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Effect of Phyto-Extracts on Growth and Yield of Oyster Mushroom

Ashok C. Jadhav* and N. V. Kokate

All India Coordinated Research Project on Mushroom, College of Agriculture, (Mahatma Phule Krishi Vidyapeeth, Rahuri, Pune, M.S., India

**Corresponding author*

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A B S T R A C T

The experiment on effect of phyto-extracts for control of *Trichoderma* mould in oyster mushroom cultivation was conducted to study the efficacy of different phytoextracts against *Trichoderma* mould on growth and yield of oyster mushroom. Results indicated that the minimum days required for spawn run and pinhead formation were recorded by Carbendazim + Formalin (16.33 and 20.33 days) where as among the phytoextracts, T_6 *Azadirachta indica* @ 6% required 17.00 and 21.33 days respectively. Maximum days were recorded for the treatment *Ocimum sanctum* @ 4% (22.67 and 26.33 days). The time taken for harvestings ranged from 24.00 to 53.67 days for the total three harvesting. The results showed that number of fruits per beds varied from 10 to 68.67 in the first, second and third harvest due to different treatments. The treatment T_{13} Carbendazim + formalin was found significantly superior over all treatments. The variation in average fruit body weight (3.23 to 6.67 g per fruit), pileus diameter (4.93 to 7.37 cm), stipe length (1.40 to 2.60 cm) and stipe size (2.43 to 3.87 cm) was noted for the different treatments. The observations on yield performance due to different treatments revealed that Carbendazim + Formalin produced maximum yield of oyster mushroom (965.78 g/kg dry substrate). Among the phytoextracts, *Azadirachta indica* @ 6% produced maximum yield (809 g) while minimum yield (556.78 g) was recorded due to *Ocimum sanctum* @ 2%. The observation on biological efficiency indicated that Carbendazim + Formalin had recorded maximum biological efficiency (96.57%) followed by the treatment T_6 *Azadirachta indica* @ 6% (80.90 %) while T_7 *Ocimum sanctum* @ 2% had recorded minimum biological efficiency (55.67%).

Introduction

The mushrooms occur naturally in fields, forest, manure heaps, water channels and hilly areas, mostly during and just after rains. The most popular varieties are European or white button mushroom (*Agaricus bisporus*), Oyster mushrooms or dhingri (*Pleurotus* sp.), Chinese or paddy straw mushroom (*Volvariella volvacea*), Shiitake mushrooms (*Lentinus edodes*) and Black ear mushroom (*Auricus laria*) (Bhatti *et al.,* 2007).

Oyster mushroom (*Pleurotus* sp.) IS popularly known as 'dhingri' in India and grows naturally in temperate and tropical forests on dead and decaying wooden logs or sometimes on dying trunks of

deciduous or coniferous woods. It may also grow on decaying organic matter.

The fresh fruiting bodies of oyster mushroom, *Pleurotus* spp., indicates a large quantity of moisture (90.8%), whereas fresh as well as dry oyster mushrooms are rich in proteins (30.4%), fat (2.2%), carbohydrates (57.6%), fiber (8.7%) and ash (9.8%) with 345 K (cal) energy value on 100 g dry weight basis; while it contains vitamins such as thiamin (4.8 mg), riboflavin (4.7 mg) and niacin (108.7 mg), minerals like calcium (98 mg), phosphorus (476 mg), ferrous (8.5 mg) and sodium (61 mg) on 100 g dry weight basis (Pandey and Ghosh, 1996).

Like all other crops, mushroom cultivation (from spawn preparation to harvesting) are also affected adversely by a large number of biotic and abiotic agents/ 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 the cultivation of oyster mushroom. Many of these act as competitor moulds thereby adversely affecting spawn run whereas others attack the fruit bodies at various stages of crop growth producing distinct disease symptoms. At times there is complete crop failure depending upon the stage of infection, quality of spawn and environmental conditions.

During the preparation of grain spawn, it is infected by many pathogens. The worst contaminants are usually moulds *viz., T. harzianum, T. viride, A. niger, A. flavus, Fusarium* sp., *Penicillium* sp. etc. They found to infect the grain spawn. However bacteria and yeasts can also be a problem, especially when attempting to isolate pure culture from natural population of mushroom.

Many mushrooms such as *L. edodes* (shiitake), *Agaricus* (button), *Pleurotus* (oyster), and *Volvariella* (straw) are affected by fungal and bacterial diseases. *Trichoderma* and *Pseudomonas* spp. are important causal agents and incur significant yield losses (Badham, 1991).

Aspergillus flavus grows on practically all types of grain. This species is of serious concern to mushroom spawn producers. Careful handling of any molds, particulary those of the genus *Aspergillus* and *Trichoderma* should be a primary responsibility of all managers and workers in mushroom farms.

For avoiding this type of contaminants, management of contaminants is necessary. Management of contaminants *in vitro* and *in vivo* can be carried out by two ways, by using chemical and using botanicals.

In the case of chemicals *viz.*, Carbendazim+ Formalin can be used while in the case of botanicals, extract of ghaneri (*Lantana camera*), neem (*Azadirachta indica*), tulsi (*Ocimum sanctum*), nilgiri (*Eucalyptus* spp.) from the leaves can be used.

Hence, the present research was planned to isolate and identify *Trichoderma* mould infecting oyster mushroom cultivation and to evaluate the inhibition efficiency of different plant extracts and chemicals against the *Trichoderma* mould with the objectives as to survey for *Trichoderma* disease incidence in different oyster mushroom farms in Pune district, isolation of *Trichoderma* sp. infecting oyster mushroom and i*n-vivo* evaluation of phyto-extracts in oyster mushroom cultivation.

Materials and Methods

The present study was carried out at All India Coordinated Research Project on Mushroom, College of Agriculture, Pune (MS) and the pure quality spawn of *Pleurotus sajor caju* (DMRP-112) was also obtained from this centre.

The phytoextracts of *Lantana camera* (Ghaneri), *Azadirachta indica* (Neem), *Ocimum sanctum* (Tulsi), *Eucalyptus sp* (Nilgiri) were used for screening against the test fungus. These botanicals were obtained from the farm area of College of Agriculture, Pune.

Preparation of phyto-extracts

For preparation of phyto-extracts, 100 g plant products were collected, washed in distilled water, air dried and homogenized with equal amount of distilled water (100 ml) by crushing them with electric grinder machine. The extract was filtered through double-layered muslin cloth and centrifuged at 4000 rpm, for 10 minutes. The supernatant was collected and filtered through Whatman No.1 filter paper which was considered as standard solution.

In-vivo study

Substrate preparation and sterilization

Wheat straw was taken as substrate for cultivation of oyster mushroom. Wheat straw was then filled in gunny bags and soaked into the solution containing appropriate concentration of phyto-extracts and chemicals separately for 16-18 h in fresh water. After soaking, the excess water was allowed to drain off. Untreated wheat straw was used as control.

Bed filling and spawning

Spawn prepared on wheat grains was used for spawning @ 2 per cent on wet weight basis of the substrate. Layer spawning was done in polythene bags of size 35 × 55 cm. The bags were filled with substrate @ 3 kg per bag. After spawning, the top of polythene bag was tied with thread and about 25 to 30 holes with sterilized pin were made per polythene bag for proper aeration. The spawned bags were then incubated at room temperature for spawn run and observations regarding spawn run were recorded at regular intervals.

Incubation and spawn run

After bed filling the beds were kept for incubation at incubation room. Sufficient amount of light, proper ventilation, optimum temperature (i.e. 25 to 28°C) and required humidity (i.e. 70 to 85 %) was maintained during entire cropping period. Beds took near about 15 to 22 days for complete spawn run and then transferred to growing room having controlled conditions as that of incubation room.

Cropping

The bags were cut opened when wheat straw was fully covered with whitish mycelium to expose the substratum surface for initiation of pinheads. The beds were then kept on racks. The environmental conditions *viz.*, temperature (25 to 27°C), relative humidity (70 to 80 per cent) and diffused light during day time were maintained for primordial formation and fruit body development. Ventilation of 2 to 3 hours per day was given for maintaining CO_2 level in the growing room and observations regarding days required for pinhead formation were taken at regular intervals. Light spray of water was given to beds twice in a day till the end of cropping seasons. Watering was stopped a day before harvesting.

Harvesting

Fruiting bodies were harvested at full maturity. Mature fruiting bodies were those which started forming spores but the margins of pileus become wavy. The fruiting bodies were harvested when it has curled under edges and well formed gills, because over matured fruit body is fragile and difficult to handle. Harvesting was done by twisting the mushroom fruit body at its base. After first harvest, beds were scrapped slightly to remove dead mycelial growth then observations on second and third flushes were taken. Harvested fruiting bodies per bed were collected and fruit body weight was recorded by using electronic balance.

Yield and biological efficiency

Fresh yield performance of *Pleurotus sajor caju* on wheat straw substrate was recorded up to third harvest. The total yield due to different treatments was recorded as g per kg dry wheat substrate used. The yield obtained per bed was expressed in terms of biological efficiency (B.E.) and calculated using following formula (Chang *et al.*, 1981)

$$\text{Biological Efficiency (BE \%)} = \frac{\text{Fresh weight of mushroom}}{\text{Dry weight of substrate used}} \times 100$$

Experiment Details

The experiment was laid out with total fourteen substrate treatments *viz;* the leaf extracts of four botanicals @ 2, 4 and 6%, chemical treatment of Carbendazim 50WP (7.5 g) + Formalin (125 ml in 100 L of water) and without any chemical or botanicals served as untreated control in Completely Randomized Design (CRD) with three replications. The strain of oyster mushroom used was *Pleurotus sajor-caju* (DMRP -112).

The observations on growth parameters *viz;* days taken for spawn run, pin head formation, I harvest, II harvest, III harvest, and yield and biological efficiency were recorded.

Results and Discussion

During present study, the efficacy of different phyto-extracts and chemical against *Trichoderma* mould were evaluated under *in vivo* conditions.

Days required for spawn run

The observations on spawn run were recorded during incubation. The results on spawn run clearly showed that the time taken for spawn run due to different treatments varied from 16.33 to 22.67 days (Table 1, Plate 1). It was revealed that the treatment T_{13} Carbendazim + formalin significantly took minimum incubation period of 16.33 days.

Among the phyto extracts, the treatment T_6 *Azadirachta indica* @ 6% recorded 17.00 days to complete spawn run while the treatment T_8 *Ocimum sanctum* @ 4% took maximum days for spawn run (22.67 days). The results obtained are in agreement to those of Singh *et al.,* (1995) and Shah *et al.,* (2004) who reported that the spawn run in paddy straw inoculated with *P. florida* was completed in 20 to 22 days after spawning and 16.67 days for completion of spawn run respectively on wheat straw.

Days required for pinhead formation

The observation on pinhead formation were recorded when the mushroom beds were transferred to the growing room and the small pinheads (primordia) started emerging from beds. The data regarding days required for pinhead formation (Table 1) revealed that the treatment T_{13} Carbendazim + formalin took minimum days (20.33) for pinhead formation which was found to be at par with treatment T_6 *Azadirachta indica* @ 6% (21.33 days) and T_5 *Azadirachta indica* @ 4% (21.67 days) while maximum days (26.33 days) for pinhead formation were observed by the treatment T_8 *Ocimum sanctum* @ 4%.

The hundred per cent *Trichoderma* mould contamination was noticed in the absolute control treatment, hence there were no any growth and yield observations recorded in the treatment T_{14} (Table 1 and Plate 1).

After the spawn run, days required for pinhead formation were recorded. It varied between 20.33 to 26.33 days. The performance of T_{13} Carbendazim + formalin was superior which showed early pinhead formation after spawn run, where as among the pytoextracts treatment T_6 *Azadirachta indica* @ 6% took minimum days (21.33 days) for pinhead formation. Similar trend of results were also obtained by Gaikwad (2004) who reported that the time required for pinhead formation varied between 17 to 23 days after spawning in *Pleurotus sajor-caju* and Sivaprakasam and Ramraj (1991) reported, 25 to 27 days for appearance of pinhead in case of *Pleurotus sajor-caju* grown on wheat straw.

Days required for harvest of mushroom

After pinhead formation, the observations for harvesting were recorded upto three harvests.

First harvest

The data presented in Table 2 revealed that the treatment T_{13} Carbendazim + formalin took minimum days for first harvest (24 days) which was found to be at par with treatment T_6 *Azadirachta indica* @ 6% (24.33 days), T_5 *Azadirachta indica* @ 4% (24.67 days) and T_{11} *Eucalyptus* sp. @ 4% (25.67 days). Whereas the treatment T_8 *Ocimum sanctum* @ 4% required maximum days for first harvest i.e. 29.67 days.

Second harvest

In case of days required for second harvest, similar trend of result was noticed where the treatment T_{13} Carbendazim + formalin took minimum days for second harvest (34.67 days) which was found to be at par with treatment T_6 *Azadirachta indica* @ 6% (36 days) and T_5 *Azadirachta indica* @ 4% (36.67 days). While the treatment T_8 *Ocimum sanctum* @ 4% took maximum days (42 days) for harvest (Table 2).

Third harvest

Similar results for days required for third harvest were recorded wherein the treatment T_{13} Carbendazim + formalin required minimum days (47.33 days) for third harvest which was statistically at par with the treatment T_6 *Azadirachta indica* @ 6% (48.67 days) and T_5 *Azadirachta indica* @ 4% (49.33 days) while the treatment T_9 *Ocimum sanctum* @ 6% took maximum days i.e. 54 days for harvest (Table 2, Fig. 1).

The minimum days were required for first, second and third harvest after pinhead formation by the treatment T_{13} Carbendazim + formalin, followed by treatments T_6 *Azadirachta indica* @ 6%, T_5 *Azadirachta indica* @ 4% and T_{11} *Eucalyptus* sp. @ 4% whereas maximum number of days were required by treatment T_9 *Ocimum sanctum* @ 6% for harvest. The observations are in agreement to the findings of Mshandete and Kivaisi (2013) who reported that the days required for harvesting varied from 42 to 46. Muhammad Iqbal *et al.*, (2005) reported that time required for harvesting in *Pleurotus sajor-caju* was 50.7 days on wheat straw.

Number of fruiting bodies per bed

At the time of every harvest, the numbers of fruits per bed was recorded and are presented in Table 3, Fig. 2.

At first harvest

The data (Table 3, Fig. 2) revealed that the treatment T_{13} Carbendazim + Formalin produced significantly higher number of fruiting bodies per bed (68.67) followed by T_6 *Azadirachta indica @ 6%* produced 46 fruits. The minimum numbers of fruiting bodies were found in the treatment T_4 *Azadirachta indica* @ 2% i.e. 27.67.

At second harvest

At second harvest, the treatment T_{13} Carbendazim + Formalin produced significantly higher number of fruiting bodies per bed (54.33).

Among the phytoextracts, treatment T_{12} *Eucalyptus* sp. @ 6% produced maximum number of fruiting bodies (36.33) which was found to be at par with other all treatment. The lowest numbers of fruiting bodies (17.33) were observed in treatment T_7 *Ocimum sanctum* @ 2% (Table 3, Fig. 2).

At third harvest

Similar trend was also observed at third harvest where the treatment T_{13} Carbendazim + Formalin produced significantly highest number of fruiting bodies per bed (44) followed by treatment T_6 *Azadirachta indica* @ 6% (28.67) while treatment T_{10} *Eucalyptus* sp. @ 2% produced lowest number of fruiting bodies per bed i.e 10.00 (Table 3, Fig. 2).

The results showed that number of fruiting bodies per beds varied from 10 to 68.67 in the first, second and third harvest due to different treatments. The treatment T_{13} Carbendazim + formalin was found significantly superior over all treatments. The results

obtained are in agreement to those of Shukla and Jaitley (2011) who observed that *Pleurotus sajor-caju* produced maximum 65 number of fruit bodies per bed.

Average fruit body weight

The observations for average fruit body weight were recorded by randomly selected ten mature fruit bodies from respective treatments and the results are presented in the Table 3, Fig 2.

The data on the average fruit body weight (g) ranged from 3.23 to 6.67 g per fruit. The treatment T_{13} Carbendazim + Formalin had significantly highest average fruit body weight (6.67 g) followed by treatments T_{12} *Eucalyptus* sp. 6% (5.10 g), T_5 *Azadirachta indica* @ 4% (5.02 g), T_9 *Ocimum sanctum* @ 6% (5.00 g) while lowest average fruit body weight (3.23 g) was recorded by treatment T_1 *Lantana camera* @ 2%.

The results obtained are in conformity with the results obtained by Sharma and Jandaik (1983) who reported that *Pleurotus* spp. recorded average fruit body weight ranging from 5.0 to 5.8g.

Morphological characters

The observations of the fruiting bodies *viz,* pileus diameter, stipe length, stipe size of randomly selected ten fruit bodies of mushroom per treatment were recorded and the results are presented in Table 4, Fig 3 and 4.

Pileus diameter

The data (Table 4, Fig. 3) revealed that the maximum pileus diameter was recorded by the treatment T_{13} Carbendazim + Formalin (7.37 cm) followed by the treatment *Ocimum sanctum* @ 2% (6.67 cm) while the minimum pileus diameter was observed in treatment T_3 *Lantana camera* @ 6% (4.93 cm).

Stipe length

The data on stipe length revealed that the treatment T_4 *Azadirachta indica* @ 2% recorded maximum stipe length (2.60 cm) followed by treatment T6 *Azadirachta indica* @ 6% (2.43cm) while the minimum stipe length was observed in treatment T_7 *Ocimum sanctum* @ 2% (1.40 cm). (Table 4, Fig. 4)

Stipe size

The maximum stipe size (3.87 cm) was recorded in the treatment T_7 *Ocimum sanctum* @ 2% followed by treatment T_6 *Azadirachta indica* @ 6% (3.50 cm) while the minimum stipe size was observed in treatment T_{11} *Eucalyptus* sp. @ 4% (2.43 cm).

The results (Table 4, Fig. 4) revealed that vide variation in morphological parameters like pileus diameter, stipe length and stipe size was observed due to different treatments and ranged from 4.93 to 7.37 cm, 1.57 to 2.60 cm and 2.43 to 3.87 cm respectively.

The results are comparable with Pruthvi (1984) who reported that the mushrooms comprise a large heterogeneous group which differs greatly in their shape, size, colour, appearance and edibility. Hassan *et al.,* (2010) who observed the same results for *Pleurotus ostreatus* and Mshandete and Kivaisi (2013) for *Pleurotus* HK-37.

Influence of phyto extracts on yield and biological efficiency

Yield

Yield performance of different treatments at first, second and third harvest was recorded separately and are presented in Table 5, Fig. 5 and Plate 2.

It was revealed that treatment T_{13} Carbendazim + Formalin recorded significantly maximum yield (965.78 g/kg dry substrate).

Table.1 Influence of phyto extracts on days required for spawn run and pinhead Formation

Sr. No.	Treatment	Days required for Spawn run*	Days required for Pinhead formation*
1	*Lantana camera* (Ghaneri) @ 2%	21.67	25.67
2	*Lantana camera* (Ghaneri) @ 4%	21.00	25.00
3	*Lantana camera* (Ghaneri) @ 6%	20.00	24.33
4	*Azadirachta indica* (Neem) @ 2%	20.00	24.00
5	*Azadirachta indica*(Neem) @ 4%	17.67	21.67
6	*Azadirachta indica*(Neem) @ 6%	17.00	21.33
7	*Ocimum sanctum*(Tulsi) @ 2%	21.00	25.00
8	*Ocimum sanctum*(Tulsi) @ 4%	22.67	26.33
9	*Ocimum sanctum*(Tulsi) @ 6%	21.00	25.00
10	*Eucalyptus* sp. (Nilgiri) @ 2%	20.00	24.00
11	*Eucalyptus* sp. (Nilgiri) @ 4%	18.67	22.67
12	*Eucalyptus* sp. (Nilgiri) @ 6%	20.33	24.00
13	Carbendazim @7.5g+formalin @125 ml per 100 L water	16.33	20.33
14	Control	0.00	0.00
SE±		0.69	0.64
CD (0.05)		2.00	1.86

*=Mean of three replications

Table.2 Influence of phyto extracts on days required for harvest of oyster mushroom

Sr. No.	Treatment	Days required for		
		1st Harvest*	2nd Harvest*	3rd Harvest*
1	*Lantana camera* (Ghaneri) @ 2%	28.67	41.67	51.67
2	*Lantana camera* (Ghaneri) @ 4%	28.33	39.67	51.00
3	*Lantana camera* (Ghaneri) @ 6%	28.33	39.33	51.33
4	*Azadirachta indica* (Neem) @ 2%	26.67	39.33	51.00
5	*Azadirachta indica*(Neem) @ 4%	24.67	36.67	49.33
6	*Azadirachta indica*(Neem) @ 6%	24.33	36.00	48.67
7	*Ocimum sanctum*(Tulsi) @ 2%	28.33	41.00	52.67
8	*Ocimum sanctum*(Tulsi) @ 4%	29.67	42.00	53.67
9	*Ocimum sanctum*(Tulsi) @ 6%	28.67	41.67	54.00
10	*Eucalyptus* sp. (Nilgiri) @ 2%	26.67	41.33	51.00
11	*Eucalyptus* sp. (Nilgiri) @ 4%	25.67	39.00	50.33
12	*Eucalyptus* sp. (Nilgiri) @ 6%	27.33	40.33	51.33
13	Carbendazim @7.5g+ formalin @125 ml per 100 L water	24.00	34.67	47.33
14	Control	0.00	0.00	0.00
SE±		0.74	0.99	0.91
CD (0.05)		2.14	2.86	2.64

*=Mean of three replications

Table.3 Influence of phyto extracts on number of fruit bodies and average fruit body weight (g)

Sr. No.	Treatment	Number of fruiting bodies			Average fruit body weight (g)*
		1st Harvest*	2nd Harvest*	3rd Harvest*	
1	*Lantana camera* (Ghaneri) @ 2%	33.33	27.67	16.67	3.23
2	*Lantana camera* (Ghaneri) @ 4%	35.67	33.33	17.00	3.96
3	*Lantana camera* (Ghaneri) @ 6%	38.00	27.33	26.67	4.33
4	*Azadirachta indica* (Neem) @ 2%	27.67	26.67	17.33	4.98
5	*Azadirachta indica*(Neem) @ 4%	41.33	28.00	18.67	5.02
6	*Azadirachta indica*(Neem) @ 6%	46.00	30.33	28.67	3.75
7	*Ocimum sanctum*(Tulsi) @ 2%	43.67	17.33	18.00	3.95
8	*Ocimum sanctum*(Tulsi) @ 4%	35.00	30.67	24.00	4.50
9	*Ocimum sanctum*(Tulsi) @ 6%	35.00	36.33	24.33	5.00
10	*Eucalyptus* sp. (Nilgiri) @ 2%	36.67	27.67	10.00	4.20
11	*Eucalyptus* sp. (Nilgiri) @ 4%	34.33	34.67	18.33	4.78
12	*Eucalyptus* sp. (Nilgiri) @ 6%	36.33	36.33	26.67	5.10
13	Carbendazim @7.5g+ formalin @125 ml per 100 L water	68.67	54.33	44.00	6.67
14	Control	0.00	0.00	0.00	0.00
SE±		4.33	4.22	2.80	0.07
CD (0.05)		12.56	12.22	8.12	0.19

*=Mean of three replications

Table.4 Influence of phyto extracts on morphological characters of *Pleurotus sajor caju.*

Sr. No.	Treatment	Pileus diameter (cm)*	Stipe length (cm)*	Stipe size (cm)*
1	*Lantana camera* (Ghaneri) @ 2%	5.70	1.80	3.30
2	*Lantana camera* (Ghaneri) @ 4%	5.60	1.57	3.27
3	*Lantana camera* (Ghaneri) @ 6%	4.93	2.00	2.93
4	*Azadirachta indica* (Neem) @ 2%	6.33	2.60	3.17
5	*Azadirachta indica*(Neem) @ 4%	5.80	2.10	3.40
6	*Azadirachta indica*(Neem) @ 6%	5.60	2.43	3.50
7	*Ocimum sanctum*(Tulsi) @ 2%	6.67	1.40	3.87
8	*Ocimum sanctum*(Tulsi) @ 4%	6.50	1.93	3.37
9	*Ocimum sanctum*(Tulsi) @ 6%	5.80	1.70	3.33
10	*Eucalyptus* sp. (Nilgiri) @ 2%	6.50	1.77	3.03
11	*Eucalyptus* sp. (Nilgiri) @ 4%	4.97	1.80	2.43
12	*Eucalyptus* sp. (Nilgiri) @ 6%	5.77	1.63	2.63
13	Carbendazim @7.5g+ formalin @125 ml per 100 L water	7.37	1.87	3.00
14	Control	0.00	0.00	0.00
SE±		0.53	0.26	0.25
CD (0.05)		1.53	0.75	0.72

*=Mean of three replications

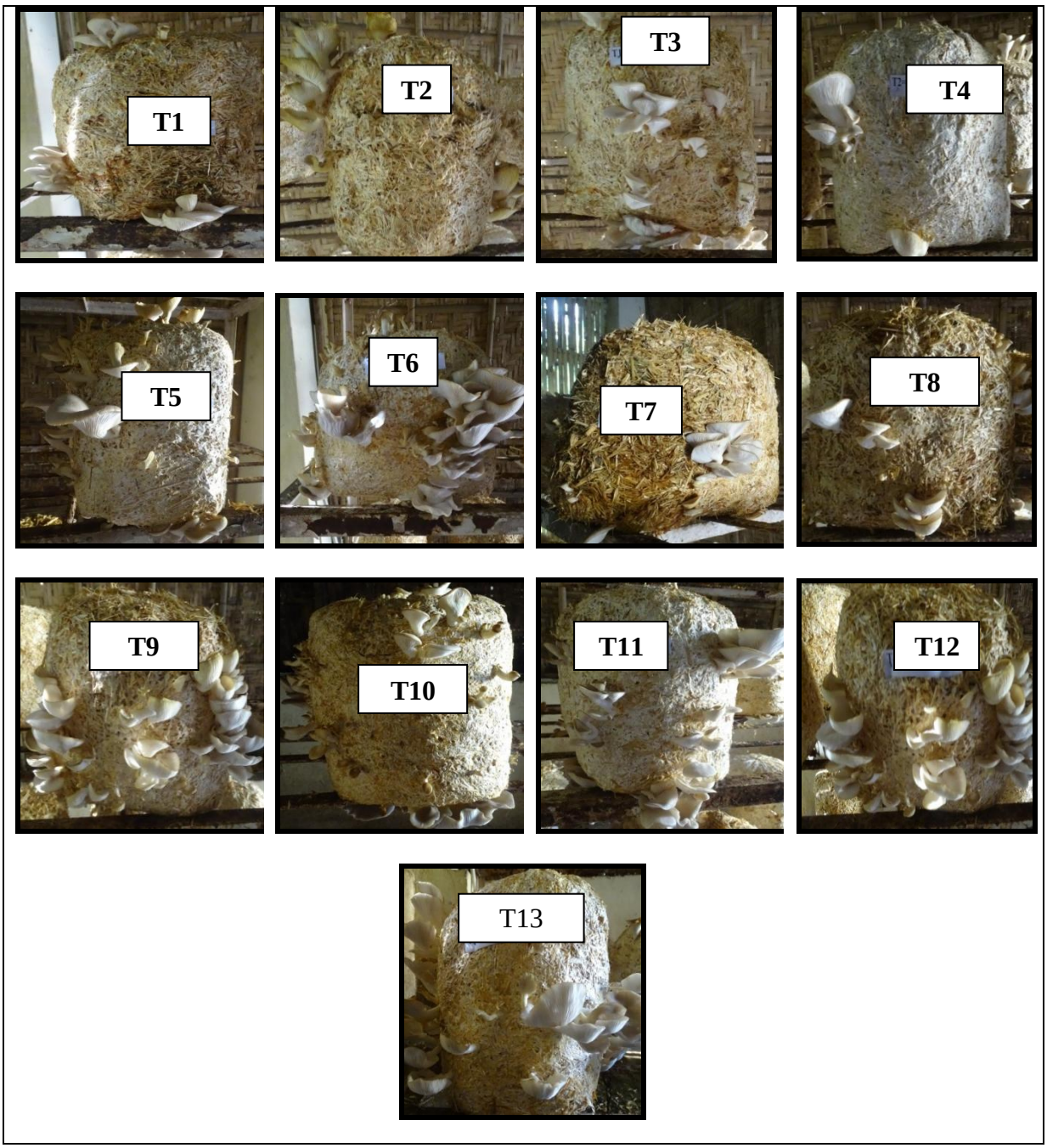
Table.5 Influence of phyto extracts on yield performance (g/kg substrate) and biological efficiency (%) of *P. sajor caju*.

Sr. No.	Treatment	Total yield (g) per kg substrate*	Biological efficiency (%)*
1	*Lantana camera* (Ghaneri) @ 2%	579.44	57.94
2	*Lantana camera* (Ghaneri) @ 4%	643.11	64.31
3	*Lantana camera* (Ghaneri) @ 6%	697.78	69.78
4	*Azadirachta indica* (Neem) @ 2%	658.89	65.89
5	*Azadirachta indica*(Neem) @ 4%	702.11	70.21
6	*Azadirachta indica*(Neem) @ 6%	809.00	80.90
7	*Ocimum sanctum*(Tulsi) @ 2%	556.78	55.68
8	*Ocimum sanctum*(Tulsi) @ 4%	592.22	59.22
9	*Ocimum sanctum*(Tulsi) @ 6%	692.67	69.27
10	*Eucalyptus* sp. (Nilgiri) @ 2%	610.56	61.06
11	*Eucalyptus* sp. (Nilgiri) @ 4%	674.78	67.48
12	*Eucalyptus* sp. (Nilgiri) @ 6%	742.56	74.26
13	Carbendazim @7.5g+ formalin @125 ml per 100 L water	965.78	96.58
14	Control	0.00	0.00
SE±		7.46	1.13
CD (0.05)		21.62	3.27

*=Mean of three replications

Plate.1 Influence of phyto extracts on spawn run of *P. sajor caju*

Plate.2 Yield performance of *Pleurotus sajor caju* in various treatments



T-1 *Lantana camera* (Ghaneri) @ 2%
T-2 *Lantana camera* (Ghaneri) @ 4%
T-3 *Lantana camera* (Ghaneri) @ 6%
T-4 *Azadirachta indica* (Neem) @ 2%
T-5 *Azadirachta indica* (Neem) @ 4%
T-6 *Azadirachta indica* (Neem) @ 6%
T-7 *Ocimum sanctum* (Tulsi) @ 2%
T-8 *Ocimum sanctum* (Tulsi) @ 4%
T-9 *Ocimum sanctum* (Tulsi) @ 6%
T-10 *Eucalyptus* sp (Nilgiri) @ 2%
T-11 *Eucalyptus* sp (Nilgiri) @ 4%
T-12 *Eucalyptus* sp (Nilgiri) @ 6%
T-13 Carbendazim 50WP(7.5 g) + Formalin (125 ml in 100 lit. of water)

Fig.1 Influence of phyto extracts on days required for harvest of oyster mushroom

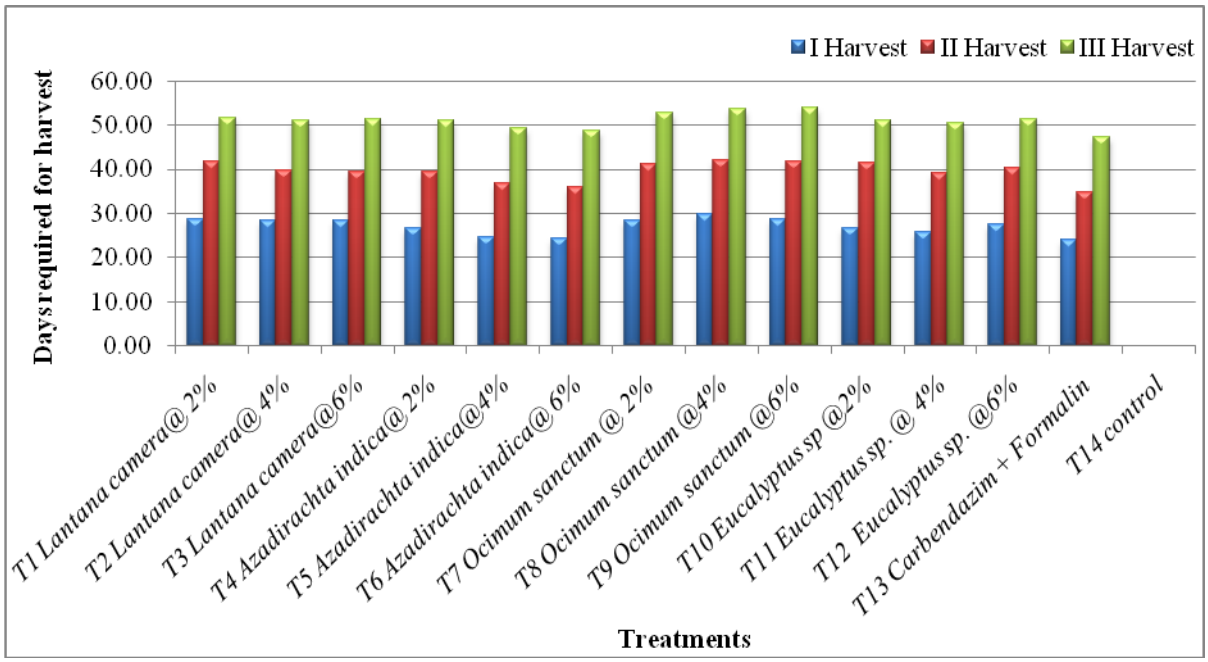


Fig.2 Influence of phyto extracts on no. of fruit bodies and av. fruit weight/bed

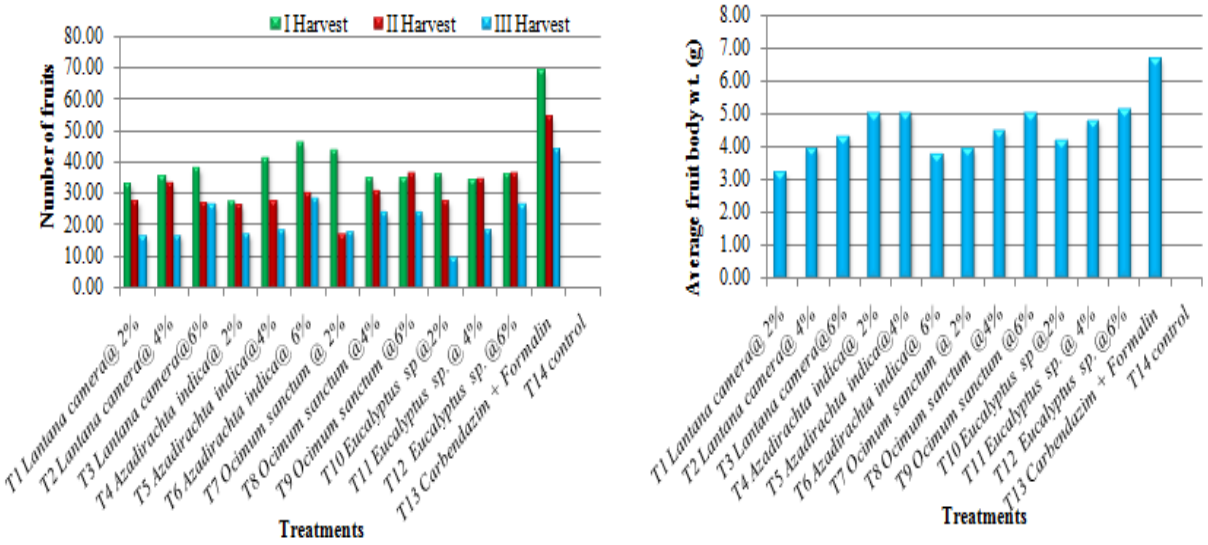


Fig.3 Influence of phyto extracts on pileus diameter (cm) of *P. sajor caju*

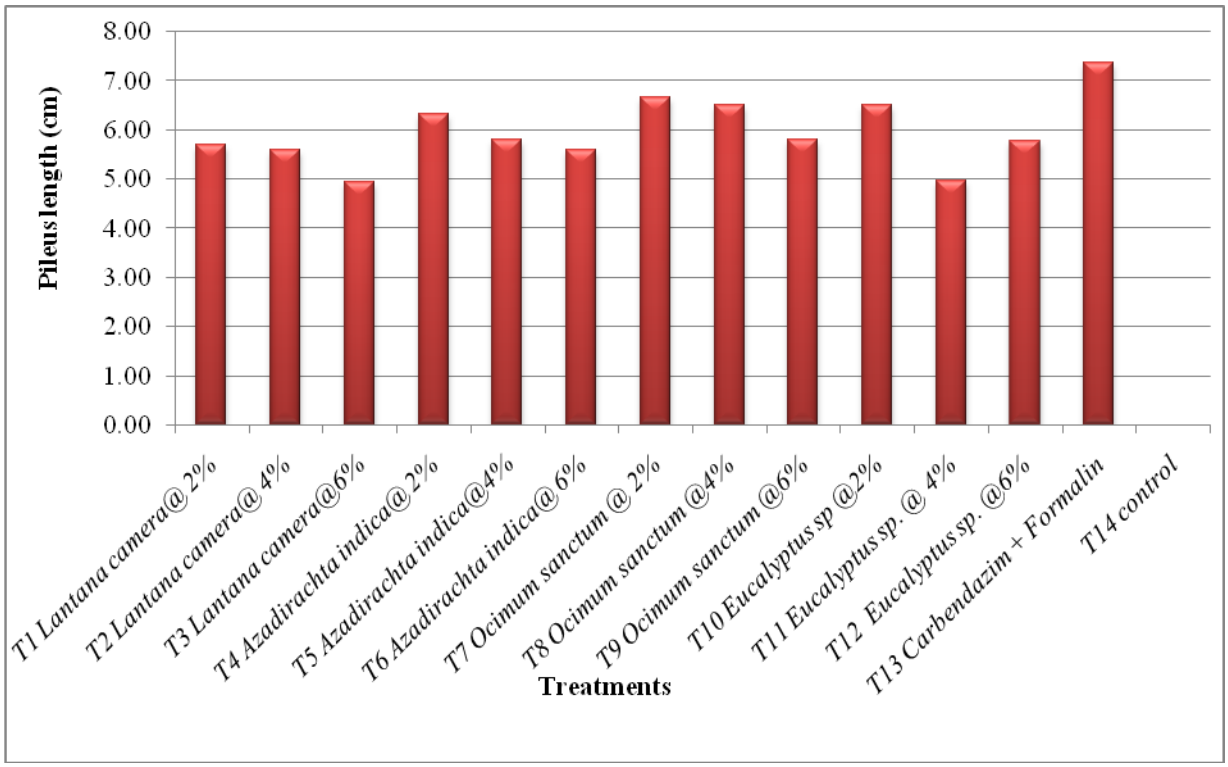
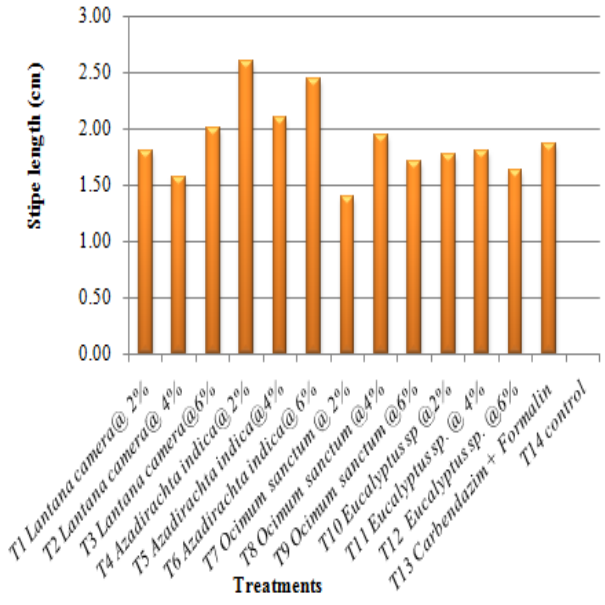


Fig.4 Influence of phyto-extracts on stipe length and stipe size (cm) of *P.sajor caju*



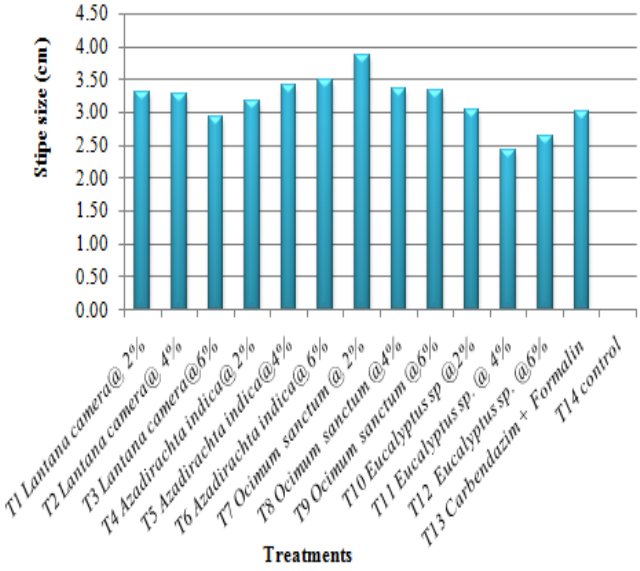
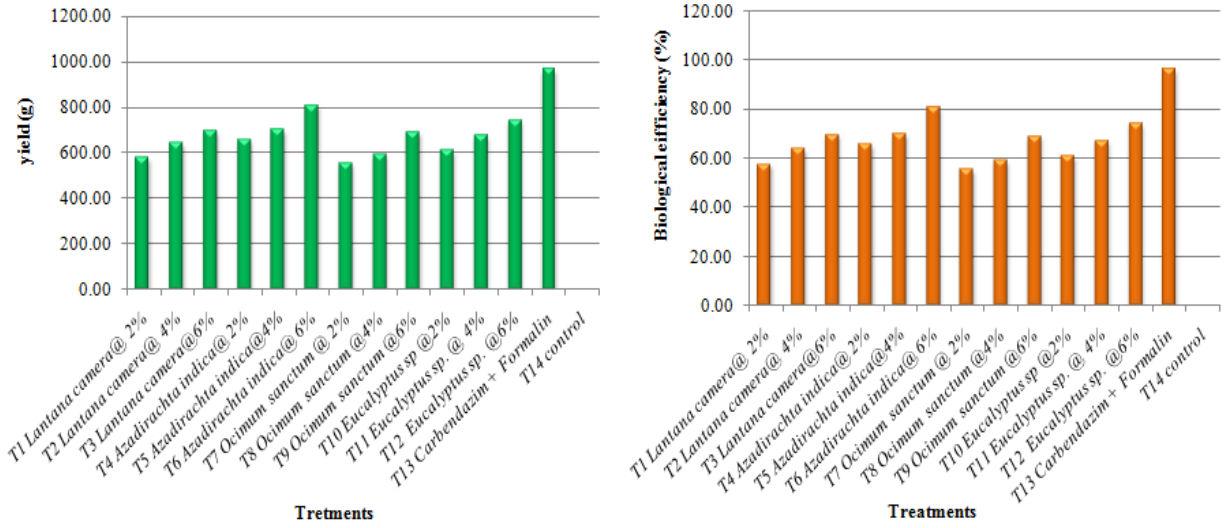


Fig.5 Influence of phyto extracts on yield (g/kg dry substrate) and biological efficiency (%) of *P.sajor caju*



Among the phytoextracts, treatment T_6 *Azadirachta indica* @ 6% recorded maximum yield (809.00 g/kg dry substrate) followed by treatment T_{12} *Eucalyptus* sp. @ 6% (742.56 g/kg dry substrate), T_5 *Azadirachta indica* @ 4% (702.11 g/kg dry substrate) and T_3 *Lantana camera* @ 6% (697.78 g/kg dry substrate). The lowest yield (556.78 g/kg dry substrate) was recorded in treatment T_7 *Ocimum sanctum* @ 2% (Table 5, Fig. 5).

Biological efficiency

In the present research work, the influence of different treatments on biological efficiency was calculated by using formulae given by Chang *et al.*, (1981) and the results are presented in Table 5 and Plate. 2.

From the data (Table 5), it was revealed that the treatment T_{13} Carbendazim + Formalin recorded significantly maximum biological efficiency (96.57%) over rest of treatments. Among phytoextracts, the treatment T_6 *Azadirachta indica* @ 6% recorded maximum biological efficiency (80.90%) which was found to be at par with treatment T_{12} *Eucalyptus* sp. @ 6% (74.26%). The minimum biological efficiency (55.67%) was recorded in treatment T_7 *Ocimum sanctum* @ 2%. The observations on yield performance due to different treatments revealed that treatment T_{13} Carbendazim + Formalin produced maximum yield of mushroom 965.78 g/kg dry substrate with high biological efficiency 96.57% followed by treatment T_6 *Azadirachta indica* @ 6% with yield of 809 g/kg dry substrate and biological efficiency of 80.90% whereas lowest yield was recorded in treatment T_7 *Ocimum sanctum* @ 2% i.e 556.78 g/kg dry substrate with biological efficiency of 55.67%. The observations are in agreement to the finding of Biswas *et al.*, (2018) who reported that chemical treatment (bavistin 75 ppm + formalin 500 ppm) was found to be most effective among all the treatments and exhibited 120.50% Biological Efficiency (B.E.).

Shaiesta Shah *et al.*, (2011) who evaluated some botanicals in controlling green mould (*Trichoderma harzianum*) disease in oyster mushroom cultivation and concluded that the polybags which receives *Azadirachta indica* showed maximum mean increase in yield (32.8%) over control.

Thus, from the above summarized results of present investigation, it could be concluded that the treatment of Carbendazim + formalin recorded minimum days for spawn run (16.33 day), pinhead formation (20.33 days) and fruiting (47.33 days) and recorded maximum yield (965.78 g/kg dry wheat straw substrate). Among the phyto extracts, the treatment *Azardirachta indica* @ 2, 4 and 6%

recorded minimum days for spawn run (20, 17.67, 17 days), pinhead formation (24, 21.67 and 21.33 days) and fruiting (51, 49.33 and 48.67 days) and recorded maximum yield (658.89, 702.11 and 809 g) than other treatments. Hence, the chemical treatment (Carbendazim + Formalin) was found to be the best for management of *Trichoderma* mould contamination in oyster mushroom cultivation. Among the phyto extracts evaluated, the treatment *Azardirachta indica* @ 6% was found to be the best for management of *Trichoderma* mould.

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