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Research Article
Integrated Management of *Mycogone perniciosa* Causing Wet Bubble Disease of White Button Mushroom (*Agaricus bisporus*) in Kashmir

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Abstract

Background and Objective: *Mycogone perniciosa* is a fungal pathogen responsible for causing wet bubble disease, a serious threat to button mushroom (*Agaricus bisporus*) production in India. Outbreaks of wet bubble disease (WBD) are seriously affecting the yield of this mushroom to a great extent. The aim of this study was to have an integrated management of wet bubble disease of white button mushroom (*Agaricus bisporus*), using the best-selected fungicide, plant extract and bioagent against the pathogen. **Materials and Methods:** The most promising botanical, bioagent and fungicide were selected from previous *in vivo* treatments and were further evaluated against *Mycogone perniciosa* in the mushroom house. **Results:** Sprays on the casing with non-systemic fungicides prochloraz manganese 50 WP or captan 50 WP at 0.2% and systemic fungicides carbendazim 50 WP or bitertanol at 0.1%, respectively were most effective in controlling wet bubble disease without causing toxicity to the mushroom mycelium. Incorporation of dry formulations of bacterial antagonists in casing mixture at the time of casing at 2-3% was much helpful for the management of the disease. Incorporation of botanicals such as *Curcuma longa* as dry powder at 1-3% with casing mixture at the time of casing, indicated broad spectrum fungicidal activity against *M. perniciosa* without affecting the quality and yield of fruiting bodies. **Conclusion:** These formulations have much scope for commercialization production of an organic mushroom crop, in view of lesser choices available for selective fungicides and the need to avoid pesticide residues in this short-duration high-value crop.

Key words: Production, integrated, formulations, toxicity, spectrum, fruiting

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Button mushroom (*Agaricus bisporus*) is widely cultivated throughout the world. This mushroom possesses a very high nutritional value, hence this mushroom has been an important component of the human diet for more than 200 years. Currently, large-scale commercial production of *A. bisporus* is at pace in India. In India, the annual production of mushrooms is estimated to be around 1,20,000 metric tonnes with 89% of this production being of button mushrooms[1]. Of late, much emphasis is being laid on the production of mushrooms in Kashmir (one of the Union Territories of India) where 79,277 spawn bottles for laying about 150,000 trays/poly bags were distributed in 2009-2010 and about 5051.61 quintals of mushroom harvested under Rashtriya Krishi Vikas Yojana (RKVY) alone[2].

Button mushroom cultivation in the valley is done usually in growing rooms in residential houses with limited facilities available, without any environmental control system and without the limited provision of compost pasteurization, thus providing the conditions conducive for the growth and multiplication of pathogens and competitor moulds associated with mushroom culture. This eventually led to the growth in the populations of a few fungal and bacterial pathogens, thus posing a serious threat to the profitable production of this crop.

In certain cases, new growing rooms with environmental control systems with proper compost pasteurization facilities are coming up in the valley, but the number of such farms is very few[3].

Among the various serious fungal impediments, wet bubble disease (WBD) is one of the most serious fungal diseases affecting the cultivation of *A. bisporus* worldwide. The causal agent is *Mycogone perniciosa*, which causes the distortions of fruiting bodies and characteristic lump formation in the affected mushrooms. This disease is very devastating and results in huge crop losses[4]. Infected mushrooms are unfit for sale. The pathogen adheres to the fruiting body of mushrooms and penetrates it during any developmental stage, forming either the undifferentiated lumps of primordia or the brown-coloured fruiting body. These distorted fruiting bodies are covered with wet bubbles, white mycelium and amber droplets over them.

The disease is most prevalent in India in temperate areas although reports of its occurrence exist in subtropics also[5].

This fungal pathogen is responsible for the deformation of fruiting bodies and the reduction of yield in mushroom houses of the valley. Controlling this impediment in mushroom houses is a serious issue as this pathogen causes huge damage to both the quantity and quality of mushrooms. The aim of this part of the research was to have an efficient management strategy to combat this impediment. The main objective of this study was to have an integrated management approach for controlling this menace.

MATERIALS AND METHODS

Study area: The present studies on the integrated management of wet bubble disease of *Agaricus bisporus* (Lange) Imbach, were conducted during 2008 and 2009 at Mushroom Research and Training Centre, Division of Plant Pathology, SKUAST-Kashmir, Shalimar, Srinagar.

Keeping in view the destructive nature of the disease on growing mushrooms crop, especially in temperate climatic conditions of the Kashmir Valley, the disease warrants control through effective management since any single method lacks the flexibility necessary to suppress the dynamic pathogen population for a longer time, studies were taken up for the harmonious use of various botanicals, bio-control agents and chemicals for efficiently managing the disease.

The selected botanical, bioagent and fungicide (systemic and non-systemic) which displayed maximum efficacy against the pathogen (*Mycogone perniciosa*) in the previous trials were *Curcuma longa* (turmeric), *Pseudomonas fluorescence*-103, carbendazim (systemic fungicide) and captan (non-systemic fungicide). All these treatments were evaluated *in vivo* in a cultivation trial of *Agaricus bisporus*.

Integrated management of wet bubble disease was attempted in two separate sets of experiments. In one set of integrated management most efficient systemic fungicide carbendazim 50 WP at 0.05% concentration, the most effective botanical *C. longa* at 1% concentration and a potential bio-control agent *P. fluorescens*-103 at 1% concentration with minimum inhibition against *M. perniciosa* were evaluated in combination.

In the second set of experiments, the most effective non-systemic fungicide captan 50 WP was utilized in treatment combinations. Treatment combinations in these two sets of experiments were mentioned in Table 1.

The botanical (*C. longa*, 1%) and the bacterial antagonist (*P. fluorescense*-103, 1%) were admixed with pathogen-infested casing soil mixture individually and also in combinations with each other, together with either a non-systemic (captan) or systemic (carbendazim) fungicidal spray for the management of wet bubble disease of button mushroom (*A. bisporus*) (Fig. 1). Treatments without admixtures of any management agents were maintained as a check.

Fig. 1(a-h): *In vivo* bio-assay of fungi toxicants botanicals and bacterial antagonists, (a-b) Layout plan of experiment, (c-d) Production bags applied with *P. manganese* and carbendazim, (e-g) Integrated management components and (h) Un-infested casing soil

Table 1: Treatment combination in the two sets of experiments

Treatments in set-I	Treatments in set-II
Carbendazim 50 WP 0.05%	Captan 50 WP 0.1%
Curcuma longa 1%	*Curcuma longa* 1%
Pseudomonas fluorescens (PS-103) 1%	*Pseudomonas fluorescens* (PS-103) 1%
Carbendazim 0.05%× *C. longa* 1%	Captan 0.1%× *C. longa* 1%
Carbendazim 0.05%×PS-103 1%	Captan 0.1%×PS-103 1%
Curcuma longa 1%×PS-103 1%	*Curcuma longa* 1%×PS-103 1%
Carbendazim 0.05%× *C. longa* 1%×PS-103 1%	Captan 0.1%× *C. longa* 1%×PS-103 1%
Control-I (sterilized casing soil)	Control-I (sterilized casing soil)
Control-II (infested casing soil)	Control-II (infested casing soil)
Control-III (un-infested casing soil)	Control-III (un-infested casing soil)

Determination of parameters: *In vitro* control of pathogen was already done by using fungicides, botanicals and bioagents. The best fungicide, botanicals and bio-agents showing high efficiency against pathogens were selected and used *in vivo* trials.

Statistical analysis: The differences exhibited by the treatments in various experiments were tested for their significance as per the methods suggested by Gomez and Gomez[6]. The 'Minitab' computer software was used for data analysis.

RESULTS

Integration with non-systemic fungicide

Effect on disease development: It was evident from Table 2 that all three management agents applied individually or in different combinations reduced the disease intensity as compared to the control. Minimum disease intensity (8.29%) was recorded in treatment which received all three management agents, whereas maximum disease intensity (73.42%) was observed in control which did not receive any management application. However, treatments which received captan 50 WP (0.1%)+*C. longa* (1.0%) or captan 50 WP (0.1%)+*P. fluorescens* (1.0%) recorded 9.45% and 9.57% disease intensity, respectively were identical with treatments which received all the three agents in combination. Captan 50 WP 0.1% individually or *C. longa* (1.0%)+*P. fluorescens* (1.0%) or *P. fluorescens* (1.0%) and *C. longa* (1.0%) recording 11.38, 13.96, 16.56 and 17.16% disease intensity was statistically inferior to other treatments.

Effect of yield and yield components: The results (Table 3) revealed that the incorporation of *C. longa* (1%) and *P. fluorescence*-103 (1%) in the casing mixture resulted in the minimum number of fruit bodies per kg mushroom. Incorporation of *P. fluorescence*-103 alone and in combination with captan was the next best treatment yielding 92.17-92.33 fruit bodies/kg mushroom similar to infested check (92.67 fruit bodies/kg mushroom).

Table 2: Effect of integration of some management components with captan sprays on percent disease intensity of wet bubble disease during spring 2009-2010

	Disease intensity (%)		
Treatments	2009	2010	Mean
Captan 50 WP 0.1%	11.06 (19.38)*	11.71 (19.95)	11.38 (19.66)^{bc**}
Curcuma longa 1.0%	17.82 (24.95)	16.51 (23.93)	17.16 (24.44)^{e}
Pseudomonas fluorescens-103 1.0%	17.83 (24.94)	15.30 (22.98)	16.56 (23.96)^{de}
Captan 0.1%+*C. longa* 1.0%	9.31 (17.72)	9.84 (18.25)	9.57 (17.98)^{ab}
Captan 0.1%+*P. fluorescens*-103 1.0%	9.63 (18.06)	9.27 (17.72)	9.45 (17.89)^{a}
Curcumalonga 1.0%+*P. fluorescens*-103 1.0%	15.43 (23.11)	12.49 (20.68)	13.96 (21.89)^{cd}
Captan 0.1%+*C. longa* 1.0%+*P. fluorescens*-103 1.0%	9.11 (17.54)	7.47 (15.83)	8.29 (16.68)^{a}
Control (untreated infested casing soil)	73.30 (59.90)	73.54 (59.34)	73.42 (59.17)^{f}
Mean	20.43 (25.58)	19.51 (24.83)	
	SE±	SEM±	CD (p = 0.05)
Treatments	1.40	0.99	2.37
Year	0.85	0.60	NS
Treatments×year	1.98	1.40	NS

*Figures in parenthesis are angular transformed values, **Means fallowed by similar letter(s) are statistically identical, *Curcuma longa* and *Pseudomonas fluorescens*-103 were incorporated in casing mixture as dry powder at the time of casing, Mean percent disease intensity recorded in pathogen un-infested sterilized casing soil and un-infested-unsterilized casing soil were recorded as 0.00 and 2.0, respectively

Table 3: Effect of integration of some management components with Captan 50 WP spray on the yield parameters of white button mushroom (*Agaricus bisporus*) during 2009 and 2010 (data pooled over years)

Treatments	Number of fruit bodies per kg mushroom	Weight of fruit bodies (g)	Button yield kg q^{-1} compost
Captan 50 WP 0.1%	95.00^{d}	10.49^{d}	11.97^{d}
Curcuma longa 1.0%	94.17^{d}	10.62^{d}	9.95^{e}
Pseudomonas fluorescens-103 1.0%	92.17^{b}	10.97^{b}	10.21^{e}
Captan 50 WP 0.1%×*C. longa* 1.0%	94.00^{cd}	10.70^{c}	11.45^{d}
Captan 50 WP 0.1%×PS-103 1.0%	92.33^{b}	10.90^{b}	12.21^{d}
Curcuma longa 1%×PS-103 1.0%	90.67^{a}	10.95^{b}	10.30^{e}
Captan 50 WP 0.1%×*C. longa* 1.0%×PS-103 1.0%	94.17^{d}	12.21^{a}	14.08^{c}
Control I (sterilized casing soil)	93.83^{c}	10.61^{d}	17.97^{a}
Control II (infested casing soil)	92.67^{bc}	10.84^{bc}	4.66^{f}
Control III (uninfested casing soil)	93.50^{c}	10.68^{cd}	15.30^{b}
SE±	0.74	0.10	0.38
CD (p = 0.05)	1.49	0.20	0.81

Means of three replications, Means followed by similar letter(s) are statistically identical

Table 4: Effect of integration of some management components with captan 50 WP spray on quality parameters of white button mushrooms (*Agaricus bisporus*) during 2009 and 2010 (data pooled over years)

Treatments	Weight of pileus (g)	Diameter of pileus (cm)	Stipe weight (g)	Stipe diameter (cm)
Captan 50 WP 0.1%	5.74^{c}	3.30	4.61^{c}	1.24^{h}
Curcuma longa 1.0%	5.70^{cd}	3.34	4.83^{ab}	1.29^{f}
Pseudomonas fluorescens-103 1.0%	5.51^{e}	3.35	4.92^{a}	1.43^{a}
Captan 0.1%×*C. longa* 1.0%	5.74^{c}	3.40	4.73^{b}	1.27^{g}
Captan 0.1%×PS-103 1.0%	5.58^{de}	3.34	4.70^{b}	1.34^{d}
Curcuma longa 1%×PS-103 1.0%	5.90^{ab}	3.36	4.85^{a}	1.36^{c}
Captan 0.1%×*C. longa* 1.0%×PS-103 1.0%	5.95^{a}	3.34	4.78^{b}	1.32^{e}
Control I (sterilized casing soil)	5.79^{bc}	3.39	4.68^{b}	1.27^{g}
Control II (infested casing soil)	5.57^{e}	3.30	4.43^{d}	1.38^{b}
Control III (uninfested casing soil)	5.57^{e}	3.34	4.47^{d}	1.37^{b}
SE±	0.06	0.06	0.04	0.00
CD (p = 0.05)	0.12	NS	0.09	0.01

Means of three replications, means followed by similar letter(s) are statistically identical

The highest weight of fruit body (12.21 g) was exhibited by the treatment where *C. longa* and *P. fluorescens*-103 were incorporated with captan spray in the casing soil followed by the treatment receiving *P. fluorescens*-103 alone and in combination with *C. longa* and (sterilized casing soil) check-I (10.84-10.97), compared to that of obtained in infested check-II and un-infested check-III (10.31 and 10.68). The treatment receiving *C. longa* 1% with captan (0.1%) spray proved the next best treatment with a fruit body weight of 10.78 g.

Table 3 further revealed that none of the treatments provided as much button yield as obtained in check-I (sterilized casing soil) and check-III (un-infested casing soil). However, the incorporation of *C. longa* and *P. fluorescens*-103 in casing soil along with a spray of captan exhibited the highest (14.08 kg q^{-1} compost) button yield. A spray of captan 50 WP (0.1%) along with the incorporation of *C. longa* or *P. fluorescens*-103 in casing were the next best treatments with regard to button yield (11.45-12.21 kg q^{-1} compost).

Effect on sporophore quality parameters: The Integrated management components significantly affected the sporophore quality parameters such as pileus weight, pileus dia, stipe weight and stipe dia.

Pileus weight: Table 4 revealed maximum pileus weight (5.90-5.95 g) exhibited by the treatments receiving both *C. longa* and *P. fluorescens*-103 1% with or without captan 0.1% spray. Applications of captan (0.1%) or *C. longa* (1.0%) singly or in combination were next as good as a check I (sterilized casing soil) with respect to pileus weight (5.74-5.79 g).

Pileus diameter: The dia of pileus did not vary much in different treatments and their combinations and thus proved to be non-significant.

Stipe weight: The maximum stipe weight of 4.85-4.92 g was exhibited by the treatments receiving *P. fluorescens*-103 or *C. longa* alone and in combinations. The next best stipe weight (4.70-4.73 g) was provided by the treatment receiving captan (0.1%) in combination with either *C. longa* or *P. fluorescens*-103.

Stipe diameter: The maximum stipe dia (1.43 cm) was exhibited in treatment receiving *P. fluorescens*-103 (1%) compared to that (1.27 cm) obtained in infested check II. The next best stipe dia of (1.36 cm) was obtained in treatments receiving both *C. longa*× *P. fluorescens*-103.

Integration with systemic fungicide

Effect on disease development: It is evident from Table 5 that, all three management components applied individually or in different combinations significantly reduced the disease intensity as compared to the control. The minimum disease intensity (8.77%) was recorded in treatment which received all three management agents, whereas maximum disease intensity (73.42%) was observed in control which did not receive any management application. However, treatments which received carbendazim 50% WP 0.05%+*C. longa* (1%) or carbendazim 50% WP (0.05%)+*P. fluorescens* or carbendazim 50% WP (0.05%) alone recorded 9.55, 10.39 and 10.96% disease intensity, respectively, were identical with treatment which received all the three agents in combinations. *Curcuma longa* 1%+*P. fluorescens* together or *P. fluorescens* (1%) and *C. longa* (1%) individually recorded 13.96, 16.56 and 17.16% disease intensity was statistically inferior to other treatments.

Table 5: Effect of integration management components with carbendazim sprays on the percent disease intensity of wet bubble disease during spring 2009-2010

Treatments	Disease control (%)		
	2009	2010	Mean
Carbendazim 50 WP 0.05%	11.78 (20.06)*	10.14 (18.53)	10.96 (19.29)a**
Curcuma longa 1.0%	17.82 (24.95)	16.51 (23.93)	17.16 (24.44)c
Pseudomonas fluorescens-103 1.0%	17.83 (24.94)	15.30 (22.98)	16.56 (23.96)bc
Carbendazim 50 WP 0.05%+*C. longa* 1.0%	9.57 (17.99)	9.53 (17.93)	9.55 (17.96)a
Carbendazim 50 WP 0.05%+*P. fluorescens*-103 1.0%	9.08 (17.53)	11.70 (19.98)	10.39 (18.75)a
Curcuma longa 1.0%+*P. fluorescens*-103 1.0%	15.43 (23.11)	12.49 (20.68)	13.96 (21.89)b
Carbendazim 50 WP 0.05%+*C. longa* 1.0%+*P. fluorescens*-103 1.0%	8.78 (17.23)	8.76 (17.21)	8.77 (17.22)a
Control (pathogen infested casing soil)	73.30 (59.00)	73.54 (59.34)	73.42 (59.17)d
Mean	20.45 (25.60)	19.74 (25.07)	
	SE±	SEM±	CD (p = 0.05)
Treatments	1.35	0.96	2.28
Year	0.68	0.47	NS
Treatments×year	1.92	1.40	NS
Uninfested-sterilized casing soil	0.00 (2.86)	0.00 (2.86)	0.00 (2.86)
Uninfested-unsterilized casing soil	2.50 (9.09)	150 (7.03)	2.00 (8.06)

*Figures in parenthesis are angular transformed values, **Means followed by similar letter(s) are statistically identical, *Curcuma longa* and *Pseudomonas fluorescens*-103 were incorporated in casing mixture as dry powder at the time of casing, Mean percent disease intensity recorded in pathogen un-infested sterilized casing soil and un-infested-unsterilized casing soil were recorded as 0.00 and 2.0, respectively

Table 6: Effect of integration of some management components with carbendazim 50 WP spray on the yield parameters of white button mushrooms (*Agaricus bisporus*) during 2009 and 2010 (data pooled over years)

Treatments	Number of fruit bodies per kg mushroom	Weight of fruit bodies (g)	Button yield kg q^{-1} compost
Carbendazim 50 WP 0.05%	97.67fg	10.34e	11.04e
Curcuma longa 1.0%	89.33c	11.00bc	10.25e
Pseudomonas fluorescens-103 1%	84.33a	12.01a	10.29e
Carbendazim 0.05%×*C. long* 1.0%	93.50e	10.67d	10.80e
Carbendazim 0.05%×PS-103 1.0%	91.00d	11.08b	12.83d
Curcuma longa 1%×PS-103 1.0%	86.83b	11.23b	10.70e
Carbendazim 0.05%×*C. longa* 1.0%×PS-103 1.0%	90.44cd	11.11b	14.27c
Control I (sterilized casing soil)	94.67e	10.75cd	17.97b
Control II (infested casing soil)	96.33f	10.36e	4.53f
Control III (uninfested casing soil)	99.00g	10.51de	15.47a
SE±	0.65	0.14	0.47
CD (p = 0.05)	1.37	0.29	0.99

Means of three replications, means followed by a similar letter(s) were statistically identical

Effect of yield and yield components: The results in Table 6 revealed that the incorporation of *P. fluorescens*-103 (1%) in the casing mixture resulted in the minimum (84.33) number of fruit bodies per kg mushroom, following by the combination treatment receiving *C. longa* (1%) with *P. fluorescens*-103 (1%) providing 86.83 number of fruit bodies per kg mushroom. Incorporation of *C. longa* (1%) alone or in combination with carbendazim and *P. fluorescens* in the casing mixture recording 89.33-90.44 fruit bodies per kg mushroom was the next best treatment compared to that of 96.33 fruit bodies per kg mushroom obtained in infested check II.

The highest weight of fruit body (12.01 g) was exhibited by the treatment receiving *P. fluorescens*-103 (1%) followed by treatments receiving *C. longa* (1%) alone or in combination with either *P. fluorescens* (1%) or *P. fluorescens*-103 and carbendazim 11.00-11.23 g compared to that 10.36 g obtained in infested check II.

Table 6 further revealed that none of the treatments provided as much button yield as obtained in check-I (sterilized casing soil) or check III (un-infested casing soil). However, the incorporation of *C. longa* (1%) and *P. fluorescens*-103 in casing soil with the spray of carbendazim (0.05%) exhibited the highest (14.27 kg q^{-1} compost) yield, followed by the incorporation of *P. fluorescens*-103 only and with the spray of carbendazim (12.83 kg q^{-1} compost) compared to the yield (4.53 kg q^{-1} compost) obtained in infested check II.

Effect on sporophore quality parameters

Pileus weight: Table 7 revealed that maximum pileus weight (5.96 g) among the different treatment combinations was exhibited by the treatment receiving only *P. fluorescens*-103 (1%) followed by that (5.87 g) obtained in the treatment receiving *P. fluorescens*-103 along with carbendazim 50 WP (0.05%) spray, compared to pileus weight (5.46 g) obtained in infested casing soil check I.

Table 7: Effect of integration of some management components with carbendazim 50 WP spray on the quality parameters of white button mushrooms (*Agaricus bisporus*) during 2009 and 2010 (data pooled over years)

Treatments	Weight of pileus (g)	Diameter of pileus (cm)	Stipe weight (g)	Stipe diameter (cm)
Carbendazim 50 WP 0.05%	5.76^{c}	3.31^{d}	4.66^{d}	1.26^{f}
Curcuma longa 1.0%	5.38^{h}	3.38	4.80^{bc}	1.29^{e}
Pseudomonas fluorescens-103 1.0%	5.96^{a}	3.37	4.91^{a}	1.43^{a}
Carbendazim 0.05%× *C. longa* 1.0%	5.57^{f}	3.28	4.75^{c}	1.28^{e}
Carbendazim 0.05%×PS-103 1.0%	5.87^{b}	3.36	4.67^{d}	1.35^{c}
Curcuma longa 1.0%×PS-103 1.0%	5.67^{de}	3.38	4.86^{ab}	1.37^{bc}
Carbendazim 0.05%× *C. longa* 1.0%×PS-103 1.0%	5.70^{cd}	3.35	4.79^{c}	1.33^{d}
Control I (sterilized casing soil)	5.83^{be}	3.39	4.76^{c}	1.27
Control II (infested casing soil)	5.46^{g}	3.42	4.46^{e}	1.35
Control III (uninfested casing soil)	5.63^{ef}	3.48	4.70^{cd}	1.39^{b}
SE±	0.03	0.04	0.05	0.01
CD (p = 0.05)	0.06	NS	0.10	0.02

Means of three replications, Means followed by similar letter(s) are statistically identical

Pileus dia: The diameter of pileus did not vary significantly among different treatments and their combinations in the present studies.

Stipe weight: The maximum stipe weight of (4.86-4.91 g) was recorded in the treatment receiving *P. fluorescens*-103 (1%) alone and in combination with *C. longa* (1%) followed by a stipe weight of (4.79-4.80 g) obtained in the treatments receiving *C. longa* (1%) alone and in combination with carbendazim 50WP (0.05%) and *P. fluorescens*-103 (1%) compared to a stipe weight (4.46 g) obtained in infested check II.

Stipe dia: The maximum stipe dia (1.45 cm) was exhibited in treatments receiving *P. fluorescens*-103 (1%) alone followed by stipe dia of 1.35-1.37 obtained in treatments receiving *P. fluorescens*-103 in combination with either carbendazim 50 WP (0.05%) or *C. longa* as compared to (1.27 cm) obtained in infested casing check II.

DISCUSSION

The effectiveness of any disease management component can better be assessed by their *in vivo* evaluation of these diseases. The *in vivo* evaluation of the fungi toxicants revealed the efficacy of carbendazim and bitertanol (systemic) or captan and prochloraz manganese (non-systemic) incorporated in pathogen-infested casing material in controlling wet bubble disease with a concomitant increase in mushroom button yield. The incorporation of bacterial antagonists such as *P. fluorescens*, *B. subtilis* or *Azotobacter* sp. at different concentrations in pathogen-infested casing also yielded appreciable disease control with corresponding yield gains. Similarly, the incorporation of *C. longa* in pathogen-infested casing soil also exhibited wet bubble control with corresponding yield gains. The incorporation of effective fungicides, botanicals or bacterial antagonists in casing soil for the control of wet bubble disease of the button mushrooms has also been demonstrated by other researchers[7-9]. The effectiveness of prochloraz manganese and captan against *M. perniciosa* mould of edible fungi has also been earlier documented[10-14]. Similarly, the usefulness of *P. fluorescens* and *B. subtilis* in the control of moulds/diseases observed in the present investigations was in conformity with those of researchers[15-19]. The antagonistic behaviour of fluorescent pseudomonads against mushroom pathogens with an increase in mushroom yields has been reported by many other workers[20-23] also claimed good success of siderophore-producing isolate (C116) of fluorescent pseudomonads against *M. perniciosa.* The incorporation of *C. longa/L. officinalis/A. annua* for successfully managing the wet bubble disease as observed during the present study was in unison with those of Sharma *et al.*[24-26].

CONCLUSION

The integration of two or more management components, thus identified, is likely to provide a cumulative or additive effect in controlling the wet bubble disease. The integration is sure to help reduce the use of fungi-toxicants. The integration of non-chemical components such as bio-agents and botanicals coupled with the adoption of compost and casing pasteurization, sanitation and avoidance of the prevalence of pre-disposing factors shall help raise a profitable and organic crop.

SIGNIFICANCE STATEMENT

Kashmir has a huge potential for growing mushrooms as all the natural conditions are in favour of mushroom growth. Despite having so much potential in the mushroom industry, the crop often faces huge losses every year because of impediments like fungal and bacterial pathogens. Wet bubble caused by *Mycogone perniciosa* is one of the serious Pathogen causing devastating losses every year. Its control becomes quite important. The aim of this study was to control the wet bubble disease of white button mushroom by following an integrated approach, using the best-selected fungicide, plant extract and bioagent against the pathogen.

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