production in India was only 5000 tonnes in 1990 that increased to over 1,00,000 tonnes in 2010, and to 1.30,000 tonne in 2016. At present (2019) the total mushroom production is estimated to be 1,90,000 tonne.

Button mushroom is cultivated throughout the year by commercial units and also during winter months by seasonal growers. The cultivation is more in Maharashtra, Gujarat, Goa, Haryana, Punjab, Utrakhand, and Himachal Pradesh. Cultivation of paddy straw mushroom is localized to Odisha while milky mushroom is more popular in southern part of India. Oyster is more popular in East, even though it is cultivated in many other parts of the country. There are many species of oyster and globally maximum numbers of species of this mushroom are under cultivation. The regions of mushrooms and the temperature range at which these are cultivated is shown in Fig. 1.8.



INTEXT QUESTIONS 1.4

Answer the following questions

- (i) Presently which mushroom is world's number one mushroom in terms of production?
- (ii) How many types of mushrooms are cultivated in China?
- (iii) What is the current world mushroom production?
- (iv) Which is the most popular mushroom in Odisha?
- (v) Which mushroom is having maximum production in our country?
- (vi) Which mushroom is India's contribution to the world?
- (vii) Maximum number of species of which mushroom are cultivated?

1.5 WHY TO GROW MUSHROOMS?

In nineteenth century, we produced the food only for our survival. In the last century, we produced adequate food in many parts of the world and convenience was an important area. For example, the ready-to-cook, ready-to-eat foods were commonly available. The 21st century is going to be a century of functional foods, that is, the foods that not only meet our calorie needs but also have compounds beneficial for our health. Mushrooms fit into this category very well as we will see when we read about why to eat mushrooms.

Introduction to Mushroom

Mushrooms are not only a quality food but also a way of utilizing agricultural wastes and generating wealth from the waste. The material left after growing mushrooms, commonly referred as spent mushroom substrate (SMS), can be processed into manure. Thus, mushroom cultivation is an important method to promote sustainable manure based farming. Addition of spent mushroom substrate is also reported to improve the soil health. The very fact that mushrooms can be cultivated on paddy straw and number of other agricultural wastes, many of which are just burnt, is sufficient reason to grow mushrooms. By growing mushrooms, we are not only producing a quality food but are also creating a healthy environment. More importantly, it leads to employment generation and women empowerment. With increasing population the land is shrinking and mushroom cultivation utilizes vertical space and requires minimal land making it possible to promote mushrooms in peri-urban and urban areas also. Mushrooms are considered to be the highest protein producers per unit area per unit time.



Notes



INTEXT QUESTIONS 1.5

Fill in the blanks

- (i) Which century is referred as convenience food age?
- (ii) The material left after growing mushrooms, commonly referred as
- (iii) Mushroom cultivation utilizes Space.
- (iv) Mushrooms are considered protein producers per unit area per unit time.
- (v) Mushroom cultivation is commonly described as generation of wealth from the

1.6 WHY TO EAT MUSHROOMS?

Our ancestors were collecting mushrooms from the forests and fields. These were considered as a delicacy and in some civilizations these were considered as the food for the kings. After cultivation of mushrooms, these have become available to all in large amounts. Now we know that these are a quality food having health benefits. In fact mushrooms are among the best vegetarian food available. Mushrooms are a rich protein source having essential amino-acids with high digestibility. Mushrooms have all the nine essential amino acids required by the human beings. We have problem of malnutrition in our country. Mushrooms can contribute in solving this problem.



Notes

Mushrooms are good for heart as they have low fat and some of the mushrooms have compounds (like lovastatin in oyster mushroom) that are known to lower the cholesterol in the blood. Moreover, mushrooms have low-sodium and high potassium contents and thus are suitable food for persons suffering from high blood pressure.

Mushrooms are a low calorie food with no starch and also have number of anti-oxidants and hence considered delight of diabetics. These are also rich in fibres and hence good for the intestine and digestive system. These are also a very good source of vitamins especially vitamin B complex. Mushrooms are the only vegetarian source of vitamin D. If we expose mushrooms to UV light after harvest for some time or expose to sunlight, the vitamin D content increases many folds. These also have vitamin B₁₂ which is not available in plants. These are also rich in minerals, which also include copper (heart-protective) and selenium (anti-cancer).

Characteristics	Benefits
High quality protein	Combats malnutrition
Low sodium high potassium	Controls hypertension
No starch, low sugar	Delight of diabetics
No cholesterol	Healthy heart
Rich in fibre	Improves digestion
Only vegetable with Vit. D	Cures Ricketsia
Folic acid, Vit. B and minerals	Improves health
Ascorbic acid and carotenoids	Anti oxidant
Low calorie food	Reduces obesity
Selenium	Anti cancer property

Fig.1.9: Characteristics and benefits of consuming mushroom

Many of the mushrooms are known to have medicinal and anti-viral properties and their consumption activates the immune system of the human body. Compounds from number of mushrooms have found applications in cancer research and numbers of them have been found to reduce the side effects of radio-therapy and chemotherapy. The benefits have been summarized in Fig.1.9. As mentioned earlier, mushrooms can be easily digested. Now we know that these can meet our nutritional needs and thus are a health food.



INTEXT QUESTIONS 1.6

Fill in the blanks

- (i) Vitamin and vitamin commonly found in animals, is also found in mushrooms.
- (ii) Mushroom is suitable for patients having high blood pressure as these have sodium and potassium.
- (iii) Mushroom is low calorie food and hence considered delight of the

1.7 ABOUT MEDICINAL MUSHROOMS

At present about 30 percent of the world trade is related with medicinal mushrooms. In India however, we have only recently started cultivating medicinal mushrooms. Some species like *Cordyceps sinensis* (keera ghaas) are collected from the forest and are sold. Some growers have started cultivating *Cordyceps militaris* in our country. Technique for cultivation of *Ganoderma* (Reishi mushroom) has been standardised but it is not being promoted because it is known to cause diseases of number of tree species. Major focus in our country is still on edible mushrooms.

Some of the medicinal mushrooms on which research is going on in different parts of the world including trials on human beings are: *Lentinus edodes*, *Grifola frondosa*, *Schizophyllum commune*, *Ganoderma lucidum*, *Trametes versicolor*, *Inonotus obliquus*, *Flammulina velutipes*, *Phellinus linteus*, *Cordyceps sinensis*. Possibly most popular medicinal mushroom is *Ganoderma*.



INTEXT QUESTIONS 1.7

Answer the following questions

- (i) Medicinal mushroom account for how much of the world trade?
- (ii) Which species of *Cordyceps* has been cultivated in India?
- (iii) Which species of *Cordyceps* is still collected from the forests?
- (iv) Which medicinal mushroom is most popular in the world?



Notes

1.8 SOME BASIC TERMS USED IN MUSHROOM CULTIVATION

Some of the words related to mushrooms may be new for you and will keep on coming again and again when you will read any book on mushroom cultivation. For example words like spawn, substrate, spawn run, casing, flush are used frequently in any book on mushrooms.

Over time you will learn that **spawn** means the seed of mushroom, **substrate** is to mushroom what soil is to plants, which is any medium on which we grow mushrooms. **Casing soil** is nothing but a mixture of soil and other materials used to cover the bags after the seed has grown inside the substrate. Some of the common terms related to mushrooms are as below.

Agar: A polysaccharide derived from sea weed used for solidifying culture media.

Agaricus bisporus: White button mushroom.

AHU: Air Handling Unit, a system installed in cropping rooms for cooling, humidification and fresh air intake.

Aerobic: In presence of oxygen/fresh air.

Anaerobic: In absence of oxygen/fresh air.

Ascomycetes: A major class of fungi having sac like ascus in the fruit bodies.

Auricularia: Scientific name for wood ear mushroom.

Bagasse: The crushed juiceless remains of sugarcane as it come from the mill.

Basidiomycetes: A major class of fungi having basidia in their gills.

Bran: The outer layer of cereal grains separated from the kernel.

Casing: A layer of material, usually soil or peat mass, placed on the surface of a substrate to regulate the humidity of the compost and to stimulate production of mushrooms.

Compost: In case of button mushroom it means material prepared by mixing straw, chicken manure, gypsum, etc in fixed quantity and fermented in a specific method under aerobic conditions.

Culture: The growing of mushroom tissue in a medium under sterile conditions.

Flush: Term used for appearance of mushroom at intervals. A cropping cycle of mushrooms, from the moment they pop their heads above the casing.

Fruit body: The sexual spore bearing structure of fungi, that is mushroom.



Gills: Spore bearing thin blades on the underside of mushroom cap.

Grain spawn: Sterile grains inoculated with mushroom culture/ spores (The mycelium sprouts from the spores and retrieves food from the grain).

Lentinula edodes: Shiitake, a Japanese common name where 'shii' refers to the tree and 'take' means mushroom.

Manual harvesting: harvesting by hand.

Mushroom: A macro fungus with visible fruit body that may be formed above or below the ground.

Mycelium: The fungal threads (comparable to plant roots) that appears as a network of white filaments which join together to form pinheads which develop into mushrooms.

Pasteurization: The elimination of all insects, pests, nematodes, harmful fungi and their spores by heating compost up to 60°C for 4-6 hours.

Pinhead: Very small initial of mushroom.

Phase-I: The initial steps in composting performed outdoors or in bunkers for button mushroom cultivation.

Phase-II: The process of composting inside tunnels for conditioning and pasteurization of compost of button mushroom.

Pleurotus: Oyster mushrooms. There are number of species of *Pleurotus* which differ in colour, shape, etc.

Spawn run: In the compost that has been mixed with grain spawn, the mycelium spreads in the compost and this is called spawn run.

Spawning: This is the process by which the spawn is mixed with ready compost. It is usually conducted in a separate room to avoid infection by other fungi and insects.

Spores: Miniscule mushroom 'seeds' that are formed in gills under the cap of the mushroom (almost impossible to see with the naked eye).

Stroma: A dense proliferation of mycelium forming on the surface of the compost and casing soil indicates vegetative and therefore non-fruiting growth.

Substrate: The material, usually organic, on which mushrooms grow.

Volvariella volvacea: Scientific name for paddy straw mushrooms that grows at high temperature range of 30-40°C.



INTEXT QUESTIONS 1.8

Fill in the blanks

- (i) Seed of mushroom is called
- (ii) Process of putting a layer of soil after spread of mycelium is called
- (iii) Process of composting before putting in tunnel is commonly called
- (iv) Process of composting inside tunnel is called
- (v) The common name of *Lentinula edodes* is
- (vi) Common name of *Agaricus bisporus* is

1.9 BASIC STEPS IN MUSHROOM CULTIVATION

Mushroom growing involves spawn production, composting, cultivation. After that we need to process and market these.

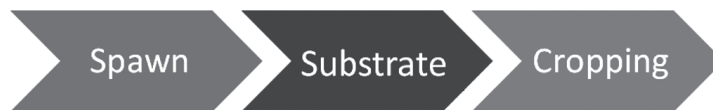


Fig. 1.10: Three steps in mushroom cultivation

Cultivation technology is different for different mushrooms. Proper knowledge on mushroom life cycle and good training of all the steps is a must before starting cultivation of any mushroom. However the basic steps are the same for majority of mushrooms (Fig. 1.10).

- The first step before starting cultivation is to procure or produce spawn of good quality.
- Second step is to prepare the substrate of good quality. As we will see in subsequent chapters that method of preparing substrate differs with the type of mushroom to be cultivated. Method of spawning, that is mixing of spawn in compost, and amount of spawn required will also vary in different mushrooms. In some cases spawn may be mixed thoroughly whereas in other cases it may be put layer wise. Spawning in some cases can be done in open under hygienic conditions whereas in other cases, particularly where the substrate has been autoclaved, the spawning can be done only under sterile conditions. We need only half kg to one kg of spawn for 100 kg of compost

Introduction to Mushroom

in button mushroom, whereas in oyster we need 2.5 kg and in milky mushroom we may require up to 5 kg spawn for 100 kg of substrate.

- The third step is cropping. After spawn run, that is allowing the fungus to spread throughout the substrate, we take steps to induce formation of mushrooms. In some cases it is required to put a layer of casing material whereas in other cases fruiting can be obtained as such. In all cases, to induce fruiting some sort of change is required. For example in case of button mushroom temperature is lowered from 25 to 17°C and carbon dioxide levels are lowered by giving fresh air. In Oyster, to induce fruiting both fresh air and diffused light is necessary.

In India, mushroom cultivation in rural areas has emerged as an important activity for educated, school dropouts, women, landless people, etc. Considering the demand for quality foods, mushroom cultivation has emerged as an important avocation. Many commercial units that grow mushrooms under controlled conditions have also been set up in different parts of our country. However, before taking up this venture a thorough knowledge of the subject and scientific aptitude towards agriculture is necessary.



INTEXT QUESTIONS 1.9

State True or False

- (i) Cultivation technology is same for all mushrooms.
- (ii) Amount of spawn required for cultivation of different mushrooms is the same.
- (iii) Both fresh air and diffused light is necessary to induce fruiting in oyster mushrooms.
- (iv) Normal concentration of Carbon dioxide in air is 1500 parts per million.



WHAT YOU HAVE LEARNT

Let us recapitulate the important points we have learnt in the lesson:

- Mushrooms are neither plant nor animal, but belong to a separate kingdom called Fungi.
- There are thousands of edible mushrooms in nature but we have succeeded in cultivating only a few.



Notes



Notes

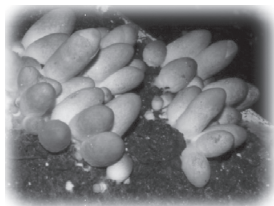
Introduction to Mushroom

- Six mushrooms namely shiitake, oyster, wood ear, button, winter mushroom and paddy straw mushroom account for 90% of the total world mushroom production.
- Different mushrooms are popular in different countries; Button is more popular in USA and Europe whereas shiitake, oyster and wood ear mushroom is more popular in East, particularly China, Japan and Korea.
- Wastes like cereal straw are burnt by farmers, which cause air pollution and these can be used to grow mushrooms, which means we not only create wealth from the waste but also are reducing environmental pollution.
- Mushroom cultivation requires labour in addition to agricultural wastes. This creates employment for farmers (during lean season), women and school dropouts and other people interested in secondary agriculture.
- Mushroom cultivation does not require much of land. These can even be grown in houses in urban and peri-urban areas.
- Mushrooms are a quality food and only vegetable having vitamin D and B₁₂.
- Basic steps in mushroom cultivation are spawn, substrate and cropping. The rate and method of spawning, method of preparation of compost and conditions required for fruiting differ from species to species.



TERMINAL EXERCISE

1. Why mushrooms cannot make their own food?
2. Name the six most important mushrooms cultivated in the world.
3. Given below are pictures of some mushrooms. These are Shiitake, Pink oyster mushroom, Oyster mushroom, Button mushroom, Wood ear mushroom, Paddy straw mushroom, King oyster, Bottle mushroom and Milky mushroom. Write correct name below each mushroom (Hint: 2. Milky mushroom).



1.



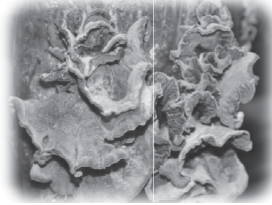
2. Milky mushroom



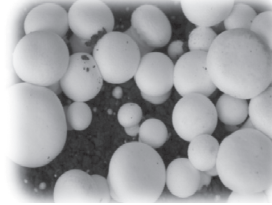
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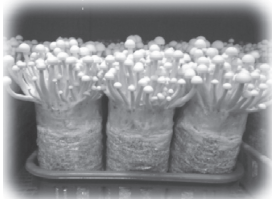
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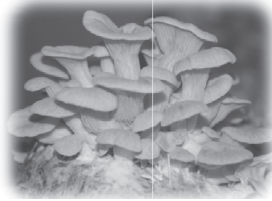
5.



6.



7.



8.



9.

4. What are the two main advantages of growing mushrooms?
5. Indicate the suitable temperature for cultivation of milky mushroom, white button mushroom, paddy straw mushroom and oyster mushroom.



ANSWERS TO INTEXT QUESTIONS

1.1

- (i) False (ii) False (iii) True (iv) False

1.2

- (i) 1500000 (ii) 200 (iii) 10

1.3

- (i) True (ii) True (iii) False (iv) False

1.4

- (i) Shiitake (ii) 60 (iii) 40 Million tonnes
(iv) Paddy straw mushroom (v) Button mushroom
(vi) Milky mushroom (vii) Oyster mushroom

1.5

- (i) 20th (ii) SMS (iii) Vertical (iv) Highest
(v) Waste



Notes

1.6

- (i) D, B₁₂ (ii) Low, High (iii) Diabetics

1.7

- (i) 30% (ii) *Militaris* (iii) *Sinensis* (iv) *Ganoderma*

1.8

- (i) Spawn (ii) Casing (iii) Phase-1 (iv) Phase-2
(v) Shiitake (vi) Button mushroom

1.9

- (i) False (ii) False (iii) True (iv) False

SUGESTED ACTIVITY

Visit nearby vegetable venders, malls and big fresh vegetable outlets and collect information on different types of fresh mushroom available there. Collect information about mushrooms available in cans or as dried. Also collect information about different mushroom products available in the market.

Key Learning Outcomes

- Display intellectual competence on the knowledge about the usefulness of mushroom in agriculture, health and industrial point of view and scope of income.
- Develop interest in mushroom cultivation.