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Full Length Research Paper

Cultivation of the oyster mushroom (*pleurotus ostreatus* (jacq.) p. kumm.) in two different agro-ecological zones of Pakistan.

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The current study describes the possibility of small-scale production facility for *Pleurotus ostreatus* under two different agro-ecological regions (Peshawar and Swat of Khyber Pukhtoon Khwa of Pakistan). Different growth parameters such as spawn running time, number of crops, stalk height, stalk diameter, cap size, fresh weight, number of production days and the interval in days between the time of bag opening and the time of starting fruiting bodies formation have shown promising results in both areas. Mean comparison of the two locations indicated that, 4 of the 7 parameters including stalk height, stalk diameter, cap size and fresh weight had greater values at Peshawar when compared with Swat. In contrast, the spawn running time, that is, mycelium growth took much longer time (84 days) at Swat compared with Peshawar (44 days). Formation of fruiting bodies at Swat was found later (7 days) than that of Peshawar (4 days). Similarly, the production period (70 days) at Swat exhibited much longer in contrast to Peshawar (49 days). The study concluded that mild winter temperatures of Peshawar region and low summer temperatures in Swat were found most conducive times of the year for growth and yield of *Pleurotus ostreatus.*

Key words: *Pleurotus ostreatus*, agro-ecological zones, growth parameters, productions.

INTRODUCTION

Small-scale mushroom production represents an opportunity for farmers interested in an additional enterprise and is a specialty option for farmers without much land. Mushroom production can play an important role in managing farm organic wastes when agricultural and food processing by-products are used as growing media for edible fungi. The used substrate can then be composted and applied directly back to the soil. Fungi have been at work since life began on earth. Mushrooms are freshly spore bearing fungi and their edible nature is the main attraction to man as a source of food. In several cases, wild verities of edible mushrooms were found less tasty and unpalatable. However, mushrooms are known to have a broad range of uses both as food and medicine (Alice and Kustudia, 2004). The complex and varying morphology, chemical composition, and biological activity of mushrooms attracted the attention of scientists. Among edible mushrooms, *Pleurotus pulmonarius* and *Pleurotus ostreatus*, exhibited strong anti-inflammatory and immunomodulatory properties due to their chemical composition (Lavi et al., 2010; Selegean et al., 2009), while *Morchella elata* showed highly potent radical scavenging activity (Kalvoncu et al., 2010). Grifolin derivatives isolated from *Boletus pseudocalopus* (Basidiomycetes) possessed anticancer and moderate radical scavenging activities (Song et al., 2009). Many mushrooms such as Hedyotis species, *P. ostreatus* and *M. giganteus,* were found to be active against bacteria and yeast (Kalvoncu et al., 2010; Ahmad et al., 2005), while *Galerina autumnalis*, *G. marginatus*, *G. venenate*, *Lepiota josserandii*, *L. helveola*, *L. castanea*, and *Amanita*

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smithiana were found toxic and contained dangerous toxins (West et al., 2009; Danel et al., 2001). The toxicity of *Cortinarius speciocissimus* was attributed to its poisonous chemical constituent orellanine which caused irreversible kidney damage (Münstermann et al., 2002). Phallolysin isolated from *Amanita phalloides* was found to be a haemolytic toxin (Erguven et al., 2007; Stijve and Seeger, 1979; Seeger, 1975), while *A. phalloides* was reported as life threatening poison because it causes acute multiorgan failure (Hydzik et al., 2005). In an earlier study conducted in Swat (Pakistan), amatoxin was established to be the main toxic compound of mushrooms from Swat region (Pakistan) which was responsible for gastro-intestinal symptoms as well as hepatic and renal failure (Jan et al., 2008).

The cultivation of oyster mushroom (*P. ostreatus*) on different substrates was found to influence its growth. Thus, making mushroom cultivation a rewarding agri-business in Pakistan, that might improve the economic status of farmers (Flores, 2006; Sher, 2006; Shah et al., 2004; Alam and Raza, 2001). Awareness about mushroom has significantly increased in Pakistan during the past two decades. It has been taken up as a part of household agriculture while some farmers are growing mushroom on commercial basis as well. The National logistic cell in Pakistan has already taken the initiative to grow mushrooms in Islamabad and Swat areas and has reached an annual production capacity of 48 tons. About 80% of which is meant for export to earn foreign exchange (Alam and Raza, 2001; Akhtar, 1992). In view of the growing importance of mushroom in the country, the current study was carried out with the aim of testing the suitability of *P. ostreatus* cultivation and to compare its growth and yield in two different agro-ecological conditions region of Pakistan.

MATERIALS AND METHODS

P. ostreatus (Jacq.) P. Kumm.

Both the scientific and common name refers to the shape of the fruiting body. The Latin *pleurotus* (sideways) refers to the sideways-growth of the stem with respect to the cap, while the Latin *ostreatus* and the English common name, oyster, refers to the shape of the cap which resembles the bivalve of the same name. *P.ostreatus* has a broad, fan or oyster-shaped cap spanning 5 to 25 cm; natural specimens range from white to gray or tan to dark-brown; the margin is inrolled when young and smooth and often somewhat lobed or wavy. The flesh is white, firm and varies in thickness due to stipe arrangement. The gills of the mushroom are white to cream and descend on the stalk if present. If so, the stipe is off-center with a lateral attachment to wood. The spore print of the mushroom is white to lilac-gray and best viewed on dark background.

Experimental procedure

The experiment was conducted in two locations with different climatic conditions which include, Khwazakhela area of district Swat with an altitude of 1000 meters above sea level (MASL) representing temperate zone and Hayatabad area of district Peshawar, with an altitude of less than 200 MASL representing sub-tropical zone, in Khayber Pkhtoon Khwa region of Pakistan (NWFP 2003). The study was conducted during winter and summer seasons of 2007 and 2008.

Oyster mushroom can be grown on various substrates including paddy straw, maize stalks/cobs, vegetable plant residues, etc. Since paddy straw is easily available and cheap, it is widely used. Paddy straw should be fresh and well dried. However, the current study used wheat straw which was purchased from a local market. It served as a compost and substrate on which the selected mushroom species are known to grow up with good performance (Sher, 2006). On November 15, 2004, 96 kg of wheat straw was thrashed in to small pieces and soaked in boiling water for 25 min. In this step, the risk of substrate contamination used was eliminated. The excess water was then carefully drained out in such a way that the compact contained about 50% moisture. In each case, one set each of 24 polyethylene bags (16 x 12 sq. inch size), was filled with 2 kg of the compost material. Each bag was slightly pressed down and tightly rapped with a rubber band.

For the current study in the defined areas, ready made standard spawn was obtained in polyethylene bags from the “Agriculture Research Station Swat”. After sterilization with boiling water (24 h), the wheat straw was inoculated with spawn in both locations. The spawn was placed in a small cavity of appropriate size on the upper side of each compact. All bags after inoculation were then closed tightly again with rubber bands and kept in a dark place (under real room conditions) in both locations. A trial experiment was conducted prior to the detailed study.

In Peshawar, all bags were opened on January 29, 2007 (44 days after inoculation) while in Swat, bags opening was carried out on May 11, 2008 (84 days after inoculation) in order to facilitate formation of the fruiting bodies. No watering was required during spawn running period because the wheat straw compact was tightly covered in polyethylene bags, which helped in maintaining sufficient moisture level during this experimental period. However, after opening of bags, the loss of moisture through evaporation was compensated by moistening the compact twice a day. Based on the fact that temperature, humidity and fresh air are the basic requirements for proper growth of mycelium, these factors were regularly monitored during the whole investigation period in both experimental locations. The maximum and minimum temperatures and humidity were regularly recorded on daily basis during the trial duration. All the mean valves for 7 parameters: spawn running time (days), number of crops/bag, stalk height (cm), stalk diameter (mm), cap size (mm), fresh weight (gm), number of production days and the interval in days between the time of bag opening and the time of starting fruiting bodies formation, were recorded according to standard protocol defined earlier (Sher, 2006).

RESULTS

Mean maximum, minimum and relative humidity persisting at the two experimental sites, Peshawar and Swat, during the trial period (December, 2007 to June, 2008) are presented in Figure 1. Maximum and minimum temperatures and relative humidity at the two sites varied greatly. Mean maximum and minimum temperatures, and the relative humidity at Peshawar remained consistently higher than that at Swat in almost all the 7 months of testing period. Figure 2 shows the instrument used in measuring these differences. The differences in minimum temperatures between the two locations were much greater than their corresponding maximum temperatures for each of the 7 months (NWFP, 2003). The results of

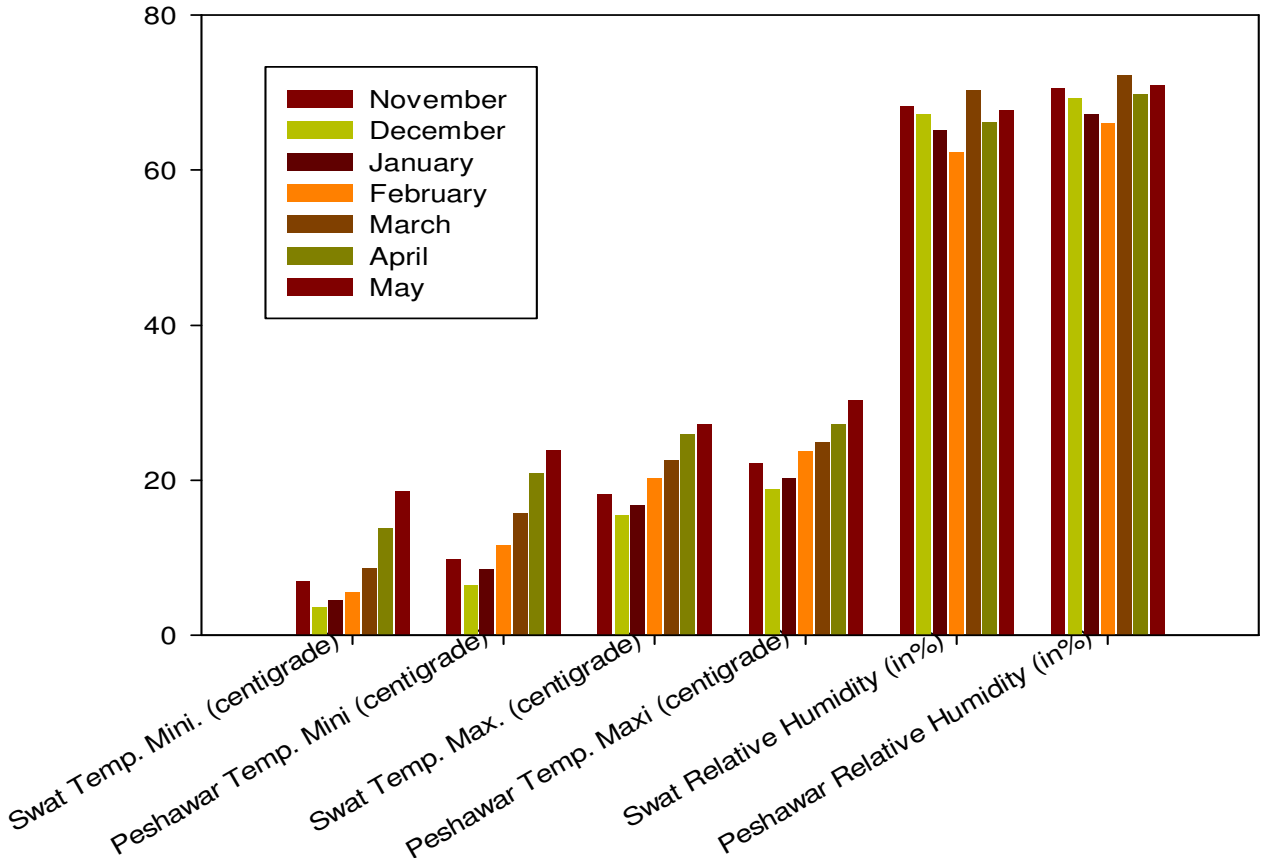

Figure 1. Mean monthly temperature (OC) and relative humidity at Swat and Peshawar from December, 2007 to June, 2008. Temperature in both locations was measured by degree centigrade, while relative humidity was measured in percentage.

Figure 3. Instruments used for the measurement of temperature and relative humidity.

mean values for seven standard parameters (Sher, 2006) are presented in Figure 3 for both locations (Swat and Peshawar).

Both locations were found different from one another for all 7 parameters except for the number of crops/bag, where no appreciable difference between these locations was observed (6.5 crops/bag for Peshawar versus 6.7 for Swat, respectively) (Figure 3). Mean comparison of the two locations indicated that, 4 of the 7 parameters namely, stalk height, stalk diameter, cap size and fresh weight had greater values for these parameters at Peshawar when compared with those found in Swat. In contrast, the spawn running time (Mycelium growth) took much longer (84 days) at Swat when compared with that at Peshawar (44 days). Formation of fruiting bodies (upcoming crop) at Swat was found later (7 days after opening of bags) than that at Peshawar (4 days after opening of bags). Similarly, the production period of 70 days at Swat appeared to have been much longer than that of Peshawar with 49 days for this parameter (Figures 4 to 6).

DISCUSSION

Various mushrooms are known to be sensitive to the

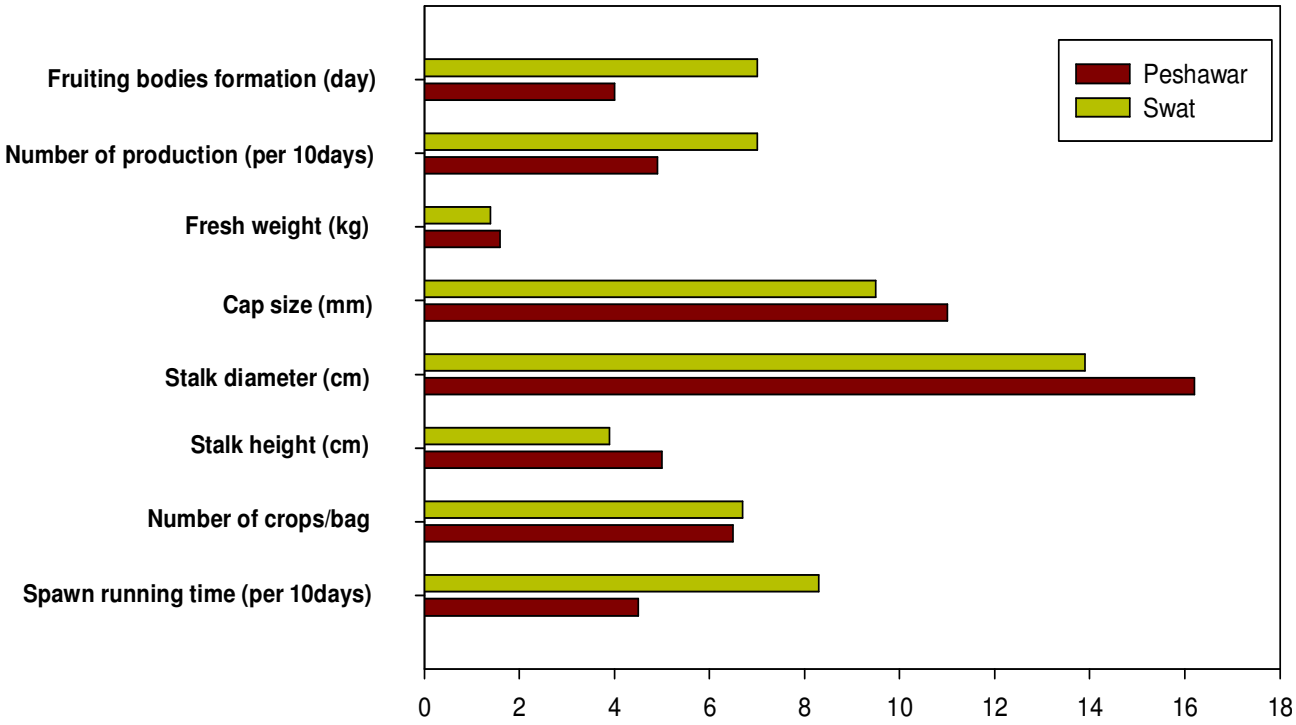

Figure 3. Mean values for spawn running time, number of crops/bag, stalk height, stalk diameter, cap size, fresh weight, number of productions and fruiting bodies formation observed at Peshawar and Swat during 2008.

Figure 4. Ready for harvesting in both regions.

climatic conditions (Van Peer et al., 2009; AMGA, 2004). In cultural conditions, high temperature tolerance of vegetative mycelia of *Lentinula edodes* strains was investigated. Mycelium of long culture age (70 days) showed significantly higher temperature tolerance when compared with mycelium of shorter culture ages of 14 and 30 days (Mahmud and Ohmasa, 2008). During the present investigations, differences for the mean maximum and minimum temperatures and the relative humidity observed between the two locations are not surprising, since these locations greatly differ in their altitudes and latitudes. The experimental site at Swat is located in the north of Khyber Pakhtunkhua, Pakistan with an altitude of 1000 meters above sea level (MASL) while, Peshawar is situated in the plains with an altitude of less than 200 MASL. Peshawar has milder winter in the months of November to May of the year when compared with lower temperatures and lower relative humidity at Swat during the same months of the year.

The major ecological factors that affect stalk height, stalk diameter and cap size in mushroom are temperature, humidity, fresh air and compact material (AMGA, 2004; Stamets, 1993; Schmidt, 1983). The lowest temperature and drought condition reduced the stalk height and cap size of mushroom (Haugen, 1998). The mild winter temperatures of Peshawar were probably more conducive for the growth of *P. ostreatus* when compared with lower temperatures at Swat. Our results are in agreement with the earlier reports where environmental factors were demonstrated to affect the growth of mushroom (Alexander et al., 2002a). However, in the present study, the non-existence of any appreciable difference between number of crops per bag in Peshawar and Swat was contradictory to the earlier findings where temperature was reported to affect the emergence percentage of

Figure 5. Sprouting at Swat region of Pakistan.

Figure 6. Sprouting at Peshawar region of Pakistan.

mushroom cultivars (Block et al., 1958).

The differences in the spawn running time (Mycelium growth) in the two specified locations indicated a strong positive relationship between temperature and the growth of mycelium, that is, the higher the temperature, the faster the growth of the mycelium resulting to shorter spawn running time. The results of our current experiment are substantiated by the results of earlier reports recommending optimum temperature for mycelium growth inside the spawn development room (Chandra and Perkaysth, 1977). Furthermore, similar results were also reported by other workers which added support to our observations (Chang and Miles, 2004). Lower temperatures and relative humidity could be the plausible explanation for the longer time required for the formation of fruiting bodies after opening of bags under Swat conditions when compared with those of Peshawar environment. It is worth mentioning that both temperature and relative humidity were lower at Swat when compared with Peshawar. Our results are well supported by an earlier report defining both temperature and humidity playing an important role in the spawn development (Bano and Srivastava, 1974). In the present study, the production period of mushroom under Swat condition was found to be considerably longer than that of Peshawar. Such differences could be attributed to spring season optimum temperatures of Swat as more favorable for the longer period of crop production for oyster species when compared with hot season temperatures at Peshawar during the month of May. These results are in conformity with those reported earlier, thus, verifying that certain variations in season seriously affect the number, weight and crop production period of mushroom (Das and Singh, 1991; Das and Singh, 1987). In addition, it was reported that favorable temperature and moisture conditions enhanced the production of fruiting bodies of mushroom (Das and Singh, 1991).

Conclusion

Based on the results of current study, it was concluded that the environmental conditions of Peshawar during winter months were more suitable for cultivation of oyster mushroom when compared with those at Swat. Furthermore, the current experiment further supported the fact that, both growth and yield of oyster mushroom under ecological conditions in the plains of Peshawar were higher at high altitudes in the valley of Swat. Nevertheless, there is potential for an innovator who can use an existing facility, obtain a low-cost substrate and produce a reliable supply of a high quality product. As part of a whole-farm system, mushrooms can augment productivity at any scale. Producing a nutritious food at a profit while using materials that would otherwise be considered "waste," constitutes a valuable service in the self-sustaining community we might envision for the future. It is a challenge some will find worth taking.

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