



ON-FARM STRUCTURES FOR MUSHROOM CULTIVATION UNDER INDIAN CONDITIONS

S. J. Kale, Prerna Nath, Pankaj Kannaujia

*Horticultural Crop Processing Division, ICAR-Central Institute of Postharvest Engineering
and Technology, Abohar, Punjab, 152116*

Mushroom is a fruiting body with no photosynthesis and vascular system like green plants. Many species of mushrooms such as straw mushroom (*Volvariellavolvacea*), button mushroom (*Aaaricusbisporus*), oyster mushroom (*Pleurotostreatus*), paddy straw mushroom, milky mushroom etc. Are grown all over the world depending upon the climatic conditions. Mushroom can be grown taking the advantage of huge agricultural waste which help in promoting and supporting the growth of mushrooms (Senyah and Robinson, 1989). Mushroom has high nutritional value due to rich composition of good quality vitamins (B1, B2 and C) and minerals such as phosphorus, sodium and potassium (Oei, 1996). Increased mushroom cultivation and its consumption would help to raise the nutritional standard of Indian population by providing as upper fluous source of protein (20 to 45 percent), valuable minerals and vitamins. Mushroom has good medicinal value and is also used to bio-remediate polluted soils, it helps in activating intestinal peristalsis thereby preventing constipation.

In India, mushroom cultivation is yet to be popularized. However, some of the states like Himachal Pradesh, Haryana and Punjab grow mushrooms. Button mushroom is the most cultivated mushroom type in the country. It contributes almost 85% of the total production. Button mushroom is mostly cultivated in temperate regions whereas oyster, milky, paddy straw and other tropical mushrooms are grown in tropical and sub-tropical regions. A season (from October to March) gives 2 to 3 crops of button mushroom in temperate regions whereas oyster, paddy straw and milky mushrooms are cultivated in tropical and subtropical regions from April to October. Mushrooms can be cultivated in open conditions i.e. naturally or in closed conditions i.e. controlled environment for all the year round in the commercial units.

Conditions for growing mushrooms

Mushroom grows properly only when the desired microclimate is provided inside mushroom growing structures. Temperature control inside mushroom house is very essential because temperature affects the growth as well as quantity and quality of fruiting bodies. Button mushroom requires 22-26°C temperature during vegetative growth (mycelium growth) and 14-18°C during reproductive growth (fruiting). Deviation from these desirable temperatures seriously affects the quality and quantity of button mushroom. Oyster (*Dhingri*) mushroom grows satisfactorily when the temperature inside mushroom structure is maintained at 25-35°C. Cheng and Hayes (1978) reported that different microclimatic factors such as temperature, humidity, pH, aeration and light may affect substrate efficiency.

Structures for mushroom cultivation

In early days of mushroom cultivation, mushrooms used to be cultivated outdoors. Mushroom farmers in the regions with favourable conditions for mushroom still grow mushrooms under natural conditions. But farmers who grow mushrooms on large-scale, commercial level cannot rely on the natural environment. Most of these farmers build mushroom growing structures which are either simple, temporary structures or retrofit an existing structure or permanent buildings. It is well understood that providing good conditions for mushroom can lead to higher yield. The major role of a mushroom structure is to provide favourable conditions for mushrooms and protect them from adverse environmental factors such as harsh weather, pests, pathogens and pollutants. Better mushroom structures perform these tasks effectively. Ideal mushroom structure is well insulated and well ventilated and provides desirable temperature and humidity.

In this context, an attempt has been made to discuss various types of mushroom structures in this paper which may provide guidance to the mushroom growing farmers during construction of their structures.

Site of the structure

The selection of suitable site for mushroom structure is very important, especially when building a simple, makeshift structure where the crop yield is mostly dependant on the environmental conditions of the growing site. The major factors that should be considered when selecting a mushroom production site are as follows.

1) Climate conditions

Optimal growing conditions vary depending upon the mushroom varieties. Button mushroom is generally preferred in cold conditions. High altitude regions provide colder environment. Hence, farmers who want round the year cultivation need to build their structures in highland areas that are cooler than other lowland areas during summer. Some large-scale commercial farmers build well-insulated growing houses, in which all the room conditions i.e. temperature, humidity and CO₂ concentration are controlled automatically. By selecting an ideal site, farmers with these types of growing structures can also minimize the cost required for maintaining desired room conditions.

2) Water

Mushrooms contain about 90% of water and are best grown at high humidity conditions, (80-90% RH). Mushroom cultivation requires large quantity of water, especially during dry spell. Mushroom farmers need continuous water supply when they prepare compost, water the compost to maintain constant high humidity, water the mushroom bags, or clean the rooms. Therefore, a site with a secure access to water source is very essential.

3) Environmental safety

Air-borne pollutants, chemicals and effluents could be detrimental to the mushrooms and the health of farmers as well. Locations near industrial complexes, waste incineration facilities, brick kilns or sewage treatment plants should be avoided.

4) Market

Mushrooms are highly perishable. The price of mushrooms depends on their quality, especially their freshness. Once mushrooms lose their freshness, their marketability and price drops drastically. Therefore growing site should be near to the markets to get more money by selling mushrooms as fresh as possible.

Different structures for mushroom cultivation

Various types of mushroom structures are used in different parts of the world. Mushroom structures are mostly classified as temporary structures and permanent structures. Temporary structures are not durable and are built using locally available materials whereas permanent structures last for considerable period of time. Generally, easily/locally available materials such as wood, bamboo, steel pipes, bricks, plastic, blankets, leaves, straw, thatch, hay etc. are used for the construction of temporary structures. Some farmers build simple structures with readily available materials. When and where environmental conditions are within acceptable temperature and humidity ranges, a simple, open-type structure made from any available material is found enough. However, if the environmental conditions are adverse farmers need to construct a closed-type structure in which room conditions are less affected by outdoor weather conditions. Different types of structures developed from different construction materials have been discussed here.

1. Outdoor cultivation

In this type of cultivation, mushroom is cultivated under open conditions (Fig.1a). Compost is kept open but sometimes it may be covered with plastics after fruiting. This type of cultivation requires no investment in constructing a structure and found suitable for poor and tribals. It is very primitive type of mushroom cultivation and it does not found suitable in adverse climatic conditions.

2. Readily available buildings

Many farmers use readily available buildings like godowns, warehouses (Fig.1b), cattle houses etc. for mushroom cultivation. Such structures do not require any investment. These structures are used for mushroom cultivation during cropping season only. Small and poor farmers can use any existing room/structure to cultivate mushroom during suitable season. Sometimes appropriate cooling arrangements need to be provided in such structures during cultivation.

3. Structures from locally available agricultural materials (Thatch houses)

Locally available agricultural materials like bamboo, woods, grass, banana leaves, sugarcane bagasse, straws from wheat, paddy etc. are used to construct thatch houses. These materials serve as good construction materials. Thatch houses are the most widely found simple growing structures. They are air permeable, thermo-insulating, lightweight and highly pliable. These structures are cheap and can be constructed from any suitable agricultural wastes. These structures found to be efficient in providing desirable microclimatic conditions. However, they are susceptible to entry of contaminants, pests, diseases etc. from outside which can deteriorate mushroom quality. Some insects spread mushroom diseases. Other pests including snails and rats and their predators like snakes gnaw and eat away mushrooms, substrate bags and even growing houses. Many farmers in Haryana and Punjab use these types of structures as shown in Fig.2. These are temporary structures and need to be constructed and repaired again and again.

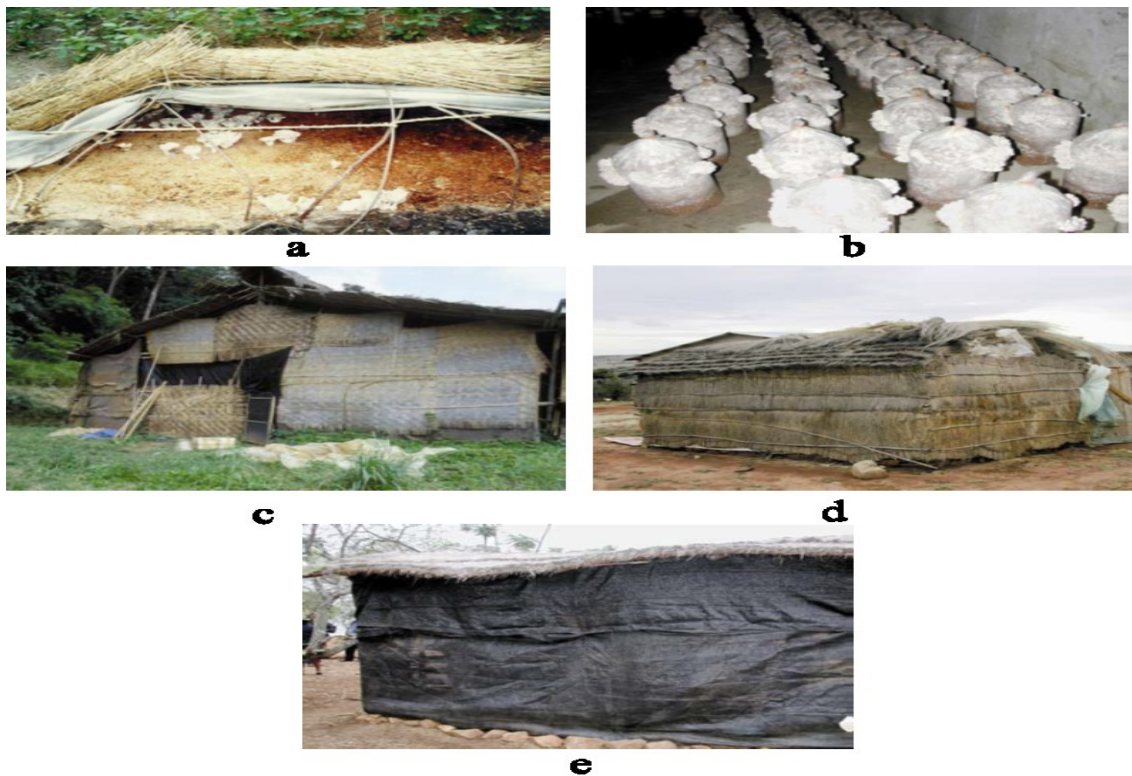


Fig. 1 (a) Outdoor straw mushroom cultivation, (b) A warehouse-turned mushroom structure (c) Bamboo matting house, (d) Thatch mushroom structure, (e) Thatch mushroom structure draped by shade cloth (Source: Kwon *et al.*, 2004)



Fig.2 Structures from locally available agricultural materials in Haryana and Punjab (Photo courtesy: S. J. Kale)

4. Improved thatch houses

Shortcomings of thatch houses are addressed in improved thatch houses. These structures are provided with appropriate sheltering, insulation, screening, barriers and other materials that could be readily placed on the structures. Installing proper physical and chemical protective barriers is recommended for these thatch houses. These barriers protect the structure from biotic as well as abiotic factors. Protective barriers include fencing, shade net (Fig.3a), insect net (Fig.3b), plastic sheeting, rodent repellent etc.

5. Brick and clay houses

Thatch wears out within a few years. Once it begins to leak, the thatch structure need to be renewed. Also, thatch structures are not found reliable in heavy rains and storms. Commercial scale farmers want more durable growing structures that are suitable for all seasons. Clay and bricks (Fig.3c) are found better options over agricultural wastes as they allow for good insulation, ventilation and prevention from pests and diseases. Walls of such structures are made of bricks and clay whereas any suitable material is used for the roof depending upon material availability and their preferences. Such structures are provided with ventilation openings in order to ensure frequent air-exchanges.

6. Ventilated structures with pitched roof

The open type structure with pitched-roof permits good ventilation (Fig.3d). Higher rate of air exchange helps in cooling of structure. However, the control of humidity in this structure is not easy when the weather is too dry or too wet. The system requires more water than other closed-type structure because of its greater evaporation water loss. Such structures are suitable in humid regions like coastal regions.

7. Steel structures draped by a plastic covering

These draped structures (Fig.3e) are more insulated from outside weather conditions, but are still simple structures. The proper covering provides a good insulation and a high humidity holding capacity for the structure but farmers need to pay close attention to temperature, ventilation - removal of excess carbon dioxide and supply of oxygen.



Fig. 3 (a) Thatch house with shade net, (b) Thatch house with insect net (c) Thatch house with brick walls, (d) Steel frame structure with roof, (e) Steel structure covered with tarpaulin/plastic (Source: Kwon *et al.*, 2004)

8. Permanent mushroom structures

The various structures described above are temporary in nature and vulnerable to various biotic and abiotic factors that affect quality and growth of mushroom. Therefore, these structures may not be suitable for round the year cultivation as well as large scale mushroom cultivation. Sustainable production and a constant supply of harvestable mushrooms are important for successful marketing that can provide farmers a sustainable income. In order to achieve sustainable production of mushroom, in some parts of the world with adverse climate conditions and varying seasons,

well insulated growing structures are essential. Farmers invest considerable amount of money to set up such growing houses and provide an ideal microclimate for the growth of mushrooms to produce the highest yields possible. Such structures require more input cost and higher technology to set up but provide better drainage, ventilation and temperature control.

In these closed-type permanent structures (Fig.4), temperature, humidity and CO₂ concentration are monitored and controlled at all the times. Such structures are equipped with sensors and controllers to maintain desirable microclimate. These structures are durable, simple insulation houses and last for 15 years or even more.



Fig.4 Permanent mushroom structures

9. Mushroom polyhouse

An ideal mushroom structure may not be a high-tech, high-cost structure with all automatic controls. The most desirable characteristic of mushroom structure is preventing possible pests and pathogens and maintaining desirable temperature, humidity and air exchanges. Hence, in recent years, mushroom is being cultivated in specially designed polyhouses (Fig.5) which provide all the desirable characteristics. Such mushroom polyhouses are quite popular in China whereas In India, farmers are still unaware of polyhouse cultivation of mushrooms.

Mushroom does not require sunlight for photosynthesis therefore; mushroom polyhouses are covered with insulation sheet to avoid heat gain from outside. Such structures are provided with an arrangement for ventilation, evaporative cooling, shade nets, insect net etc. Mushroom polyhouses require lesser capital investment as compared to permanent mushroom structures. They are durable, and with proper maintenance can be last for 10-15 years. Using mushroom polyhouses, farmers can cultivate different mushrooms round the year.

Mushroom polyhouse structure at ICAR-CIPHET Abohar, Punjab

Abohar is located in hot and arid region of Punjab. In this region, some of the farmers grow button mushroom from November to February. However, they are able to grow only one crop during season due to



Fig.5 Mushroom polyhouse structures

unfavourable climatic conditions. Also, cultivation of oyster mushroom in the region is found difficult during April-August as temperature in the region is very high and humidity drops considerably (From April-June). In order to increase the cultivation season of button mushroom and to provide favourable conditions for oyster mushroom, a specially designed mushroom polyhouse structure (Fig.6) was constructed at ICAR-Central Institute of Postharvest Engineering and Technology (CIPHET), Abohar, Punjab. This polyhouse is insulated from external environment using thermal insulators and polythene. It is also provided with an evaporative cooling arrangement (foggers and cooling pads) to control the temperature and humidity. A pasteurization unit, in the form of polytunnel, is provided with the structure to prepare the compost at elevated temperature.

As a fungus, mushroom needs moist environment and moderate temperature to flourish therefore, humidity needs to be controlled in dry regions. The mushroom polyhouse constructed at ICAR-CIPHET Abohar is found suitable to provide moist environment with reduced temperature.

Fig.6 Mushroom polyhouse at ICAR-CIPHET, Abohar (a: mushroom polyhouse, b: pasteurization unit, c: inside view of mushroom polyhouse) (Source: Kale et al, 2018)



Summary

In India, states like Himachal Pradesh, Haryana and Punjab grow mushrooms. Button mushroom is the most cultivated

mushroom type in the country contributing almost 85% of the total production. It requires 22-26°C temperature during mycelium growth and 14-18°C during fruiting whereas Oyster mushroom grows satisfactorily at 25-35°C. Appropriate mushroom structure is essential for successful mushroom farming.

The mushroom structure should be located at a site with secure source of water, desirable climatic conditions, safe environment and access to market. Various types of mushroom structures are available ranging from very simple to the state-of-the-art structures providing controlled environment.

However, in recent times, protected cultivation of mushrooms in polyhouse structures is gaining popularity due to their efficacy in providing desirable temperature, humidity, ventilation and air-exchanges which are essential for mushroom growing.

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