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Effect of different date of spawning on various growth and yield parameters of white button mushroom (*Agaricus bisporus*)

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Abstract
White button mushroom (*Agaricus bisporus*) is the most popular mushroom species in the world as well as in India. Production and consumption of button mushrooms have tremendously increased in India mainly due to increase in awareness of the commercial and nutritional significance of this commodity. The experiment was conducted at Mushroom Production Technology unit at Bihar Agricultural University, Sabour, Bhagalpur during November 2019- February 2020.
Agaricus bisporus (Lange) Sing. was screened for its ability to grow at different temperatures on different date of spawning with the objective of selecting the best time for producing button mushrooms. Seven dates (5th November to 5th February) were evaluated for their effect on growth and production at different mean temperatures and mean relative humidity. Among different date of spawning, 20th November gave the best result with spawn run completed in 11.60 days and case run in 15 days. The pinheads developed into solid button sized mushrooms in 30.6 days. Maximum yield of 1.13 kg/bag was also found on 20th November followed by 5th November and 5th December with total yield of 1.02 and 1.01 kg/bag respectively.

Keywords: *Agaricus bisporus*, temperature, relative humidity, spawning, pinheads

1. Introduction
Agriculture has remain to be the major force of Indian economy but a fight is still on to meet the ever increasing demand of nutritional security following secondary agricultural vocation. To meet such challenges, diversification in the agricultural activities which include mushroom production is important to address the problems of quality food, health and environmental sustainability (Singh *et al*. 2017) [5]. In the present diet conscious era, mushrooms are increasingly considered as a future vegetable and their consumer demand has markedly expanded owing to its nutritional and medicinal properties (Netam *et al*. 2018) [2]. Mushroom is an excellent source of vitamin- D, minerals such as iron, potassium, copper and are low in calories, carbohydrates, fat, sodium and almost cholesterol-free (Sharma *et al*. 2017) [4]. World's total production of mushroom is about 10.37 million tons with China contributing highest share (Pandey *et al.* 2018) [3]. In India, mushroom production is about 1.3 lakh metric tons which is 3 per cent of world production. From 2010- 2017, the mushroom industry in India has registered an average growth rate of 4.3% per annum. (Sharma *et al.* 2017) [4]. Out of the total mushroom produced, white button mushroom share is 73% followed by oyster mushroom (16%), paddy straw mushroom (7%) and milky mushroom (3%) (Sharma *et al*. 2017) [4].
The white button mushroom (*Agaricus bisporus*) is very popular throughout the world and is the most important mushroom of commercial significance in India (Maheswari 2013) [8]. It belongs to phylum Basidiomycota, class Agaricomycetes, order Agaricales and family *Agaricaceae*.
Keeping in mind the demand of button mushroom, the most popular variety still dominating the Indian and International market, we have to think for the production of white button mushroom so that we can meet the requirement of it. Based on these facts the present study has been undertaken to study the effect of different date of spawning on various growth and yield parameters of white button mushroom (*Agaricus bisporus*) in the mushroom production technology unit of Bihar Agricultural University, Sabour, Bhagalpur.

2. Material and Methods

2.1 Inoculation and Spawn Production

Pure culture of *Agaricus bisporus* was prepared using tissue culture method. For tissue culture, the basidiocarp after alcohol sterilization was cut longitudinally into 2 halves and bits from collar region was transferred to pre- sterilized Potato Dextrose Agar (PDA) culture medium. The Petri-plates were incubated at 25 ℃ ± 2 ℃ in BOD incubator for one week. Mycelium from growing edges were carefully transferred to PDA slants and again incubated for 2-3 weeks to obtain pure cultures.

Wheat grains were used as support media for spawn production. Wheat grains were boiled in water for 30 min (wheat grains: water, 1:2 w/v) so as to cook them soft enough to be pressed within the fingers. Extra water was sieved out, the grains were allowed to cool and then mixed with calcium carbonate and calcium sulphate powder. The ratio in which they were mixed was obtained by using 200 g gypsum and 50 g chalk powder for 10 kg grains (dry weight basis). Empty glucose bottles were filled with these grains upto 2/3 volume, plugged with non-absorbent cotton, wrapped with paper and then autoclaved at 15 psi for 30 min. After cooling the autoclaved bottles overnight, these were shaken to restore transparent visibility of the glass and then inoculated aseptically with mycelial bits from the slant cultures. The bits were placed in such a manner that their mycelium touched the grains. These bottles were incubated at 25 °C±2 °C for 15-20 days. The culture bottles thus produced were the Master/mother cultures. After 10 days, Master/mother culture was shaken so that grains were transferred into 10-15 freshly prepared bottles. These spawn bottles were stored at 25 ℃ to use for spawning the substrate.

2.2 Compost preparation

Compost was prepared using zero- energy polytunnel method according to Wakchaure and Singh, (2013) [6].

The trapezoidal compost pile was formed by inserting the perforated HDPE pipes in parallel zigzag arrangement from the properly mixed pre-wetted compost ingredients. The compost ingredients included wheat straw (300 kg), wheat bran (30 kg), gypsum (25 kg), benoula khali (30 kg), chicken manure (100 kg), DAP (10 kg), Urea (5 kg), MOP (5 kg), Phephronil (1 kg), Furadan (3 kg) and Carbendazim (1 kg) respectively. For making compost, 300 kg of dry wheat straw was wetted with water properly for 1-2 days upto moisture level 75-80% and all other ingredients was added to it at once. The standard process involved, the mixing of pre-wetted compost ingredients including gypsum, natural pasteurization by covering of compost pile with polythene sheet for three days at 66-70 °C and conditioning of compost at 50-60 °C for another two days. The first turning of compost pile was done on sixth day. Again, second natural pasteurization of compost was done after two days at 60-65 °C and conditioned the compost for next two days at 50-54 °C. The pile was turned secondly on 11th day and covered with polythene cover for next three days and conditioned at 48-52 °C. The desirable quality of matured compost (moisture content 62-66%, pH 7-7.7, ammonia < 7-10 ppm) was obtained after 14-16 days. Mature compost was broken, spread for cooling and after sterilization left overnight before spawning.

2.3 Spawning and Filling of bags

For spawning, mixed spawning method was used. Mixing of wheat grain based spawn was done @ 2 kg per 100 kg compost of *Agaricus bisporus* under clean conditions (i.e., with clean hands and pre-sterilized area). Good quality compost with temperature of 25 °C was used. Then filling of spawned compost into polythene bags (size 16" x 22") to a depth of 10-12". Little compressing and levelling of spawned compost was done.

2.4 Casing

A mixture of FYM (one year old) + Soil (1:1 wt / wt) was prepared, sterilized with 2% formalin solution. It was added upto 3 cm on top of spawn run compost. Sterilization was done by making a heap of casing material (FYM + Soil) on a cemented platform and wetted upto 50-60% water holding capacity. The wet casing was drenched with formalin @ 0.2 % by mixing with shovel. It was then covered with polythene sheet and the outer periphery was sealed with bricks. The material was kept for 24-48 hrs in sun for fumigation effect. The cover was removed after 48 hrs and the material was exposed to open air and sunlight by spreading over with clean tools and permitting the formalin fumes to escape in to air for 2-3 days before it was used as casing (formalin treatment effect decreases at low temperature due to inadequate fumigation). After application of casing materials water sprays were given in installments immediately.

2.5 Cropping

Under favourable environmental conditions viz. temperature initially 23 ± 2 °C for about a week and then 16 ± 2 °C), moisture (2-3 light sprays per day for moistening the casing layer), humidity (above 85%), proper ventilation and CO_2 concentration (0.08-0.15 %) the fruit body initials which appeared in the form of pin heads started growing and gradually developed into button stage. The first crop appeared about three weeks after casing. Mushrooms were harvested by gentle twisting and soil end parts were cut off. After harvesting was complete, the gaps in the beds were filled with fresh sterilized casing material and then watered. Yield data for average weight and total yield of fruiting bodies per bag was recorded and biological efficiency was calculated as

$$\text{Biological efficiency (in percentage), B.E.} = \frac{\text{Total weight of fresh mushroom}}{\text{Total dry weight of compost}} \times 100$$

3. Results and Discussion

3.1. Effect of different date of spawning on various growth and yield parameters of white button mushroom

Various growth parameters like spawn run, case run, pinhead emergence, date of first and last harvest were observed for different date of spawning and their relation with mean temperature and mean relative humidity in the cropping room was established. The observations are tabulated in Table 1 and table 2 and illustrated graphically in Fig 1.

3.1.1 Effect of different date of spawning on various growth parameters of white button mushroom

From Table 1, it is clear that the minimum days for spawn run and for case run, were found on 20th November (11.60 days after spawning and 15.00 days after casing) followed by 5th December (13.2 days after spawning and 16.8 days after casing) and 5th November (13.6 days after spawning and 17.20 days after spawning). For pinhead emergence, date of first and last harvest, maximum days were found on 20th

November (22.8 days, 30.6 days and 60.6 days) followed by 5th November (24.6 days, 31.6 days and 61.6 days) and 5th December (25.4 days, 33.2 days and 63.2 days) after casing.

3.1.2 Effect of different date of spawning on various yield parameters of white button mushroom

From Table 2, it is evident that maximum production (1.13 kg /bag) and maximum average weight of fruiting bodies (13.28 g/bag) was found on 20th November followed by 5th November (1.02 kg /bag) and 5th December (1.01 kg /bag). The maximum weight of fruiting bodies (13.28 g /bag) was found on 20th Nov. 2019 followed by 12.72 (g /bag) to 12.20 (g /bag) for 5th Nov. 2019 and 5th Dec. 2019 respectively. The mean temperature and mean relative humidity recorded on these dates of spawning was 23.75 ℃ and 85.5 % RH on 20th November 2019, 24.85 ℃ and 87% RH on 5th November 2019 and 19.25 ℃, 80.5% RH on 5th December 2019 respectively. The lower mean temperature in the range of 23-25 ℃ and mean RH in the range of 80-85% on these dates of spawning were found ideal for growth of mycelium on compost after spawning while for fruiting mean temperature in the range of 14 ℃ to 19 ℃ and mean relative humidity of 80-89% was found to be the best for maximum production of button mushrooms.

Table 1: Effect of different date of spawning on various growth parameters of white button mushroom

Treatments			Parameters*		
Date of Spawning	**Spawn run(days)**	**Case run (days)**	**Days for pinhead emergence after casing**	**Date of first harvest after casing**	**Date of last harvest after casing**
05 Nov. 2019	13.60	17.20	24.60	31.60	61.60
20 Nov. 2019	11.60	15.00	22.80	30.60	60.60
05 Dec. 2019	13.20	16.80	25.40	33.20	63.20
20 Dec. 2019	15.00	19.00	29.00	34.60	64.40
05 Jan. 2020	15.40	19.80	29.20	35.20	65.20
20 Jan. 2020	14.40	18.80	31.20	36.40	66.40
05 Feb. 2020	16.20	21.00	31.40	36.80	66.80
SE(m) ±	0.36	0.40	0.39	0.30	0.33
CD (P = 0.05)	1.05	1.18	1.15	0.89	0.95
CV (%)	5.70	4.99	3.20	2.01	1.15

* Denotes Mean value of five replications

Table 2: Effect of different date of spawning on various yield parameters of white button mushroom and its relation with Mean Temperature (℃) and Mean Relative Humidity (%)

Treatments	Yield parameters*		Av. environmental conditions in the cropping room#	
Date of Spawning	**Av. Weight of fruiting bodies (g per bag)**	**Total yield (kg per bag)**	**Mean Temp. (℃)**	**Mean RH (%)**
05 Nov. 2019	12.72	1.02	24.85	87.00
20 Nov. 2019	13.28	1.13	23.75	85.50
05 Dec. 2019	12.20	1.01	19.25	80.50
20 Dec. 2019	11.88	0.90	14.65	84.00
05 Jan. 2020	11.64	0.73	14.30	89.00
20 Jan. 2020	11.44	0.62	15.55	80.00
05 Feb. 2020	8.60	0.50	17.10	87.50
SE(m)±	0.33	0.03	0.14	1.05
CD (P=0.05)	0.96	0.09	0.50	3.57
CV (%)	6.33	8.13	1.12	1.75

* Denotes Mean value of five replications, # denotes mean of two values

The results of the present investigation are in close agreement with Xu *et al.* (1993) [7] who studied different temperature for mycelial growth and biomass production of button mushroom and found better mycelial and vegetative growth at 24-27° C. Maheshwari (2013) [1] found that temperature should be maintained at 24 °C in the culture room, with relative humidity maintained between 80–85% for better production of button mushrooms which was similar with our present findings. Wakchaure and Singh (2013) [6] reported the favourable conditions required for *A. bisporus* fruiting should be temperature (18 ± 2 °C) and relative humidity (85–90%).

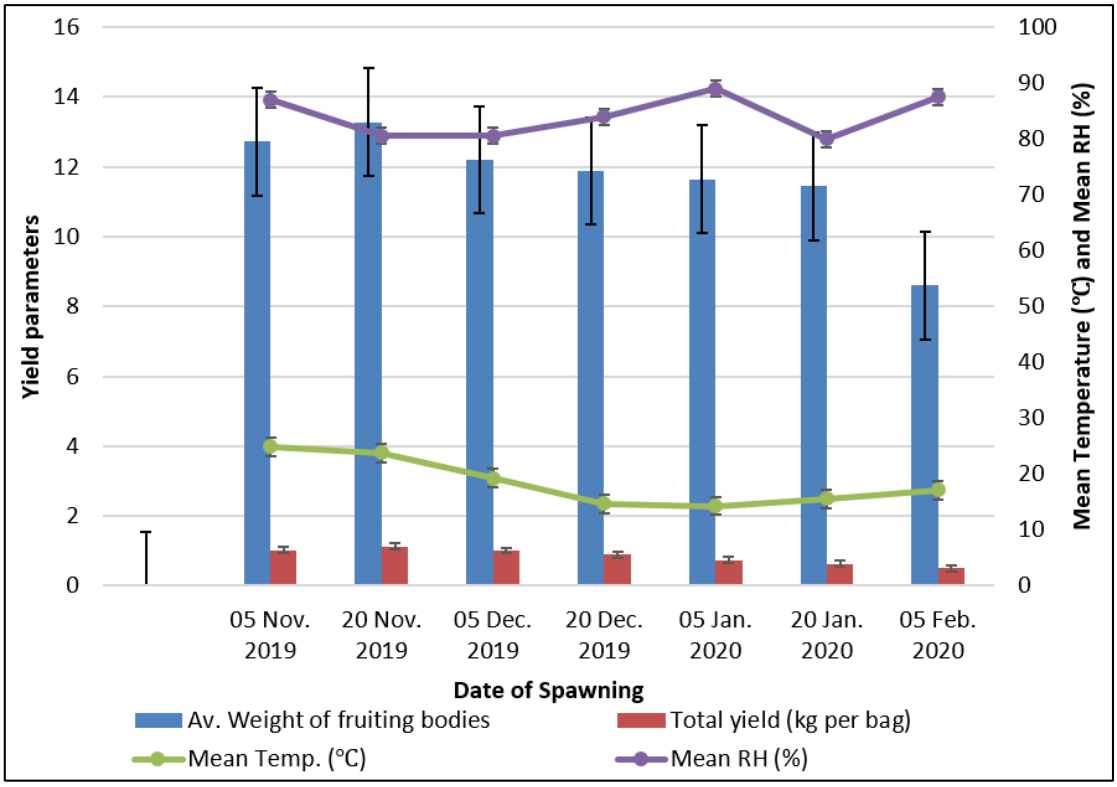

Fig 1: Effect of different date of spawning on various yield parameters of white button Mushroom and its relation with Mean Temperature (℃) and Mean Relative Humidity (%)

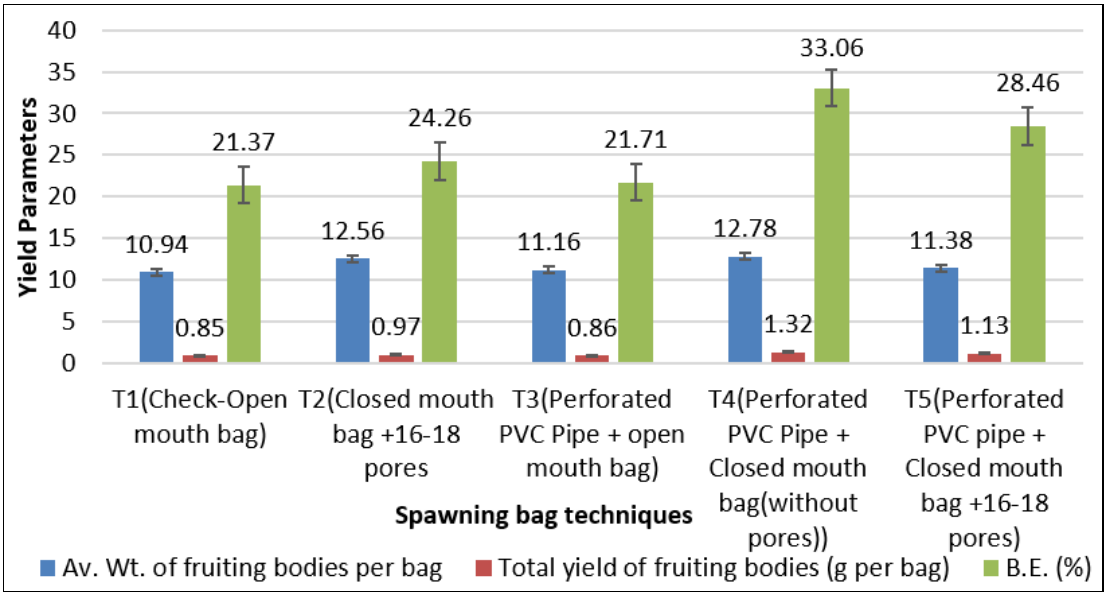

Fig 2: Effect of different date of spawning on various yield parameters of white button

4. Conclusion

It can be concluded that early and mid of Nov. and early Dec. were found to be the most suitable months of spawning giving maximum yield i.e., 1.02, 1.13 and 1.01 kg per bag respectively in minimum time i.e., 31.6, 30.6 & 33.2 days after casing. Thus, productivity could be sustained for a longer time, and the production was enhanced with more return in less input.

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