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Status and Management of Dry Bubble Disease of White Button Mushroom (*Agaricus bisporus*) under the Conditions of Sub Tropics of Jammu

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ABSTRACT: Axtensive survey was conducted during spring and autumn seasons of 2019-20 and 2020-21 in major mushroom growing areas of Jammu, Samba and Udhampur districts of Jammu division to record the status of the disease. The survey revealed that dry bubble disease was prevalent in all mushroom growing districts with varied degrees of incidence. The overall mean disease incidence was 6.52 per cent both years in three districts, the disease incidence was more (5.76 and 6.22 %) in spring than in autumn season (6.27 and 7.39 %). The highest disease incidence (7.22 %) in Jammu district followed by (6.49 %) in Samba district and the lowest disease incidence (5.85 %) in Udhampur district. *In vitro* study of different bio agents against *Veticillium fungicola* revealed that inhibition of mycelia growth was maximum with *Trichoderma harzianum* (46.43 %) followed by *Trichoderma viride* (35.80 %) and *P. fluorescens* (17.43 %). *In vitro* evaluation of different botanicals *viz., Azadirachta indica*(neem leaf), *Azadirachta indica* (seed), *Allium sativum* (garlic), *Aloe vera* (aloevera), *Lanatana camara* (lantana), *Ocimum sanctum* (tulsi) and *Azadirachta indica* + *Lantana camara* revealed that *Azadirachta indica* at 10 per cent was best (63.04%) for inhibition of mycelia followed by *Azadirachta indica* +*Lantana camara* (55.95%). At 5 per cent *Azadirachta indica* was found to be most effective (33.18%) followed by *Azadirachta indica* + *Lantana camara* (55.95 %). Plant extracts showing maximum efficacy and minimum inhibition against *Veticillium fungicola* were further evaluated against *Veticillium fungicola* infection in mushroom crop room (*in-vivo* test). In *in-vivo* study, the polybags which receive *A. indica* showed maximum mean increase in yield (17.99%) over control and exhibited minimum mean disease incidence (28.92%).

Keywords: *Agaricus bisporus,* Dry bubble disease, Plant extracts, *Verticillium fungicola.*

INTRODUCTION

Mushroom production represents one of the commercially important microbial technologies for large scale recycling of agro wastes. Among commercially cultivated mushrooms, *Agaricus bisporus* popularly known as white button mushroom or European mushroom is extensively cultivated throughout the world. In the present scenario of economy, it has opened up new vistas of export earnings. Button mushroom contains high amounts of protein, minerals, vitamin B group, vitamin D and K and also A and C vitamins. The amount of fat, calorie, sodium and cholesterol levels are low in button mushroom (Saiqa *et al.*, 2008). *A. bisporus*is one of the most important mushrooms that is cultivated in the world (Toker *et al.*, 2007). *Verticillium fungicola* var. *fungicola* the causal agents of dry bubble disease is important fungal pathogens of the button mushroom. Symptoms of dry bubble, caused by *Verticillium fungicola* var. *fungicola*, vary depending on the time of infection. Infection at an early stage in mushroom development results in the production of undifferentiated masses of mushrooms. If maturing mushrooms are infected, then spotting symptoms develop (Potocnik *et al.*, 2008). White button mushroom is the most popular mushroom, grownall over in India. In Jammu commercial cultivation of button mushroom introduced by number of organizations since long and a good amount of reasonable work has been done on various aspects of this mushroom in SKUAST- Jammu .The cultivation of button mushroom has increased in the Jammu division due to easy cultivation process. But the major constraint in the speedy popularization of this crop is diseases and

pests. The diseases and pests happen to be devastating and perpetuate easily from one season to another. *V. fungicola* is responsible for causing a serious disease called dry bubble which major fungal problem for mushroom growers. The pathogen inhibits the growth of mushrooms and hinders the production of fruiting bodies. It is a common contaminant, badly hindering the production of mushroom in the Jammu division. Some workers have recommended bio-control and fungicides for the treatment of dry bubble. But growers hardly use the fungicides for the treatment of this havoc disease. They often found fungicidal treatment as non-economical (Shah and Nasreen, 2011). The present study was carried out to develop economically viable and eco-friendly management of this devastating disease through the application of botanicals.

MATERIALS AND METHODS

The present study was conducted during 2019-20 and 2020-21 at mushroom Research and Training Centre, Division of Plant Pathology, SKUAST –Jammu. Survey of different mushroom units in Jammu, Samba and Udhampur districts of Jammu division was conducted in both spring and autumn crop season of 2019-20 and 2020-21 to ascertain the status of dry bubble disease (*Verticillium fungicola*) of white button mushroom.

***In vitro* evaluation botanicals**

In this experiment, ethanol extract of 7 botanicals *viz. Azadirachta indica* (neem leaf), *Azadirachta indica*(seed), *Allium sativum* (garlic), *Aloe vera* (aloevera), *Lanatana camara* (lantana), *Ocimum sanctum* (tulsi), *A. indica* + *L. camara*were evaluated in the laboratory for their efficacy against *Vertricillium fungicola.* The plant extracts were evaluated *in-vitro* through poison food technique (Nene and Thapliyal, 2000). Five per cent and ten per cent test concentrations were obtained by adding appropriate amount of sterile distilled water to the standard solution (100%). Two ml of each extract (5% and 10%) was dispensed in petriplates (90mm) and then 20 ml of molten PDA was poured gently in petriplates containing extract solution. After solidification, inoculation was done with 5 mm diameter mycelial cut from 12 days old cultures of *V. fungicola* separately. The media without the plant extract served as control. The plates were incubated at 27±1°C till the complete growth was observed in control plates. Percent inhibition of growth was calculated in relation to the growth in control using the following formula of Vincent (1947):

$$\text{Per cent mycelial growth inhibition} = \frac{(C - T)}{C} \times 100$$

Where, C = radial mycelial growth (mm) in check, T = radial mycelial growth in the treatment (mm)

***In vivo* evaluation of botanicals.** In this study, the botanicals which showed least adverse effects on the growth of *Agaricus bisporus* were evaluated against *V. fungicola* in*in vivo* conditions during the month of September-March of 2019-20 and 2020-21 in Mushroom Cropping Room, Division of Plant Pathology, SKUAST-Jammu. Wheat straw was used as substrate for cultivation of white button mushroom. Compost was made using long method (28 days). The botanicals were dried under shade after collection and crushed into a fine powder with the help of the grinder. The powder was passed through double layered muslin cloth and mixed with the mixture of the compost at 1, 2 and 3% (w/w) and the polythene bags of 22.5 cm × 30 cm size were filled with 1 kg of prepared compost. Spawn of *A. bisporus* was added at 15 g/kg of compost. The untreated bags (devoid of botanicals) were kept as control. All the treatments including control were replicated five times. Then, the bags were incubated inside the Mushroom Cropping Room, where temperature kept at (22-24°C), four days after casing temperature kept at 15-18°C and humidity (80-85%) was maintained. Room having spawn running bags was kept in dark for 10-15 days till complete colonization of the compost with fungal mycelium (El-Kattan and El-Hadded, 1998). After complete colonization on compost with mycelium of *A. bisporus* the bags were inoculated with 3 ml spore suspension of *V. fungicola* with a spore load of 1×10^3 spores ml^{-1} in the middle of the bag with the help of syringe. The untreated bags (devoid of botanicals) with the same inoculums load were kept as control (Shah *et al.,* 2012). While carrying the above experiment *in vivo,* the observations on days for complete spawn run, days for pin head initiation, per cent increase in yield over control and disease incidence were recorded.

$$\text{Per cent increase in yield over control} = \frac{\text{Yield in treatment (g)} - \text{Yield in control (g)}}{\text{Yield in treatment (g)}} \times 100$$

$$\text{Per cent disease incidence} = \frac{\text{Number of infected bags}}{\text{Total number of bags}} \times 100$$

Analysis of data. In the *in-vitro* experiments, complete randomized design was applied. In *in-vivo* trial, Factorial design (RBD) was applied. All the experiments were analyzed statistically by Analysis of Variance (ANOVA). The calculated value was compared with tabulated value at 0.05% level of probability for the appropriate degree of freedom.

RESULTS AND DISCUSSION

Status of dry bubble disease. In the present investigations, an extensive survey of mushroom

growing units in Jammu, Samba and Udhampur districts of Jammu division during both the seasons of spring and autumn in the year 2019-20 and 2020-21 was undertaken to record the status of the disease. The survey conducted in all the three districts revealed that the disease was present in varying degrees of incidence all the surveyed areas of the Jammu division.

Disease incidence. Data presented in (Table 1 & Fig. 1) revealed that overall incidence of dry bubble disease in Jammu district ranged between 4.44-36.83 per cent with an overall mean of 6.52 per cent during both year (2019-20 and 2020-21) of cropping season. On an overall basis, the disease incidence was noticed more in spring season (5.99%) than in autumn season (7.39%). The highest disease incidence was (7.22%) in Jammu district followed by Samba district (6.49%) and the lowest disease incidence (5.85%) in Udhampur district. The overall mean of disease incidence recorded in spring of both year revealed that disease incidence was maximum (7.72%) in Jammu district followed by (6.12%) Samba district however, minimum incidence (5.15%) was recorded in Udhampur district.

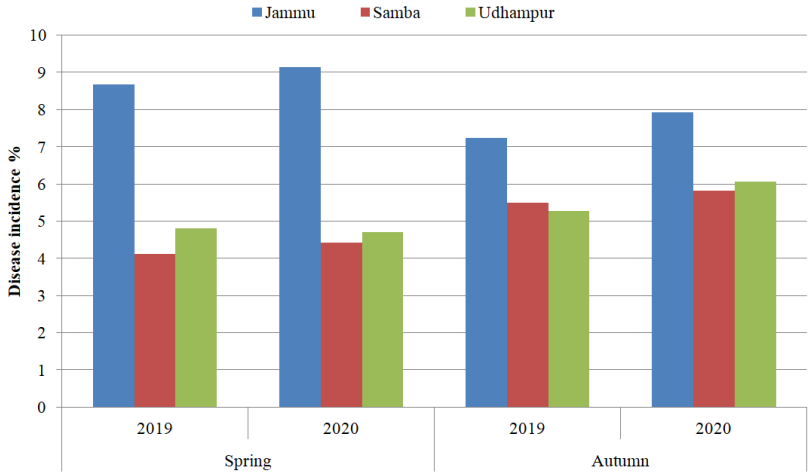

Fig. 1. Incidence of dry bubble disease of white button mushroom at different mushroom units of Jammu division.

Table 1: Incidence of Dry bubble disease of white button mushroom at different mushroom units of Jammu division.

District	Location of farm	Dry bubble disease incidence (%)						Overall Mean
		Spring			Autumn			
		2019-20	2020-21	Mean	2019-20	2020-21	Mean	
Jammu	Ban Talab	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Bhalwal	10.74	15.17	12.96	9.44	12.43	10.94	11.95
	Kot	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Chak Bhalwal	7.89	6.87	7.38	11.10	13.23	12.17	9.78
	Burn	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sarora	12.77	11.69	12.23	19.54	20.33	19.94	16.09
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Bhadore	11.74	14.17	12.96	21.22	12.90	17.06	15.01
	Gura Jagir	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Udhayawala	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Chatha Burn	23.65	21.78	22.72	20.10	22.44	21.27	22.00
	Chatha burn	11.89	9.55	10.72	7.43	8.10	7.77	9.25
	Choril	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kalyanpur	16.43	20.43	18.43	12.30	19.05	15.68	17.06
	Kantowal	33.43	39.05	36.24	23.54	33.04	28.29	32.27
	-do-	12.03	10.81	11.42	16.43	12.44	14.44	12.93
	-d0-	2.78	7.89	5.34	3.55	8.05	5.80	5.57
	Pain	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Balgara	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Manna	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sai	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Khour	4.32	5.44	4.88	8.09	10.32	9.21	7.05
	-do-	1.32	3.33	2.33	9.10	8.12	8.61	5.47
	Patari	10.31	12.32	11.32	14.40	16.03	15.22	13.27
	Krishan Pur	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Shibu Chack	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	2.22	3.21	2.72	4.00	8.30	6.15	4.44

	Maria Muthi	23.43	20.11	21.77	19.12	13.09	16.11	18.94
	Akhnoor	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Dhok Khalsa	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Rajwal	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Thandi Choi	8.01	7.04	7.53	17.87	11.98	14.93	11.23
	Chak Kirpal	23.88	27.98	25.93	23.00	30.98	26.99	26.46
	-do-	33.56	34.55	34.06	39.06	40.11	39.59	36.83
	Dub Ditt	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Hajuri bagh	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Miran Sahib	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kot Ghari	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	R.S.Pura	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Purkhoo Ghari	23.43	30.43	26.93	40.33	39.03	39.68	33.31
	Misri wala	12.67	13.43	13.05	19.43	20.43	19.93	16.49
	Gangoo Chaks	32.44	11.23	21.84	19.43	21.30	20.37	21.11
	Chak	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Amia	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	6.64	6.80	6.72	7.47	7.95	7.71	7.22
Samba	Jatta	1.33	3.54	2.43	4.54	5.78	5.16	3.80
	-do-	9.02	12.43	10.73	20.43	23.33	21.88	16.31
	Kapai	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	kapai	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Nand	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Nand	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	23.39	22.43	22.91	20.11	19.00	19.56	21.24
	Simblana	13.43	17.44	15.44	18.33	22.40	20.37	17.91
	Makroli	2.89	5.98	4.44	9.01	10.00	9.51	6.98
	-do-	11.21	18.32	14.77	19.00	21.01	20.01	17.39
	Rakh Badoi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Badhori	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Balore	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kartholi	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Bir pur	22.32	29.09	25.71	34.65	38.54	36.60	31.16
	Khare madana	39.55	27.44	33.50	22.32	23.45	22.89	28.20
	Raya	7.66	5.77	6.72	9.04	10.43	9.74	8.23
	Chajwal	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mandal	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Naid	23.44	20.19	21.82	17.04	16.33	16.69	19.26
	Dhora	6.32	7.09	6.71	2.12	3.02	2.57	4.64
	Sarian	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sarian	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Purani Kali	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	5.95	6.29	6.12	6.54	7.16	6.85	6.49
Udhampur	Bali	23.66	31.45	27.56	20.65	29.04	29.04	28.30
	Damont	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Chackhar	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Chani	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Chani	5.60	12.30	8.95	16.04	13.43	14.74	11.85
	Chani	9.30	12.45	10.88	15.04	20.09	17.57	14.23
	Chani	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kansal	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Kooh	23.55	19.05	21.30	20.34	28.54	24.44	22.87
	-do-	8.45	7.45	7.95	10.45	11.43	10.94	9.45
	Mansar	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	12.87	17.40	15.14	20.50	28.04	24.27	19.71
	Nagrota	1.30	1.04	1.19	3.65	4.76	4.21	2.70
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Tikri	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	-do-	9.42	10.43	9.93	5.30	6.03	5.67	7.80
	-do-	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	4.71	5.58	5.15	4.81	7.07	6.54	5.85
	Grand Mean	5.76	6.22	5.99	6.27	7.39	7.03	6.52

During spring season (2019-20) maximum disease incidence (33.56%) was recorded in village Chak Kirpal followed by Gangoo Chaks (32.44%), while lowest was found in village Khour (1.32%) of the district Jammu. In samba district the maximum disease incidence was found in village Khare madana (39.55%) followed by Naid (23.44%) however lowest was found in village Jatta (1.33%). In Udhampur district the maximum disease incidence was found in village Bali (23.56%) followed by Kooh (23.55%), however lowest was found in village Nagrota (1.30%). Whereas, in 2020-21 spring the disease incidence was recorded maximum (39.05%) in village Kantowal followed by Chak Kirpal pur (34.55%), however lowest disease incidence was found in village Shibu Chack (3.21%) of the district Jammu. In samba district, the maximum disease incidence was found in village Bir pur (29.09%) followed by Khare madana (27.44%) however lowest disease incidence was found in village Jatta (3.54%). In Udhampur district, the maximum disease incidence was found in village Bali (31.45%) followed by Kooh (19.05%), but the lowest disease incidence (1.04%) was noticed in village Nagrota.

The data collected during the autumn seasons of 2019-20 revealed that the maximum disease incidence (40.33%) was recorded in village Purkhoo Ghari followed by Chak Kirpal pur (39.06%), while the lowest disease incidence (3.55%) was noticed in village Kantowal of the district Jammu. In samba district, the maximum disease incidence was found in village Bir pur (34.65%) followed by Khare madana (22.32%), whereas the lowest disease incidence was found in village Dhora (2.12%). In Udhampur district, the maximum disease incidence (20.65%) was found in village Bali followed by Mansar (20.50%), while lowest disease incidence was found in village Nagrota (3.65%). Whereas, in spring (2020-21) the disease incidence was recorded maximum (40.11%) in village Chak Kirpal pur followed by Purkhoo Ghari (39.03%), however lowest disease incidence was found in village Kantowal (8.05%) of district Jammu. In samba district, the maximum disease incidence was found village Bir pur (38.54%) followed by Khare madana (23.45%) however lowest disease incidence was found in village Dhora (3.02%). In Udhampur district, the maximum disease incidence was found in village Chani (29.09%) followed by Bali (29.04%), however lowest disease incidence was found in village Nagrota (4.76%). The overall mean disease incidence recorded during autumn season of 2019-20 and 2020-21 revealed that maximum disease incidence (7.71%) was found in Jammu district followed by Samba district (6.85%). The minimum disease incidence (6.54%) was recorded in Udhampur district.

***In vitro* evaluation of different botanicals.** Under *in vitro* conditions, all the botanical treatments were significantly effective over control in checking the growth of *Verticillium fungicola* in (Table 2 and Fig. 2). All the treatments were highly effective at maximum concentration of 10 per cent followed by 5 per cent. *Azadirachta indica* was significantly most effective in checking the growth inhibition of the *Verticillium fungicola* (33.18 % and 63.04 %) at two concentration of 5 per cent and 10 per cent, respectively followed by *Azadirachta indica* +*Lantana camara* recording (55.95 %) growth inhibition at 10 per cent followed by 5 percent (30.71%) growth inhibition, respectively, whereas lower growth inhibition was recorded in *Aloe vera* (18.31%) at 10 per cent followed by 5 per cent (13.54%).

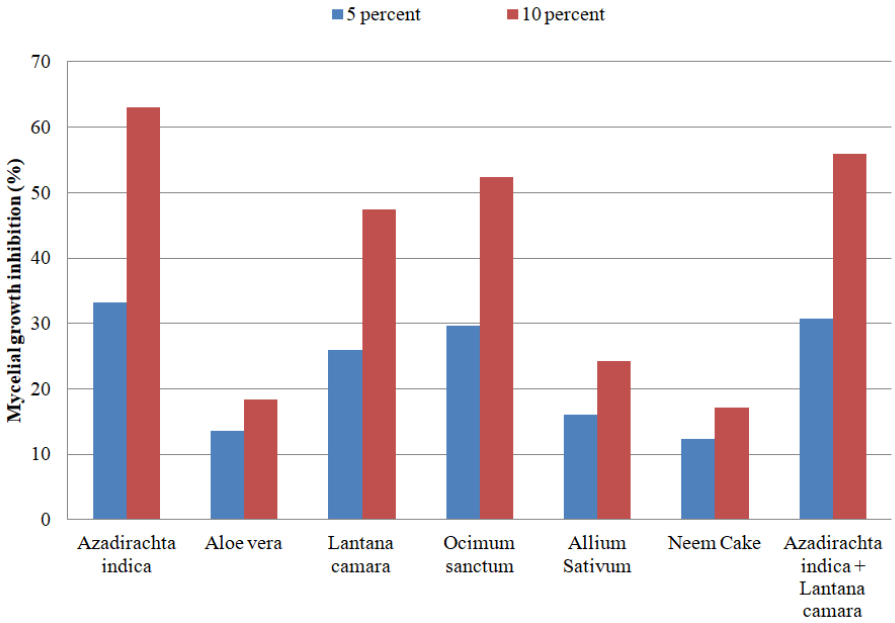

Fig. 2. *In vitro* evaluation of different botanicals extracts against *Verticillium fungicola.*

Table 2: **Evaluation of botanicals against *Verticillium fungicola* of button mushroom.**

Treatment	Mycelical growth (mm)* at concentrations (%)		Mycelial growth inhibition (%)	
	5	10	5	10
Azadirachta indica	54.19	30.36	33.18	63.04
Aloe vera	70.12	67.11	13.54	18.31
Lantana camara	60.11	43.16	25.89	47.46
Ocimum sanctum	57.12	39.19	29.57	52.30
Allium sativum	68.14	62.28	15.99	24.19
Azadirachta indica (seed)	71.11	68.12	12.32	17.10
A. indica + L. camara	56.20	36.19	30.71	55.95
Control	81.11	82.16	-	-
Source Botanical (B)	Concentrations (C)	Botanical × Concentration		
$SEm_{\pm}$ 0.44	0.68	0.96		
$CD_{(0.05)}$ 0.80	0.89	1.73		

***In vivo* evaluation of botanicals.** In this experiment which botanicals displayed maximum efficacy against *Verticillium fungicola* as well as lowest adverse effects on *Agricus bisporus* growth consequently evaluated under *in vivo* condition. Out of seven plant extracts selected, only six botanicals selected for *in vivo* trial were, *Azadirachta indica,* neem seed kernel*, Allium sativum, Ocicum sanctum, Lantana camera* and *Azadirachta india + lantana camara*were consequently evaluated foe *Verticillium fungicola* under *in vivo* condition. The data pertaining to *in vivo* botanicals evaluation for *Agricus bisporus* as well as *Verticillium fungicola* is presented under the following heads.

Days taken for complete colonization run. It is obvious from the (Table 3) that significant difference to selected botanicals efficiency were observed upon days taken for complete colonization run by *Agricus bisporus*. The minimum days required to complete colonization run (14.58 and 14.41 days) was recorded in treatment *Azadirachta india+lantana camara* and (14.84 and 14.16 days) *Azadirachta india*, However maximum for complete colonization run *Allium sativum* (16.58 and 16.29 days) followed by neem seed kernel (16.00 and 15.93 days) *Ocicum sanctum* (15.50 and 15.36 days) and *lantana camara* (15.10 and 14.95 days) in comparison of control, without botanicals (18.32 and 19.11 days), respectively during 2019 and 2020.

Days taken for pin head initiation. Efficiency of selected botanicals for days taken pin head initiation by *Agricus bisporus* detected significant difference between botanicals effects and concentrations on days taken to pin head initiation by *Agricus bisporus* (Table 3) .The minimum days required to pin head initiation (5.53 and 5.37 days) was recorded in treatment *Azadirachta india* and (5.60 and 5.65 days) *Azadirachta india +Lantana camara* , However maximum pin head initiationneem seed kernel (6.93 and 7.20 days), followed by *Allium sativum* (6.13 and 6.36 days) *ocicum sanctum* (6.06 and 6.00 days) and *Lantana camara* (6.00 and 5.93 days) in comparison of control, without botanicals (10.30 and 9.80 days), respectively during 2019 and 2020.

Yield. The data presented in (Table4) revealed that the all concentrations of botanicals were significantly effective and recorded higher yield than unprotected control in both the crop seasons. *Azadirachta indica* was found to be best where the in yield was recorded (402.37 g and 397.11 g/kg) followed by *Azadirachta indica+ Lantana camara* (357.91 g and 360.47 g/kg), *Lantana camara* (357.54 g and 358.81 g/kg), *Ocicum sanctum* (349.96 g and 353.37g/kg), *Allium sativum* (337.31g and 337.35g/kg) and neem seed kernel (342.72 g and 343.01 g/kg).

Per cent increase in yield over control. When compared to unprotected control, all the botanicals treatments recorded increase in yield over control of button mushroom in both the crop seasons (Table 4). *Azadirachta indica* was found to be best where the increase in yield was recorded (18.55% and 17.44%) followed by *Azadirachta indica + Lantana camara* (8.45% and 8.05%), *Lantana camara* (8.86% and 8.43%), *ocicum sanctum* (6.63% and 6.93%), *Allium sativum* (3.23% and 2.62%) and neem seed kernel (4.76% and 4.23 %), respectively.

Table 3: Efficiency of selected botanicals on time taken for complete mycelium run, pin head inhibition of button mushroom

Treatment	Concentration (%)	Complete Colonization (days)			Pin head initiation /first picking (days)		
		2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Azadirachta indica	1	15.65	15.10	15.38	5.7	5.5	5.60
	2	14.54	14.43	14.49	5.6	5.4	5.50
	3	14.32	14.30	14.31	5.3	5.2	5.25
	Mean	14.84	14.61	14.73	5.53	5.37	5.45
Azadirachta indica (seed)	1	16.54	16.69	16.62	7.3	7.7	7.50
	2	15.79	15.56	15.68	6.9	7.2	7.05
	3	15.67	15.54	15.61	6.6	6.7	6.65
	Mean	16.00	15.93	15.97	6.9	7.2	7.07
Allium sativum	1	17.60	17.23	17.42	6.6	6.9	6.75
	2	16.64	16.54	16.59	6.3	6.5	6.40
	3	15.50	15.11	15.31	5.5	5.7	5.60
	Mean	16.58	16.29	16.44	6.1	6.3	6.25
Ocicum sanctum	1	15.87	15.32	15.60	6.3	6.4	6.35
	2	15.44	15.55	15.50	5.9	6.0	5.95
	3	15.21	15.22	15.22	5.6	5.8	5.70
	Mean	15.50	15.36	15.43	5.9	6.0	6.00
Lantana camara	1	15.45	15.54	15.50	6.3	6.4	6.35
	2	15.43	15.01	15.22	6.2	5.8	6.00
	3	14.43	14.32	14.38	5.5	5.6	5.55
	Mean	15.10	14.95	15.03	6.0	5.9	5.97
Azadirachta indica+Lantana camara	1	14.55	14.16	14.36	5.9	5.7	5.80
	2	14.65	14.54	14.60	5.7	5.8	5.75
	3	14.54	14.54	14.54	5.5	5.3	5.40
	Mean	14.58	14.41	14.50	5.7	5.6	5.65
Control		18.32	19.11	18.72	9.3	10.3	9.80
$CD_{(0.05)}$		0.21	0.05	-	0.34	0.56	-

Table 4: Efficiency of selected botanicals on time taken for complete mycelium run, pin head inhibition of button mushroom

Treatment	Concentration (%)	Yield (g)/kg			Per cent increase in yield over control		
		2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Azadirachta indica	1	374.05	371.43	372.74	12.75	13.09	12.92
	2	395.25	386.26	390.76	17.43	14.97	16.20
	3	437.81	433.65	435.73	25.46	24.26	24.86
	Mean	402.37	397.11	399.74	18.55	17.44	17.99
Azadirachta indica(seed)	1	337.37	340.31	338.84	3.26	3.49	3.38
	2	341.36	339.27	340.32	4.40	3.19	3.80
	3	349.44	349.45	349.45	6.61	6.01	6.31
	Mean	342.72	343.01	342.87	4.76	4.23	4.49
Allium sativum	1	331.12	332.43	331.78	1.44	1.20	1.32
	2	337.25	335.32	336.29	3.23	2.05	2.64
	3	343.56	344.29	343.93	5.01	4.60	4.81
	Mean	337.31	337.35	337.33	3.23	2.62	2.92
Ocicum sanctum	1	333.41	336.21	334.81	2.12	2.32	2.22
	2	353.24	357.44	355.34	7.61	8.11	7.86
	3	363.22	366.46	364.84	10.15	10.37	10.26
	Mean	349.96	353.37	351.66	6.63	6.93	6.78
Lantana camara	1	348.43	350.93	349.68	6.33	6.41	6.37
	2	356.48	357.65	357.07	9.23	8.16	8.70
	3	366.81	367.85	367.33	11.03	10.71	10.87
	Mean	357.24	358.81	358.03	8.86	8.43	8.65
Azadirachta indica+ Lantana camara	1	349.43	351.46	350.45	6.60	6.55	6.58
	2	356.23	360.86	358.55	8.39	8.98	8.69
	3	368.08	369.09	368.59	11.33	11.01	11.17
	Mean	357.91	360.47	359.20	8.45	8.05	8.25
Control		326.34	328.43	327.38	-	-	-
$CD_{(0.05)}$		35.25	37.03				

Disease incidence. The data presented in (Table 5) revealed that the different concentrations of botanicals were significantly reduced the disease incidence of *Verticillium fungicola*. *Azadirachta indica* was found to be best where the disease incidence was recorded (28.63% and 29.20%) followed by *Azadirachta indica* +*Lantana camara* (34.99% and 30.50%), *Lantana camara* (37.75 % and 38.44%), *ocicum sanctum* (44.44% and 45.55%), *Allium sativum* (52.09% and 50.97%) and neem seed kernel (53.85% and 54.04%). However, highest disease incidence as (65.19% and 64.76%) was recorded under control during the both years 2019 and 2020, respectively.

It was also found with increase in concentrations of selected botanicals, the disease incidence was reduced. The minimum incidence (22.17% and 21.19%) was recorded with *Azadirachta indica* 3 per cent followed by 2 per cent (29.41% and 30.21%) and 1 per cent (34.32% and 36.22%) during both the years, respectively. The maximum disease incidence (56.46% and 57.46%) was recorded by neem seed kernel 1 per cent followed by 2 per cent (54.23% and 53.24%) and 3 per cent (50.87% and 51.43%), while *Allium sativum* recorded (58.31% and 57.74%) with 1 per cent, (50.54% and 51.12%) with 2 per cent and (47.41% and 44.04%) with 3 per cent during both years, respectively.

Disease control. The data presented in (Table 5) revealed that the different concentrations of botanicals recorded higher yield than unprotected control in both the crop seasons. The maximum in yield (437.81g and 433.65 g/kg) was recorded *Azadirachta indica* 3 per cent,(395.25g and 386.26g/kg) 2 per cent and (374.05g and 371.74g/kg) at 1 per cent followed by *Azadirachta indica+Lantana camara*(368.08g and 369.09g /kg) 3 per cent and 2,1 per cent (356.23g and 360.86g /kg),(349.43g and 351.46g/kg). The minimum yield was recorded in *Allium sativum* (331.12 g and 332.43g/kg) with 1 per cent (337.25 g and 335.22g/kg) with 2 per cent and ((343.56g and 344.29g/kg) with 3 per cent during both years, respectively.

Table 5: Efficiency of botanicals incorporated in casing on disease incidence of dry bubble disease of white button mushroom during spring 2019-20 and 2020-21.

Treatment	Concentration(%)	Disease incidence (%)			Diseases control (%)		
		2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
Azadirachta indica	1	34.32	36.22	35.27	47.35	44.07	45.71
	2	29.41	30.21	29.81	54.88	53.35	54.11
	3	22.17	21.19	21.68	65.99	67.49	66.63
	Mean	28.63	29.20	28.92	56.07	54.97	55.48
Azadirachta indica(Seed)	1	56.46	57.46	56.96	13.39	11.85	12.32
	2	54.23	53.24	53.74	16.81	11.27	17.28
	3	50.87	51.43	51.15	21.96	20.58	21.27
	Mean	53.85	54.04	53.95	17.38	14.56	16.96
Allium sativum	1	58.31	57.74	58.025	10.55	10.84	10.68
	2	50.54	51.12	50.83	21.60	21.06	21.76
	3	47.41	44.04	45.72	27.27	31.99	29.62
	Mean	52.09	50.97	51.53	34.04	29.66	20.69
Ocicum sanctum	1	47.33	49.10	48.22	27.21	24.18	25.78
	2	44.87	45.21	45.04	31.17	30.18	30.67
	3	41.12	42.33	41.73	36.92	34.63	36.38
	Mean	44.44	45.55	45.00	31.76	29.66	30.94
Lantana camara	1	42.65	44.65	43.65	34.57	31.05	32.81
	2	40.26	42.01	41.14	38.24	35.12	36.67
	3	30.34	28.65	29.49	53.45	55.75	54.60
	Mean	37.75	38.44	38.09	42.08	40.64	41.36
Azadirachta indica+Lantana camara	1	41.12	42..54	41.12	36.92	34.31	36.70
	2	36.65	35.23	35.94	43.17	45.59	44.63
	3	27.21	25.76	26.48	58.26	59.24	59.23
	Mean	34.99	30.50	34.51	46.11	46.38	46.85
Control I (Untreated inoculated)		65.19	64.76	64.97	-	-	-
CD($_{p=0.05}$)		2.56	2.17				

DISCUSSION

Evaluation of plant extracts against *V. fungicola* under *in-vitro* condition revealed that all the plant extracts more or less suppress the growth of *V.fungicola*. Out of Seven locally available plant which grow in abundance *viz., Azadirachta indica* (neem leaf), *Azadirachta indica* (neem seed cake), *Allium sativum* (garlic), *Aloe vera* (aloevera), *Lanatana camara* (lantana), *Ocimum sanctum* (tulsi) and *Azadirachta indica* +*Lantana camara* were used and aqueous extracts of two concentrations 5 and 10 % were tested for their efficacy against pathogen. These plant species may contain chemical compounds having antifungal properties. Sharma and Jarial (2000) evaluated neem leaves against False Truffle (*Diehliomyces microsporus*) disease of *Agaricus* spp. and recorded good results in controlling this disease *in vitro* which supports the present investigation. Sharma and Rajesh

(2005) observed that 10% neem leaf extract was effective in inhibiting the growth of *Sepedonium chrysospermum,* responsible for causing yellow mold disease in white button mushroom which support the present investigation.Similar findings have also been reported by Shah *et al.* (2012), who observed that neem leafextract at both 5and 10 per cent was found effective in inhibiting the growth of *Trichoderma harzianum.* Mishra (2009) also reported similar results with the use of neem leaf extract, neem cake solution and neem saw dust against *Trichoderma viride* . Similar findings have also been reported by Shivam Singh *et al.* (2016), who observed that neem leaf extract at both 5 and 10 per cent was found effective in inhibiting the growth of *V. fungicola*.

In-vivo evaluation of selected plant extracts, *viz., A. indica*(neem leaf), *A. indica* (neem seed cake), *A. sativum* (garlic), *Aloe vera* (aloe vera), *l. camara* (lantana), *O. sanctum* (tulsi) and *Azadirachta indica* +*Lantana camara* against *V. fungicola* was carried out in mushroom crop room. *A. indica and Azadirachta indica* +*Lantana camara* was found best treatment among the selected botanicals for *in-vivo* evaluation in all parameters, *viz.,* time taken for complete mycelium run and pin head initiation, yield and per cent disease incidence. Antifungal activity ofthe product of *L. camara* and *A. indica* plant have very low toxic to mammals (Kleeberg, 1992) and are relativelysafe to non-target organisms (Schmutterer, 1995). Similar findings have been reported by Grewal and Grewal (1988); Sharma and Jandiak (1994); Sharma and Jarial (2000); Sharma and Rajesh (2005); Inam-ul-Haq *et al.* (2010) in that the neem was the best treatment among all used botanicals. Findings of mentioned authors support the present investigation that neem increases the yield of *A. bisporus* and suppresses the infection by *V. fungicola.* Shivam Singh *et al.* (2016), in that the neem and *L. camara* was the best treatment among all used botanicals. Findings of mentioned authors support the present investigation that neem and *lantana camara* increases the yield of *A. bisporus* and suppresses the infection by *V. fungicola.*

CONCLUSION

White button mushroom cultivation in Jammu division in primarily in the hands of resource-poor growers. The prevalence of unhygienic conditions in and around the mushroom farms and lack of pasteurization facility result in recurrence of wet bubble and other mould diseases causing heavy economic losses to these growers. The disease can be managed at farmer's field levels by the use of safer fungicides, botanicals and bio agents on or in the casing soils and adhering to farm sanitation.

This study has found two most promising botanicals, *A. indica* and *A. indica* +*Lantana camara* that were able to inhibit the infection of dry bubble disease (*V. fungicola*) of white button mushroom (*A. bisporus*) under both *in-vitro* and *in-vivo* conditions. In *in-vitro* study, *A. indica* and *A.indica* + *Lantana camara* have been best treatments among all botanicals as they inhibit the growth of *V. fungicola.* In *in-vivo* study Incorporation of botanicals such as *A. indica* or *A. indica* +*Lantana camara* as dry powder at 1 to 3 per cent with casing mixture at the time of casing has indicated broad spectrum fungicidal activity against *V. fungicola* without affecting the quality and yield of fruiting bodies. These formulations have much scope for commercialization for production of an organic mushroom crop, in view of lesser choice available for selective fungicides and the need to avoid pesticide residues in this short duration high value crop.

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