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Influence of weather parameters and casing materials on wet bubble disease of white button mushroom [*Agaricus bisporus* (Lange)] under *in-vivo* conditions

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Abstract

The studies were conducted under *in-vivo* conditions to see the effect of weather parameters (temperature and relative humidity) and different components of casing materials on wet bubble disease of white button mushroom. The results showed AUDPC and rate of disease increase (r) as 375.09 and 0.61 respectively. Simple correlation showed negative correlation between disease incidence with mean temperature (-0.311) and also negative with RH (-0.097) whereas, multiple correlation coefficient between disease incidence with mean temperature and mean relative humidity were not significant. Regression equation i.e. $Y = 111.45 - 17.7X_1 + 3.30X_2$ obtained showed that prevailing mean temperature had negative impact while relative humidity had positive impact on development of disease. Regarding casing materials coco peat provided least disease incidence of 1.3 per cent and maximum yield was obtained in formalin treated coco peat + FYM (1.44kg), while sand resulted in minimum yield (0.30kg) of sporophore under *in-vivo* conditions.

Key words: Wet bubble, weather parameters, casing materials, disease incidence, yield.

Wet bubble disease of white button mushroom caused by *Mycogone perniciosa* (Magnus) has been regarded as one of the most devastating disease in all significant mushroom farming regions of the world. Wet bubble produced two main symptom types and if young pin heads are infected, they develop monstrous shapes which often do not resemble mushrooms. When infection take place before the differentiation of stipe and pileus, the selerodermoid form resulted, whereas, infection after differentiation resulted in the production of thickened stipe with deformation of the gills. Both types of infections may exude water drops on the surface of infected sporophores. Symptoms in the form of white fungal growth on the mushrooms, leading to their putrefaction (giving foul odor) with golden brown liquid exudates are also observed. The water drops later change into amber color.

The disease was first reported in 1978 in Jammu and Kashmir region of India (Kaul *et al.*1978). Thereafter, it was observed in Himachal Pradesh, Haryana and Maharashtra (Anonymous 2007). During 2008 and 2009, experiments conducted in three districts of Kashmir showed prevalence of 67, 56 and 33 per cent disease in Budgam, Pulwama and Srinagar districts, respectively (Kouser *et al.* 2013). Being a short duration crop, cultivation of white button mushroom (*Agaricus bisporus*) in India plays a very crucial role in doubling farmers' income. Nair and Baker (1978) reported immense destruction by wet bubble disease in several economically important mushroom growing areas of Australia. According to Fan *et al.* (2012), this disease has resulted in 15-30 per cent yield losses in China and under severe infestation, complete crop loss has also been reported. Sharma and Kumar (2000) reported that the disease incidence ranging from 1 to 100 per cent has been observed in Solan and Bilaspur district of Himachal Pradesh. Keeping in view the destructive nature of the disease on white button mushroom, the present studies were undertaken under *in vivo* conditions to see the impact of weather parameters and casing materials on disease development.

Materials and Methods

Weather parameters

The experiment was conducted in the Department of Plant Pathology, CSK HPKV, Palampur. The parameters viz., date of application of casing material in the mushroom bags followed by inoculation with

pathogen *Mycogone perniciosa*, date of case run in the mushroom bags, date of pinhead formation and date of first harvest, disease incidence, temperature and relative humidity were recorded. Area under disease progress curve (AUDPC) and rate of disease increase (r) were also calculated as per standard procedure.

The AUDPC was calculated by using formula given by Shaner and Finny (1977)

$$AUDPC = \Sigma[(yi)+(yi+1)] / 2 * [(ti+1)-(ti)]$$

The infection rate was calculated by using formula given by Vander Plank (1963)

$$r = \frac{2.3}{t_2 - t_1} \times Log_{10} \frac{X_2 (1-X_1)}{X_1 (1-X_2)}$$

Data on temperature and relative humidity inside the growing room were recorded daily by using hygrometer and correlated with the disease development. Correlation between disease incidence and weather variables i.e. mean temperature and mean RH was calculated and regression equations were derived from them.

Casing material components

Casing material was prepared by using coco peat, FYM, sand and spent mushroom compost applied individually and in different combinations like coco peat + FYM (1:0.5), sand + FYM (1:1), spent mushroom compost + FYM + coco peat (1:1:0.25), ash + FYM (1:2). A uniform layer of casing material was applied on the compost bags. Each treatment consisted of three bags per replication. The casing material was treated with formaldehyde (0.8%), before that casing materials were water leached for 8 hrs. The pH of casing material was adjusted to 7.2 to 7.8 with $CaCO_3$. The treatments were applied as three replications having five bags in each treatment. For proper casing run the temperature of 24±1°C, relative humidity of 90-95% and CO_2 level of more than 10,000 ppm was maintained in the growing room. The temperature of the growing room was reduced to 16-18°C, relative humidity to 80-85% and CO_2 level to less than 10,000 ppm during rest of the fruiting period. Watering was done whenever required with the help of spray pump and relative humidity was maintained accordingly. The mushrooms were harvested by slightly twisting and uplifting the fruiting body with the help of two fingers and thumb. The lower soiled portion was removed with the help of knife and observations were recorded.

Disease incidence

For calculating the per cent disease incidence, the number of infected fruiting bodies out of the total number fruiting bodies present in each replication was documented and enumerated with the help of procedure described by Fletcher *et al*. (1983). Statistical analysis was done online by using OP Stat software.

$$\text{Disease incidence} = \frac{\text{Number of infected fruiting bodies/ bag}}{\text{Total number of fruiting bodies/ bag}} X\ 100$$

Results and Discussion

Weather parameters

The step by step details of experiment conducted were as follows:

i) Date of casing material application in the mushroom bags followed by inoculation with pathogen *Mycogone perniciosa* (4th December, 2019)

ii Date of case run in the mushroom bags (29thDecember, 2019)

iii) Date of pinheads formation (3rd January 2020)

iv) Date of first harvest (10thJanuary 2020).

The data on disease incidence, temperature and relative humidity were recorded in the range of 2.00 to 84.33 per cent, 14.45 to 17.34°C and 58.20 to 66.40 per cent, respectively (Table1 & Fig.1). The disease incidence was correlated with mean temperature; mean relative humidity and correlation coefficients are presented in table 2. The data of nine weeks were evaluated to calculate the AUDPC and rate of disease increase (r) and were recorded as 375.09 and 0.61, respectively.

Simple correlation showed the negative correlation between disease incidence with mean temperature (-0.311) and also negative with RH (-0.097). Regression analysis clearly showed that temperature and RH are most important factors for disease development. Multiple correlation coefficients between disease incidence with mean temperature and mean relative humidity were not significant. Coefficient of determination (r^2) revealed that weather variables (both temperature and relative humidity) contributed 14.1 per cent for the development of disease. In the regression equation ($Y = 111.45 - 17.7X_1 + 3.30X_2$) it is clearly visible that prevailing mean temperature has negative impact on the disease development while relative humidity has positive impact on the development of wet bubble disease (Table 3).With the perusal of the prevailing weather data during different periods, it was observed that disease development of wet bubble of white button mushroom was favored by temperature > 16°C and relative humidity of > 64 per cent. Although the optimum temperature for disease development is 25±2°C, however, in this case the inoculum build up was maximum in the casing material

after inoculation which served as further source of inoculum for the development of wet bubble disease. Fletcher *et al.* (1994) reported that the primary source of inoculum of wet bubble disease is contaminated casing material which results in symptom development within 10 to 14 days. They also concluded that spores present on walls and floors of the cropping room acted as source of further spread.

Effect of various casing material components on disease development

Among all the casing materials tested, maximum disease incidence was recorded in SMC (38.1%) followed by sand (29.6%), FYM (18.5%), SMC + FYM + sand (18.5%), ash + FYM (14.7%), sand + FYM (12%), ash + FYM (with formalin) and SMC + FYM + coco peat (with formalin). However, minimum disease incidence was recorded in coco peat (1.3%) followed by formalin treated coco peat + FYM mixture (4.3%), steam sterilized coco peat + FYM mixture (5.2%).

Table 1. Effect of weather parameters on per cent disease incidence

Date	Temperature (°C)	Relative Humidity (%)	Disease Incidence (%)
10/01/2020	16.60	65.00	2.00
17/01/2020	15.24	64.67	10.00
24/01/2020	14.60	58.20	22.28
31/01/2020	15.57	65.28	38.33
7/02/2020	17.34	66.40	45.00
14/02/2020	15.01	60.30	63.00
21/02/2020	14.45	60.00	70.20
28/02/2020	15.25	64.00	75.13
6/03/2020	15.30	65.00	84.33

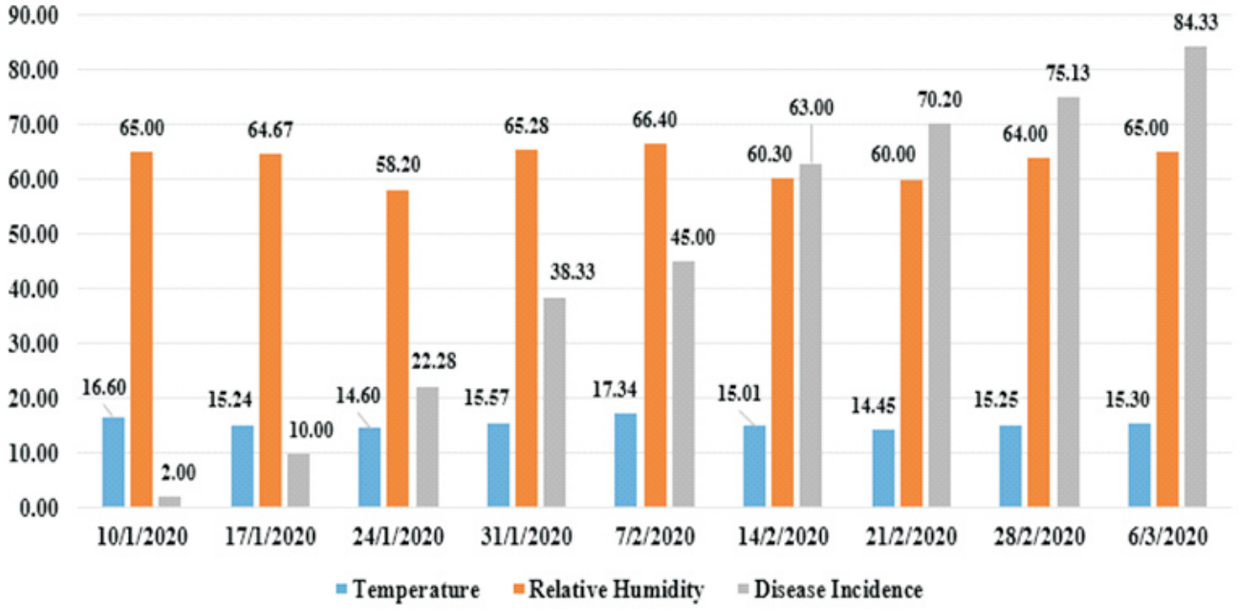

Fig. 1 Effect of weather variables on the development of wet bubble disease

Table 2. Effect of temperature and relative humidity on disease progress parameters

Date of casing soil application and inoculation	Date of first harvest	Disease incidence (%)	AUDPC	Rate of disease (r)
4-Dec-2019	10-Jan-2020	84.33	375.09	0.61

Table 3. Correlation of disease incidence of wet bubble disease of white button mushroom

		Simple		Partial		Correlation coefficient		
Casing soil application	Disease incidence (%)	DI x T	DI x RH	DI x T	DI x RH	Multiple correlation coefficient (r)	Coefficient of determination (r^2)	Regression equation
4-12-2019	84.33	-0.311	-0.097	-0.364	0.212	0.376	0.141	$Y = 111.45 - 17.7X_1 + 3.30X_2$

DI = Disease Incidence, T = Temperature, RH = Relative Humidity

Table 4. Effect of various casing material components on disease development

Treatment	Application Ratio	Disease incidence* (%)	Average yield (kg/quintal compost)
Coco peat + FYM	1 : 0.5	5.2 (13.13)	17.65
Coco peat	-	1.3 (6.58)	16.22
Sand + FYM	1.5 : 1.5	12.0 (15.60)	13.11
SMC + FYM + Coco peat	1 : 2 : 0.5	18.5 (20.28)	11.51
FYM	-	18.5 (25.47)	11.21
SMC	-	38.1 (38.07)	8.05
Sand	-	29.6 (32.95)	7.07
Ash + FYM	1 : 2	14.7 (22.57)	11.28
Coco peat + FYM (with formalin)	1 : 0.5	4.3 (12.00)	18.40
Ash + FYM (with formalin)	1 : 2	8.7 (17.18)	12.35
SMC + FYM + Coco peat (with formalin)	1 : 1 : 0.5	7.9 (16.28)	16.11
CD (P=0.05)	-	1.17	0.23

FYM = Farm Yard Manure, SMC = Spent Mushroom Compost
*Average value of three replications, Figures in parenthesis are angular transformed values

It was also found that coco peat resulted in slow growth of culture in the casing material as compare to mixture of coco peat + FYM. Hence, coco peat, coco peat + FYM (steam sterilized) were found to be most effective in the management of wet bubble disease (Table 4). It is also evident that steam sterilization of casing material is less effective than formalin treated casing material. The maximum average yield of fruiting bodies per quintal of compost bag was obtained in formalin treated coco peat + FYM (18.40 kg) followed by steam sterilized casing material composed of coco peat + FYM (17.65 kg), coco peat (16.22 kg), SMC + FYM + coco peat with formalin (16.11 kg), sand + FYM (13.11 kg),formalin treated ash + FYM (12.35 kg), steam sterilized SMC + FYM + coco peat (11.51 kg), ash + FYM (11.28 kg), FYM (11.21 kg) and SMC (8.05 kg). However, minimum amount of yield was obtained in casing material consisting sand (7.07 kg). A study was conducted by Carrasco *et al*. (2019) on casing material composed of blonde peat, black peat and a 50:50 mixture of both. All these casing material were compared to check out their suppressive impact against dry bubble, *Lecanicillium fungicola* (Preuss), and wet bubble, *Mycogone perniciosa* (Magnus). The highest mushroom production was obtained from crops cultivated using the mixed casing and black peat and both produced good yields which were not significantly different. In present studies also coco peat provided best disease control with disease incidence of 1.3 per cent whereas SMC gave the least disease control .The maximum yield was obtained in formalin treated coco peat + FYM (18.40 kg).

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