



RESEARCH ARTICLE

Influence of chemicals on the growth and yield of five species of oyster mushroom (*Pleurotus* spp.) in North-western Himalayas

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ABSTRACT: Eight chemicals viz. salicylic acid (0.1%), ferrous sulphate (1%), copper sulphate (1%), manganese sulphate (1%), potassium sulphate (1%), magnesium sulphate (1%), zinc sulphate (1%) and calcium carbonate (1%) were tried to see their influence on five species of oyster mushroom (*P. sajor caju*, *P. florida*, *P. flabellatus*, *P. fossulatus* and *P. sapidus*) with respect to radial growth, days for spawn run, number of fruiting bodies and yield. Maximum radial growth was observed at 6th days in ferrous sulphate and copper sulphate supplemented medium in *P. sajor caju* (8.56 & 9.00 cm), *P. florida* (9.00 & 8.75 cm), *P. flabellatus* (8.26 & 8.50 cm), *P. fossulatus* (8.45 and 8.93 cm) and *P. sapidus* (9.00 and 8.50 cm), respectively. Minimum time was observed for spawn run in *P. sajor caju* (16.33 days), *P. fossulatus* (16.66 days) and *P. sapidus* (15.00 days) supplemented with ferrous sulphate followed by magnesium sulphate (18.00, 16.66 and 16.00 days), respectively. Maximum numbers of fruiting bodies were harvested from *P. sajor caju* (79.95) supplemented with ZnSO₄, *P. florida* (77.03) supplemented with salicylic acid, *P. flabellatus* (76.12) supplemented with CuSO₄, *P. fossulatus* (79.91) supplemented with MnSO₄ and *P. sapidus* (80.62) supplemented with K₂SO₄. Yield was harvested significantly well in all the five species, *P. sajor caju* (602.90 g/kg), *P. florida* (592.10 g/kg), *P. flabellatus* (566.55 g/kg), *P. fossulatus* (604.00g/kg) and *P. sapidus* (612.12 g/kg) supplemented with ferrous sulphate.

Key words: Chemical, oyster mushroom, *Pleurotus* spp., spawn run, yield

Most fascinating concept of mushroom science is production of fruiting bodies of excellent taste from agro-waste. Mushroom has been recognized as food contributing to ameliorate the protein malfunction of the countries which are largely depending upon cereals (Tandon and Sharma, 2007). Mushroom cultivation today is being practiced in more than 100 countries and its production is increasing at an annual rate of 6-7%. Present world production of mushrooms is around 12 million tones and ranking is, button mushroom (31%), shitake mushroom (24%), oyster mushroom (14%), black ear mushroom (9%), paddy straw mushroom (8%) and milky/others of the rest (Vision, 2025). In India during seventies and eighties button mushroom was grown as a seasonal crop, but with development of the technologies for environmental control and increased understanding of cropping systems, mushroom production shot up from mere 5000 tones in 1990 to 1,00,000 tones in 2006. The cultivation of oyster mushroom is now becoming popular in developing countries amongst growers due to easy and cheap cultivation technology, high nutritive value, good shelf life, agreeable distinctive taste, abundant availability of agro-wastes, choice of species and suitability to varying agro-climatic conditions (Rajaratnam *et al.*, 1989). Moderate summer climate of Uttarakhand offers a good opportunity of oyster mushroom cultivation without any manipulation of temperature. Different *Pleurotus* species are reported to show much diversity in their adaptation to the varying agro-climatic conditions and yield potential depending on the substrates nutrient quality. Keeping above importance in view, eight chemicals have been tried to increase the productivity of five species of

oyster mushroom namely *P. sajor caju*, *P. florida*, *P. flabellatus*, *P. fossulatus* and *P. sapidus* for growth, spawn run, number of fruiting bodies and yield.

MATERIALS AND METHODS

The experiments were carried out during May to August, 2009 at the Experimental farm, Hawalbagh, Vivekananda Institute of Hill Agriculture, Almora (Uttarakhand). In the present investigations, eight chemicals viz. salicylic acid (0.1%), ferrous sulphate (1%), copper sulphate (1%), manganese sulphate (1%), potassium sulphate (1%), magnesium sulphate (1%), zinc sulphate (1%) and calcium carbonate (1%) were tried on wheat straw extract agar (WSEA) medium for radial growth *in vitro*. For this experiment, WSEA medium was prepared and chemicals were added in the medium after sterilization. The 20 ml medium was poured in each sterilized Petri plate and subsequently inoculated with 5 mm disc of 7 days old culture of every tested species. Inoculated plates were incubated at 25±1°C with four replications. The observations of radial growth were taken at each 48 hrs till the first colony covered the full plate. Cultivation of *Pleurotus* species (namely *P. sajor caju*, *P. florida*, *P. flabellatus*, *P. fossulatus* and *P. sapidus*) were also tried in substrate supplemented with chemicals in mushroom crop room. The substrate wheat straw was soaked in treated water tank (carbendazim 7.5 gm and formalin 100ml/100lit) for over night, so as to make it soft (Vijay and Sohi, 1987). The tank was covered with polythene sheet to prevent the evaporation of formalin. Thereafter, straw was taken out from the tank and dipped again in water solution of salicylic acid (0.1%), ferrous sulphate (1%), copper sulphate (1%), manganese sulphate (1%), potassium sulphate (1%), magnesium sulphate (1%), zinc

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sulphate (1%) and calcium carbonate (1%) for half an hour and spread on cemented floor treated with 2 per cent formalin for two hours to drain out excess of water. Spawning was done @ 3 per cent of the spawn dry weight of substrate and after spawning this mixture was filled in polythene bags @ 1.0 kg/bag. The upper portion of the polythene bags was folded and stapled. Thereafter, 8-10 small holes were made on polythene bags to permit proper aeration during spawn run. These bags were placed in the mushroom crop room at relative humidity of 75-95 per cent and temperature maintained at $25 \pm 2^\circ\text{C}$. After the full spawn run in the wheat straw, it becomes compact mass which was also sticking to the polythene bag after two to three weeks. The polythene was removed from the mass of compact substrate (stack). The fruiting bodies started to appear in 4-5 days. The sporophores were harvested 3-4 days thereafter by one gentle twisting at the base, taking care that the broken stumps were not left there to avoid rotting in the remaining flushes of running crop. The initial 3-4 flushes were taken as after that very few fruiting bodies appear. After the first two flushes, the spawn run blocks were over turned to allow the lower surface and the base to produce fruiting bodies. Watering of the crop is quite important which must be done with a mist sprayer. The water spraying should be done by sprinkler on the blocks after the fruit body start coming up and the floor and walls of the mushroom crop room also must be kept moist to maintain requisite humidity (75-95 per cent). Adequate ventilation in the crop room was provided by opening the doors and windows at night for a short time. The crop room floor and wall were sprayed with 0.1 per cent Malathion or sevin to protect it from insect infestation. Observations were recorded for spawn run, number of fruiting body, yield (g/kg dry substrate) and weight per fruiting body in three replications. The experiments were laid as per Completely Randomized Design.

RESULTS AND DISCUSSION

All the chemicals viz. salicylic acid (0.1%), ferrous sulphate (1%), copper sulphate (1%), manganese sulphate (1%), potassium sulphate (1%), magnesium sulphate (1%), zinc sulphate (1%) and calcium carbonate (1%) significantly

increased the radial growth of the five species of oyster mushroom as compared to control *in vitro*. Maximum radial growth was observed at 6th day in ferrous sulphate and copper sulphate supplemented WSEA medium in *P. sajor caju* (8.56 & 9.00 cm), *P. florida* (9.00 & 8.75 cm), *P. flabellatus* (8.26 & 8.50 cm), *P. fossulatus* (8.45 and 8.93 cm) and *P. sapidus* (9.00 and 8.50 cm) followed by manganese sulphate (8.25, 8.52, 8.34, 8.64 and 8.75 cm), respectively. The minimum growth was recorded with calcium carbonate supplemented medium in *P. sajor caju* (5.80 cm), *P. florida* (6.00 cm), *P. flabellatus* (5.82 cm), *P. fossulatus* (6.30 cm) and *P. sapidus* (5.90 cm). In all the tested chemicals the best results were given by *P. florida* (9.00 cm) and *P. sapidus* (9.00 cm) species in ferrous sulphate supplemented treatment while the *P. sajor caju* (9.00 cm), *P. flabellatus* (8.50 cm) and *P. fossulatus* (8.93 cm) was given in copper sulphate treatment (Table 1). The results are almost in accordance with the findings of Yidz and Yesil (2006) and Mukhopadhyay *et al.* (2005). Huang *et al.* (2003) studied the effect of various source of carbon (brown sugar, fructose, lactose, glucose, sucrose, starch and maltose), nitrogen (wheat bran, yeast cream, beef cream, peptone, $(\text{NH}_4)_2\text{SO}_4$, NH_4Cl and $(\text{NH}_4)_2\text{CO}_3$) and inorganic salts K_2SO_4 , MgSO_4 , CaSO_4 , MnSO_4 and FeSO_4 on the mycelial growth of *P. ostreatus*. The mycelial growth was more pronounced with brown sugar as the carbon source, wheat bran as the nitrogen source and MgSO_4 as the inorganic salts source.

The experiments were conducted to find out some beneficial effect of the chemical supplements on spawn run i.e. mycelial ramification in wheat substrate, period of cropping, total yield and number of fruiting bodies. It is clear from the results mentioned in Table-2 that incorporation of the chemical supplements increased the yield and number of fruiting bodies of all the tested species of oyster mushroom. Wheat straw substrate supplemented with chemicals took less period for pinhead formation, first harvesting, higher yield and number of fruiting bodies in case of *P. sajor caju*, *P. florida*, *P. flabellatus*, *P. fossulatus* and *P. sapidus* as compared to control (without supplemented). Minimum time was observed for spawn run

Table 1. Effect of chemicals on radial growth of different species of *Pleurotus* species on WSEA medium

Chemicals	<i>P. sajor caju</i>		<i>P. florida</i>		<i>P. flabellatus</i>		<i>P. fossulatus</i>		<i>P. sapidus</i>	
	Radial growth (cm)	Radial growth (cm/day)	Radial growth (cm)	Radial growth (cm/day)	Radial growth (cm)	Radial growth (cm/day)	Radial growth (cm)	Radial growth (cm/day)	Radial growth (cm)	Radial growth (cm/day)
Ferrous sulphate(FeSO_4)	8.56	1.43	9.00	1.50	8.26	1.38	8.45	1.41	9.00	1.50
Manganese sulphate (MnSO_4)	8.25	1.38	8.52	1.42	8.34	1.39	8.64	1.44	8.75	1.46
Copper sulphate(CuSO_4)	9.00	1.50	8.75	1.46	8.50	1.42	8.93	1.49	8.50	1.42
Magnesium sulphate (MgSO_4)	8.15	1.36	8.35	1.39	7.62	1.27	8.47	1.41	8.20	1.37
Zinc sulphate (ZnSO_4)	7.23	1.21	6.62	1.10	6.55	1.09	6.90	1.15	6.40	1.07
Salicylic acid $\text{C}_6\text{H}_4(\text{OH})\text{COOH}$	6.51	1.09	6.35	1.06	6.20	1.03	6.80	1.13	6.20	1.03
Potassium sulphate (K_2SO_4)	5.89	0.98	6.25	1.04	5.60	0.93	6.70	1.12	6.10	1.02
Calcium carbonate (CaCO_3)	5.80	0.97	6.00	1.00	5.82	0.97	6.30	1.05	5.90	0.98
Control (only PDA)	5.40	0.93	5.35	0.89	5.10	0.85	5.02	0.84	5.50	0.95
CD at 5%	0.27	-	0.38	-	0.34	-	0.47	-	0.33	-

Average of four replications

Table 2. Effect of chemicals on spawn run and yield of *Pleurotus sajor caju*, *P. florida*, *P. flabellatus*, *P. fossulatus* and *P. sapidus*

Chemicals	Spawn run (days)	Mean yield			
		Wt/fb*	No. of fruit body	Yield (gm)	B.E.
<i>P. sajor caju</i>					
Ferrous sulphate(FeSO ₄)	16.33	8.23	73.26	602.90	60.29
Manganese sulphate (MnSO ₄)	18.66	7.89	64.25	506.92	50.69
Copper sulphate(CuSO ₄)	17.00	7.26	73.13	530.90	53.09
Magnesium sulphate (MgSO ₄)	18.00	8.32	67.88	564.76	56.48
Zinc sulphate (ZnSO ₄)	21.00	6.35	79.95	507.66	50.77
Salicylic acid C ₆ H ₄ (OH) COOH	17.33	6.88	78.07	537.10	53.71
Potassium sulphate (K ₂ SO ₄)	18.00	7.50	67.76	508.20	50.82
Calcium carbonate (CaCO ₃)	18.33	7.63	74.28	566.76	56.68
Control (only substrate)	22.66	6.35	77.50	492.10	49.21
CD at 5%	1.32	0.49	3.86	13.27	-
<i>P. florida</i>					
Ferrous sulphate(FeSO ₄)	17.00	7.32	80.89	592.10	59.21
Manganese sulphate (MnSO ₄)	18.33	7.66	71.66	548.92	54.89
Copper sulphate(CuSO ₄)	17.66	7.06	74.33	524.80	52.48
Magnesium sulphate (MgSO ₄)	18.66	8.20	66.25	543.23	54.32
Zinc sulphate (ZnSO ₄)	22.33	6.86	73.61	504.96	50.50
Salicylic acid C ₆ H ₄ (OH) COOH	16.66	6.82	77.03	525.34	52.53
Potassium sulphate (K ₂ SO ₄)	19.00	7.42	67.47	500.64	50.06
Calcium carbonate (CaCO ₃)	18.00	7.86	65.94	518.28	51.83
Control (only substrate)	23.33	6.50	70.58	458.80	45.88
CD at 5%	1.46	0.56	3.88	15.23	-
<i>P. flabellatus</i>					
Ferrous sulphate(FeSO ₄)	15.84	8.70	65.11	566.50	56.65
Manganese sulphate (MnSO ₄)	18.62	7.60	66.74	507.20	50.72
Copper sulphate(CuSO ₄)	17.44	7.06	76.12	537.40	53.74
Magnesium sulphate (MgSO ₄)	15.62	8.26	65.28	539.22	53.92
Zinc sulphate (ZnSO ₄)	18.24	7.28	72.82	530.10	53.01
Salicylic acid C ₆ H ₄ (OH) COOH	20.30	7.56	68.79	520.02	52.00
Potassium sulphate (K ₂ SO ₄)	18.86	7.68	64.99	499.15	49.92
Calcium carbonate (CaCO ₃)	19.40	7.66	67.31	515.60	51.56
Control (only substrate)	21.10	6.87	67.46	463.47	46.35
CD at 5%	1.48	0.56	4.87	13.88	-
<i>P. fossulatus</i>					
Ferrous sulphate(FeSO ₄)	16.66	8.80	68.64	604.00	60.40
Manganese sulphate (MnSO ₄)	19.00	6.87	79.91	549.00	54.90
Copper sulphate(CuSO ₄)	17.66	7.90	74.54	588.90	58.89
Magnesium sulphate (MgSO ₄)	16.66	8.68	69.44	602.70	60.27
Zinc sulphate (ZnSO ₄)	19.33	6.80	78.24	532.00	53.20
Salicylic acid C ₆ H ₄ (OH) COOH	19.00	7.50	74.15	556.10	55.61
Potassium sulphate (K ₂ SO ₄)	20.33	6.44	78.91	508.20	50.82
Calcium carbonate (CaCO ₃)	19.66	7.98	63.88	509.76	50.98
Control (only substrate)	22.33	6.92	64.47	446.10	44.61
CD at 5%	1.67	0.42	4.56	14.78	-
<i>P. sapidus</i>					
Ferrous sulphate(FeSO ₄)	15.00	8.20	74.65	612.12	61.21
Manganese sulphate (MnSO ₄)	18.66	7.90	68.19	538.70	53.87
Copper sulphate(CuSO ₄)	17.00	7.16	76.10	544.85	54.49
Magnesium sulphate (MgSO ₄)	16.00	8.64	69.91	604.00	60.40
Zinc sulphate (ZnSO ₄)	20.33	6.78	78.89	534.90	53.49
Salicylic acid C ₆ H ₄ (OH) COOH	18.66	8.84	61.69	545.32	54.53
Potassium sulphate (K ₂ SO ₄)	19.00	7.42	80.62	598.20	59.82
Calcium carbonate (CaCO ₃)	17.33	7.26	74.13	538.21	53.82
Control (only substrate)	20.33	6.58	74.24	488.52	48.85
CD at 5%	1.39	0.54	3.98	16.42	-

Average of three replicates, *Average of five fruit bodies

in *P. sajor caju* (16.33 days), *P. fossulatus* (16.66 days) and *P. sapidus* (15.00 days) supplemented with ferrous sulphate followed by magnesium sulphate (18.00, 16.66 and 16.00 days) while in *P. florida* (16.66 days) supplemented with salicylic acid and *P. flabellatus* (15.62 days) supplemented with magnesium sulphate, respectively, which were significantly superior comparison to without supplemented treatment (control). Maximum numbers of fruiting bodies were harvested from different-different treatment in all five species like *P. sajor caju* (79.95) supplemented with ZnSO_4 , *P. florida* (77.03) supplemented with salicylic acid, *P. flabellatus* (76.12) supplemented with CuSO_4 , *P. fossulatus* (79.91) with MnSO_4 and *P. sapidus* (80.62) supplemented with K_2SO_4 . Maximum yield was harvested significantly well in all the five species *P. sajor caju* (602.90 g/kg), *P. florida* (592.10 g/kg), *P. flabellatus* (566.55 g/kg), *P. fossulatus* (604.00g/kg) and *P. sapidus* (612.12 g/kg) supplemented with ferrous sulphate, respectively. However, maximum average weight per fruit body was recorded significantly well in magnesium sulphate and ferrous sulphate supplemented treatment from most of the tested oyster species, respectively. These findings are accordance with Kachroo *et al.* (1998) that maximum yield of *P. sajor caju* was observed in magnesium sulphate followed by ferrous sulphate. Huang *et al.* (2003) studied the effect of various source of carbon (brown sugar, fructose, lactose, glucose, sucrose, starch and maltose), nitrogen (wheat bran, yeast cream, beef cream, peptone, $(\text{NH}_4)_2\text{SO}_4$, NH_4Cl and $(\text{NH}_4)_2\text{CO}_3$) and inorganic salts K_2SO_4 , MgSO_4 , CaSO_4 , MnSO_4 and FeSO_4 on the mycelial growth of *P. ostreatus*.

The mycelial growth was more pronounced with MgSO_4 as the inorganic salts source.

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