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Evaluation of Variability, Colony Characters, Productivity and Quality Parameters in Different Strains of *Agaricus bisporus* (Lange) Sing.

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Thirty-three strains of button mushroom (*Agaricus bisporus)*were procured from Indian Type culture Collection (ITCC) and evaluated for their cultural characteristics, fruit body traits and yield potential. The isolates were grown on Yeastral Potato Dextrose Agar medium and on the basis of cultural characteristics, the strains were broadly divided into three groups having viz. fast, medium and slow growing colonies. Most of the fast growing colonies had fluffy mycelium (ITCC-3607, 3614, 3615, 3616, 3697, 3706 and 3708), a few with appressed, patchy and dendric growth characteristics (ITCC-1924, 2075 and 3710), where as slow-growing strains had appressed (ITCC-1929, 3608, 4004, 4291 and 3502), a few with dense (ITCC-1927, 3696, 3709 and 4290) and patchy growth (ITCC-3609 and 4291). The strains having medium mycelial growth had both fluffy and appressed mycelium with dense and strandy mycelia. The colour of colonies varied from milky white, creamy white and snowy white in different strains according to their specific character. Sector formation were observed in most of the fast (ITCC-1924, 1928, 3607, 3616 etc.), in few medium (ITCC-3554, 3618 and 3741) and slow growing strains (ITCC-3609 and 3696). Zone formation was observed in ITCC-1926, 1927, 3613, 3615, 3617, 3707 and 3741 and in majority of slow-growing strains. The isolates were cultivated for sporophores production on wheat straw compost, prepared by long method of composting. On the basis of yield productivity, the strains were broadly grouped into three categories viz. high, medium and poor yielding strains. Yield potential of different strains ranged from 2050g (ITCC-4289) to 15360g (ITCC-3741)/100 kg compost. Fruit body colour also varied from creamy white, snowy white, milky white, buff white and brown among different strains. On the basis of compactness, unchanged colour and shelf-life of the fruit bodies, the strains were divided into three categories, viz. best (13 strains), good (10 strains) and average (9 strains) quality respectively. Fast and medium fast growing strains (ITCC-1924, 1926, 1931, 2074, 2075, 3554, 3607, 3618, 3708, 3710 and 4288) with fluffy, strandy and dendric mycelial characters (together with appressed mycelium), produced high productivity and quality mushrooms than those strains with slow, appressed and patchy mycelial growth characteristics. A few slow growing strains (ITCC-1927, 3608, 3609, 3611 and 4004), also yielded good quality mushrooms, in spite of their lower yield productivity.

Key words: *Agaricus bisporus*, Colony characteristics, Mushroom cultivation, Strains evaluation, Variability, Yield potential.

There are a number of parameters for evaluation of a particular strain of cultivated mushrooms. Stamets (2000)[18] described 28 features for evaluation and selection for a mushroom strain. In general, three types of mycelia, namely aerial/ fluffy, slow-growing and strandy have been reported in fungi (Kligman, 1943[7]; Raper *et al*., 1945[13]). Sigel and Sinden (1953)[16] added the growth character of being cottony and fluffy, powdery or appressed, when growing on the surface of agar medium. They also recorded various character of growing mycelium like zonation, color development

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and other abnormalities,since colony characteristics are influenced by different agar media, temperatures and manure substratum. Evans (1959)[4] suggested that mycelial and sporocarp variations may be due to irregular nuclear constitutions of spores and hyphae as basidia of *A.bisporus* may produce 2 or 4 spores each, but 2 being most common. These newly produced spores further, may contain 1-4 nuclei of sister or non-sister type and before germination may contain as few as one or as many as 36 nuclei.

There are reports for evaluating commercial strains of *A. bisporus* for production and quality parameters usingcompost and casing variablesto get their effect on size, yield and dry weight of mushrooms (Pardo *et al.*, 2010[11]; Schroeder and Schisler, 1981[14]). Effect of different environmental factors on mycelial growth and productivity of different strains of *A.bisporus* was studied by Kaur *et al*., (2014)[6] and Tschirpe (1983)[21]. De-Andrade *et al*., (2014)[2] studied effect of gamma irradiation on nutritional quality of *A.bisporus*, cultivated in different composts, whereas Singh and Kamal (2011)[17] studied genetic variability in single spore isolates and hybridization in *A. bisporus*. There are a number of reports of different compost formulations and chemical composition of mushrooms (De-Andrade *et al*., 2008[3]; Tewary and Pandey, 1991[20]). Shelf life and storage studies of *A. bisporus* were conducted by Sharma and Bahukhandi (2003)[15] by using different chemicals. A lot of work have been conducted on improvement in various parameters i.e. compost and casing, environmental factor affecting vegetative and reproductive phase, use of growth hormones for enhanced and quick growth, improvementof nutrients in fruit bodies and post-harvest losses of various strains of *A. bisporus* and *A.bitorquis* (Prakasam and Singh, 2008[12], Mehta, 1988)[8]. Bahukhandi and Bahl (1991)[1] studied cultural characteristics of fourteen strains of *A.bitorquis*, suggesting that appressed and strandy growth is preferred for cultivation of a trait in general. Pahil *etal*. (1994)[10] suggested that fast and slow growing dikaryons show no significant differences in *A.bitorquis* as slow growing interstrain dikaryons grew better and produced best quality fruit bodies. Variations in vegetative and fruiting stage indicates possible genetic decline or mutation in mushroom strain, since a good strain is easy to keep and difficult to impossible to regain, ones it senesces (Stamets, 2005)[19]. Since a large number of strains of button mushroom are in cultivation in north Indian plains, thirty three strains of *A.bisporus* were evaluated for their suitability on account of their cultural characteristics, productivity and quality parameter.

MATERIALS AND METHODS

For present study various strains/ isolates of *Agaricus bisporus* (ITCC- 1924, 1926, 1927, 1928, 1929, 1931, 2074, 2075, 3554, 3607, 3608, 3609, 3611, 3613, 3614, 3615, 3616, 3617, 3618, 3696, 3697, 3706, 3707, 3708, 3709, 3710, 3741, 4004, 4288, 4289, 4290, 4291 and 5102) were procured from stock cultures of The Indian Type Culture Collection (ITCC), Division of Plant Pathology,IARI, New Delhi. These strains were deposited by various mushroom workers from different sources, i.e. tissue/multi-spore/single-spore/mutants/hybrids cultures from different places/countries. These trains were revived by growing them on freshly prepared Yeastral Potato Dextrose Agar (YPDA) and fresh mycelium obtained by hyphal tip method for further studies. For morphological studies of strains, their actively growing mycelium was transferred on YPDA mediated Petri plates (90mm dia.) and were placed in BOD incubator at 25^0_C with three replicates for each strain. The linear growth of fungus was recorded as an average diameter of colony after15 daysof incubation. Besides growth, various characters like appearance, zonation, colour, sectoring, formation of pigment and exudation were recorded (Table1). These cultures were brought for spawn preparation on wheat grains by standard method (Munjal, 1973)[9]. The wheat grains were inoculated with 3x1cm bit of 14-15 days old cultures, and the time period for complete spawn run on wheat grains for each isolate was recorded (Table 2).

Mushroom production studies were conducted on wheat straw compost prepared by long method of composting. The studies were carried out in plastic trays, with each tray holding 33.5 kg prepared compost, thorough spawned with 50g of grain spawn and three replicates were kept for each strain. The mushroom house was kept closed and temperature was maintained at 20-25^{0}C for complete spawn run in compost. Casing soil was prepared by

mixing two year old well decomposed farmyard manure and spent compost and garden soil in a 2:2:1 ratio (v/v), sterilized with 40% formaldehyde solution of 4% concentration. Hydrogen ion concentration (pH) of casing soil was adjusted 7.5 by adding $CaCO_3$ in soil mixture. After complete spawn run, compost was covered with 3.5–4.0 cm thick layer of casing soil. The temperature of mushroom house was maintained between 20 and 25^{0}C for one week up to colonization of casing soil with mycelium. After 6-7 days of colonization of mycelium in casing soil, pinheads started appearing. The mushroom house was kept open for 3-4hours during early morning and evening. Water was sprayed on floor of mushroom house and gunny bags and tarpaulins, hanging as curtains on walls of mushroom house, for maintaining the humidity 80-90% and lowering the temperature below 20^{0}C. The temperature and RH of mushroom house were recorded daily. The average mushroom house temperature was 13-18^{0}C from November to February. Pinhead formation, first harvesting and totalyield of each strain were recorded (Table2). Mushroom quality was adjudged by texture, colour changing and opening of pileus (i) texture- light pressing the fruit body, whether it was compact, light compact and soft and (ii) duration of opening the pileus after harvesting. Shelf-life of mushroom was recorded by keeping mushrooms in polybags with 200g mushroom in each bag under refrigerated conditions at 10-12^{0}C with three replicates for each strain. Iffruit bodies remain intact without opening of vails and change in colour for more than three days, the shelf life was considered as very good, if these qualities retain for 2-3 days, then shelf life was considered as good and if these qualities has retained only for 1-2 days, mushroom quality was considered as average or poor. For each strain, 3 replicates were kept. Completely randomized block designs (CRBD) was followed for setting up the experiment for cultural and cultivation studies and statistical analysis of results were done (Table 1, 2).

RESULTS AND DISCUSSION

Mycelium and Colony Characteristics

The linear mycelial growth of different strains of *A. bisporus*grown onYeastral PDA showed difference in growth rate pattern after 15 days of incubation at 25^0 C (Table1, Figs 1).For variable mycelial growth, these trains were divided into three main groups: (i) fast growing strains, having colony diameter more than50 mm, the mycelium were mostly aerial/fluffy and appressed as observed in strains viz, ITCC- 1924, 1928, 2075, 3607, 3614, 3615, 3616, 3697, 3706, 3708, 3710 and 4289. The mycelial growth in most of the strains was dendric and thick. Pigment and exudate formation was observed in ITCC-3607 and 3708, margin of all colonies was uneven except ITCC-2075 and 3697 and submerged growth in strain ITCC-2075. (ii) the strains having medium growth and colony diameter between 31 and 49 mm, mostly showed appressed with strandy growth and dense mycelium (ITCC-1926, 1931, 3613, 3617, 3618, 3707 and 4288), few strains had fluffy (ITCC-3554 and 3741) and submerged mycelium (ITCC- 2074). Zonation in ITCC- 1926, 3613, 3617, 3707and 3741 and sector formation observed in ITCC-3554, 3618 and 3741.

Margin of most of the colonies was uneven, pigment and exudate formation were observed in ITCC 3613 and 3741; (iii) The colonies of slow growing isolates, were less than 30 mm in diameter, with weak mycelial growth, mostly with appressed and dense mycelium(ITCC-1927, 1929, 3609, 3696, 3709, 4291), others with light appressed mycelium. These colonies had almost circular margin (even), except uneven margin in ITCC-3609, 3696 and 4291. Zonation in form of concentric rings was observed in almost 75% slow growing strains and sectors formed in ITCC-3609 and 3696. Pigment was observed in ITCC- 1929, 3608, 3611, 4290 and 5102, where as exudate formation observed in ITCC-1929, 4290 and 5103.

The colour of colonies of different strains varied from creamy white, snow white and milky white. In some colonies the margin was even (mostly in slow growing) and in others uneven (Fig1). There was abundance growths of mycelium formed in sectors mostly in medium and fast growing colonies (ITCC- 1924, 1928, 3554, 3607, 3615, 3617, 3706 etc.), whereas in most of the medium and slow growingcolonies, there was zonation due to growth of hyphae in radial and peripheral manner (ITCC-1927, 2074, 3613, 4004 etc.). Some isolates had exudation and color development during mycelial growth (ITCC-3741, 4290, 5102). Statistical analysis of the comparison of colony growth (in dia.) of fast, medium and slow

Table1. Mycelial growth and colony characteristics of different strains of *Agaricus bisporus*

ITCC No.	Source	Growth	Diameter (mm)	Appearance	Colour	Zonation	Sectoring	Margin	Pigments	Exudates
1924	New Delhi	Fast	51	Fluffy, appressed	Milky white	_	+	Uneven	_	_
1928	Solan	Fast	50	Fluffy, patchy	Milky white	_	+	Uneven	_	_
2075	R G Lincon-California	Fast	50	Appressed, sub merged	Snowy white	_		Slightly uneven	_	_
3607	LS-11, Sri Nagar	Fast	56	Fluffy, dendric	Milky white	_	+	Uneven	+	+
3614	649-Solan	Fast	76	Fluffy, dense	Creamy white	_	+	Uneven	_	_
3615	L-20, Solan	Fast	54	Fluffy, dendric	Milky white	+		Uneven	_	_
3616	LM-70, Solan	Fast	60	Fluffy, dendric	Milky white	_	+	Uneven	_	_
3697	Solan	Fast	84	Fluffy, dense	Snowy white	_	_	Even	_	_
3706	PA- USA	Fast	70	Fluffy, dendric	Milky white	_	+	Uneven	_	_
3708	CBS,USA-Hyb-3	Fast	58	Fluffy, patchy, dendric	Milky white	_	+	Uneven	+	_
3710	CBS-USA-Hyb-1	Fast	58	Fluffy, appressed	Snowy white	_		Uneven	_	_
4289	L-2-C, Jammu Tawi	Fast	54	Fluffy, patchy	Milky white	_	+	Slightly uneven	_	_
1926	New Delhi	Medium	42	Appressed, strandy	Creamy white	+		Uneven	_	_
1931	New Delhi	Medium	44	Appressed, strandy	Creamy white	_		Slightly uneven	_	_
2074	R G Lincon-California	Medium	46	Appressed, sub merged	Snowy white	_		Slightly uneven	_	_
3554	UMX-15, Mauritius	Medium	46	Fluffy, dense	Milky white	_	+	Uneven	_	_
3613	S-56, Solan	Medium	40	Appressed, dense	Milky white	+	_	Even	+	+
3617	TM-7, Solan	Medium	45	Appressed, strandy	Snowy white	+		Uneven	_	_
3618	791-Solan	Medium	40	Appressed, deformed	Creamy white	_	+	Uneven	_	_
3707	USA	Medium	42	Appressed, strandy	Snowy white	+		Slightly uneven	_	_
3741	MACS-Pune,310	Medium	36	Fluffy, partly	Milky white sub merged, patchy	+	+	Uneven	+	+
4288	56-JammuTawi	Medium	42	Appressed, strandy	Creamy white	_		Uneven	_	+
1927	S-11, Solan	Slow	25	Appressed, dense	Milky white	+		Even	_	_
1929	Solan	Slow	18	Appressed	Creamy white	+		Even	+	+
3608	L-310, Sri Nagar	Slow	18	Appressed	Creamy white	+	+	Even	+	_
3609	L-56, Sri Nagar	Slow	29	Appressed, patchy	Creamy white	+		Slightly uneven	_	_
3611	M2, Sri Nagar	Slow	19	Appressed, sub merged	Creamy white	_	_	Even	+	_
3696	Solan	Slow	28	Appressed, dense	Milky white	_	+	Uneven	_	_
3709	CBS,USA-Hyb-2	Slow	28	Appressed, dense	Milky white	+		Slightly uneven	_	_
4004	INRA JR. Mrzrs, France	Slow	30	Appressed	Snowy white	+		Even	_	_
4290	Hybrid	Slow	30	Appressed, dense	Creamy white	+	_	Even	+	+
4291	M2, Jammu Tawi	Slow	26	Appressed, patchy	Milky white	_	_	Uneven	_	_
5102	333-3, USA	Slow	24	Appressed	Creamy white	+	_	even	+	+

+ = Present, - = Absent,
Stat Analysis: SEM=2.06, CD = 5.83, CV=8.31

Table 2. Spawn run, productivity and quality parameters of different strains of *Agaricus bisporus*

ITCC No.	Source	Colony growth	Spawn run in grains (days)	Spawn run in compost (days)	Pin initiation (days)	Yield(g)	Appearance	Texture	Shelf life
1924	New Delhi	Fast	18	14	26	11025	Creamy white	Closely compact	V good
1926	New Delhi	Medium	16	14	26	8320	Buff white	Lightly compact	Average
1931	New Delhi	Medium	16	14	26	10580	Milky white	compact	V good
3608	L-310, Sri Nagar	Slow	16	14	25	9640	Buff white	Closely compact	V good
3609	L-56, Sri Nagar	Slow	19	14	29	9120	Snowy white	Lightly compact	Good
3708	CBS,USA-Hyb-3	Fast	16	24	33	12760	Milky white	Closely compact	V good
3741	MACS-Pune,310	Medium	16	18	28	15360	Snowy white	Lightly compact	Average
1928	Solan	Fast	15	18	30	7000	Buff white	Lightly compact	Average
2074	R G Lincon-California	Medium	15	13	27	5850	Brown	Closely compact	V good
2075	R G Lincon-California	Fast	13	15	28	5460	Brown	Closely compact	V good
3554	UMX-15, Mauritius	Medium	18	18	30	6775	Buff white	Closely compact	V good
3607	LS-11, Sri Nagar	Fast	19	13	26	6050	Milky white	Closely compact	V good
3615	L-20, Solan	Fast	15	14	32	6440	Snowy white	Compact	Average
3616	LM-70, Solan	Fast	13	13	30	6725	Snowy white	Compact	Good
3617	TM-7, Solan	Medium	15	14	29	5640	Buff white	compact	Good
3618	791-Solan	Medium	13	17	30	6150	Snowy white	Closely compact	V good
3697	Solan	Fast	13	13	26	5400	Snowy white	Compact	Good
3707	USA	Medium	19	20	28	6050	Snowy white	Closely compact	Good
3709	CBS,USA-Hyb-2	Slow	18	24	34	7840	Milky white	Closely compact	Good
3710	CBS-USA-Hyb-1	Fast	20	21	33	7900	Snowy white	Closely compact	V good
4004	INRA JR. Mrzrs, France	Slow	20	26	34	7640	Buff white	Closely compact	V Good
4288	56-JammuTawi	Medium	16	18	30	6780	Creamy white	Compact	Average
1927	S-11, Solan	Slow	20	15	28	4160	Creamy white	Closely compact	V good
1929	Solan	Slow	18	18	30	4200	Creamy white	Compact	Average
3611	M2, Sri Nagar	Slow	18	16	29	3340	Buff white	Closely compact	V good
3613	S-56, Solan	Medium	18	18	31	3140	Creamy white	Light compact	Average
3614	649-Solan	Fast	13	15	28	4440	Snowy white	compact	Good
3696	Solan	Slow	18	20	31	3360	Buff white	Lightly compact	Good
3706	PA- USA	Fast	13	20	30	2975	Creamy white	Compact	Good
4289	L-2-C, Jammu Tawi	Fast	18	21	35	2050	Buff white	Light compact	Average
4291	M2, Jammu Tawi	Slow	18	28	36	3650	Buff white	compact	Good
5102	333-3, USA	Slow	18	28	37	2360	Creamy white	Lightly compact	Average

Stat Analysis: SEM=1015.5, CD=2869.19, CV=27.04

growing strains (difference between two colony diameters is more than 5.83-CD) shows that the data obtained are significant and relevant and more significant when growth of slow and fast growing isolates were compared (Table 1).

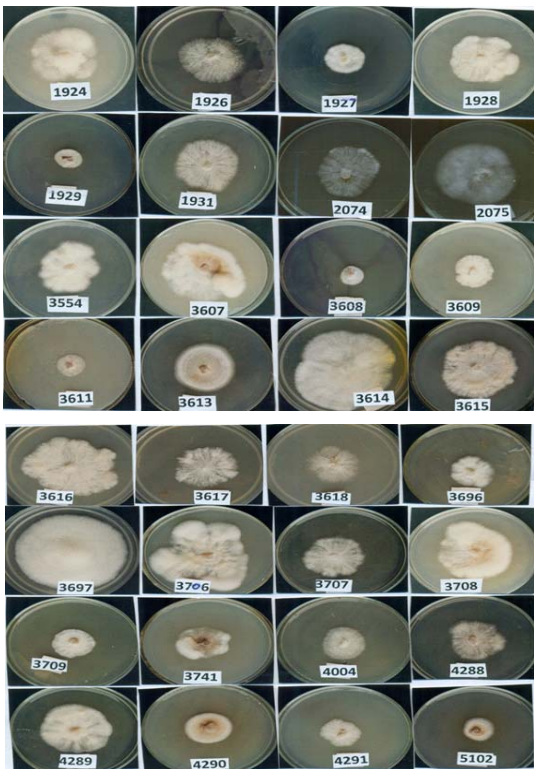

Fig.1. a, b- Strains of *Agaricus bisporus* growing in yeasral Potato Dextrose Agar medium

Mycelium run in wheat grains spawn, compost and casing soil

The growth of mycelium of different mushroom strains on wheat grains impregnated completely within 13-20 days (Table 2). An equal amount of 50 g grain spawn was mixed with compost (33.5 kg/tray), which was colonized by mycelium within 13-28 days by different strains. The beds were cased with 3-4 cm thick, well prepared casing soil made by standard method.The mycelium of isolates/ strains, viz. ITCC-1924. 1926, 1927, 1931, 2074, 2075, 3607, 3608, 3609, 3614, 3615, 3616 and 3697 colonized the compost completely within 13-15 days, while in ITCC 1928, 1929, 3554, 3611, 3613, 3618, 3706, 3707, 3708, 3709, 3710, 3741, 4288 and 4289, spawn run completed in 16-25 days. In strains ITCC- 4004, 4291 and 5102, spawn run completed in 26-28 days. After complete spawn run in compost and casing, temperature (15-18^{0}C) and humidity (80-90%) in mushroom house were maintained by spraying water on floor and hanging gunny bags on walls (Table 2).

Primordial initiation and crop productivity

Time period for primordial/pin-head formation in different strains of *A. bisporus*varied. The earliest pin head initiation was started after 26-30 days of spawning in majority of the strains, where as 31-34 daysof spawningin strain, ITCC-3708, 3615, 3709, 3710, 4004, 3613 and 3696, and35-37 days of spawning in ITCC-4289, 4291 and 5102. The fruit bodies were harvested after 2-3 days of pin head initiation, when there cap size attained 33- 35mm dia. (Fig2). After weighing the harvested

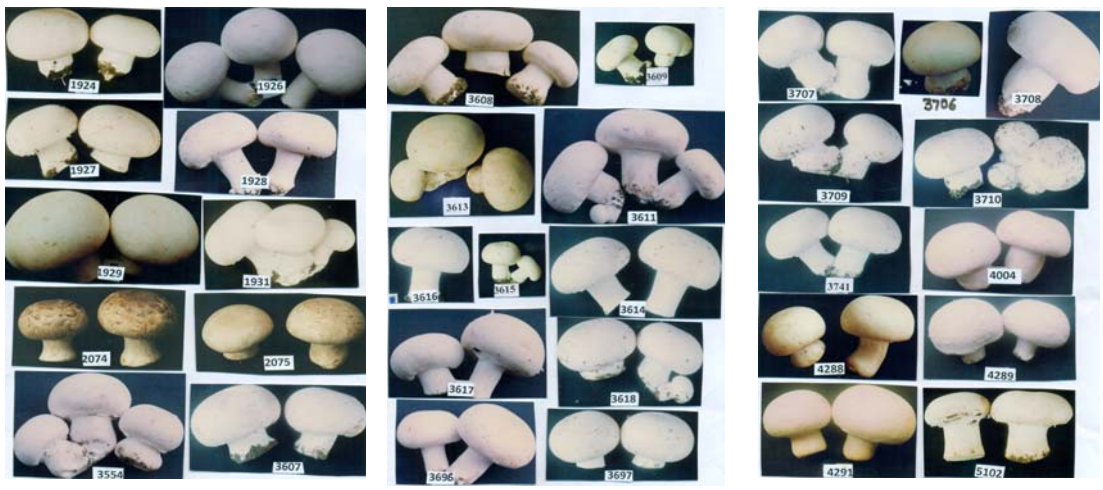

Fig. 2. A, B, C- Sporophores of different strains of *Agaricus bisporus*

fruit bodies, the mushrooms were kept for storage to study their shelf-life and the data were recorded (Table 2). On the basis of yield parameter, isolates/ strains were divided into three groups; strains ITCC-1924, 1926, 1931, 3608, 3609, 3708 and 3741, were placed in high yield producing group (more than 8000g fresh mushrooms/100 kg compost), as maximum production (15360g) being in strain, ITCC-3741. The mycelial growth characters could not be correlated with the productivity as among seven high yielding strains, two strains had fast growing fluffy hyphal growth(ITCC-1924 and 3708), three strains had medium mycelial growth (1926, 1931, 3741), and two strains (3608 and 3609), had slow growing mycelium. On the basis of their shelf life the overall quality of mushrooms in this group was very good (4 strains), good (1 strain) and average (2 strains). The strains those produced 5000g - 7999g fresh mushroom were; ITCC-1928, 2074, 2075, 3554, 3607, 3615, 3616, 3617, 3618, 3697, 3707, 3709, 3710, 4004 and 4288. Among them, highest yield was given by ITCC-3710 (7900g), followed by 3709 (7840g) and 1928 (7000g)/100 kg compost. Seven strains of this category had fast growing, six medium growing and two strains had slow growing hyphae. Majority of them had appressed and strandy growth but aerial/fluffy growth was also recorded in a few isolates (Table1, 2). The quality of mushrooms in this category varied as very good in seven, good in five and average in three strains.

The strains whose production recorded below5000g/100 Kg compost were; ITCC-1927, 1929, 3611, 3613, 3614, 3696, 3706, 4289, 4291 and 5102, while the lowest yield (2360g) was produced by ITCC-5102, and highest (4440g) by ITCC-3614.In this group six strains had slow growing, one strain had medium andthree strains had fast growing mycelium on Potato Dextrose agar medium. Two strains had very good and fourstrains each had goodand average quality mushrooms (Fig. 2 a, b, c).

On basis of present study, although there was no direct relationship among mycelial characters, productivity and quality of mushrooms, but productivity and their mycelial growth on agar medium (fast and slow growth) had a correlation. Among 12 fast growing strains, 9 isolates (ITCC-1924, 1928, 2075, 3607, 3615, 3616, 3697, 3708 and 3710) were good yielder as they produced more than 5000 g mushrooms/100 kg compost. Similarly among 10 medium growing strains, 9isolates (ITCC-1926, 1931, 2074, 3554, 3617, 3618, 3707, 3741 and 4288)) were good yielder and they produced more than 5000 g mushrooms/100 kg compost. Among 11 slow growing strains, only 4 isolates (ITCC-3608, 3609, 3709 and 4004) were good yielder as they produced more than 5000g mushrooms/100 kg compost. Similarly fluffy with appressedmycelial growth having patchy/dendric character on agar medium indicated the strains as good yielder. Early spawn run in compost and casing resulted in better and early crop than in strains with delayed spawn run in the compost. The ratio of quality of mushroom (very good, good and poor/average) in fast, medium and slow growing strains were 5:4:3, 4:2:4 and 5:3:3respectively. On the other hand, among seven high, fifteen mediumand eleven poor/ average, yielding strains, the ratio of quality of mushroom (very good, good and poor/average) was 4:2:1, 7:5:3, and 2:4:5respectively (Table 1, 2).It is clear from the observations that the ratio of very good and good qualitymushrooms wasmore in fast and medium fast growing strains than slow growing strains. Strain ITCC-3741, had medium mycelial growth on agar medium and produced highest yield (15360g), but the quality of mushroom was average/poor. StrainITCC-4290 did not produce fruit bodiesdue to very slow mycelial growth and non colonization of the compost with mycelium.Statistical analysis of mushroom productivity shows that data obtained in high, medium and poor/average yielding strains,were relevant when yield difference was more than 2869(CD).The mushroom production obtained from slow, medium and fast growing isolates had also significant differences (Table2).

In appearance, fruit bodies of different strains varied from creamy white (1924, 1927, 1929, 4288, 3613, 3706 and 5102),buff white (ITCC-1926, 1928, 3554, 3608, 3617, 4004, 3611, 3696, 4289 and 4291), milky white (ITCC-1931, 3607, 3708, 3709), snowy white (ITCC- 3609, 3614, 3615, 3616, 3618, 3697, 3707, 3710 and 3741), and brown (2074 and 2075),which is peculiar character of individual strain. The colour of an individual strain did not affect growth, productivity and quality of mushrooms.

After studyingcultural characteristics of different strains of *A.bisporus* and *A. bitorquis*, Goltapeh and Kapoor (1989)[5], and Bahukhandi and

Bahl (1991)[1] reported that specific colony characteristics of a strain have correlation with mushroom productivity. Whereas Evans (1959)[4] reported that sporocarp and mycelial variation may be due to irregular nuclear constitution of spores or hyphae for prolonged storage conditions and their effect signify the productivity of mushrooms. There are a number of factors influencing the vegetative growth and productivity in cultivated mushrooms (Stamets, 2000[18], 2005[19]) and growing the strains on various media and at various temperatures, affect their growth pattern, growth rate and other characteristics (Sigel and Sinden, 1953[16]). Evaluation of *Agaricus bisporus* strains was carried out by various workers for improvements in quality, shape, size, compactness of pileus and nutritional characters by implementing growth hormones, altering the production methodology, addition of ingredients in compost and casing, use of quality strains/ hybrids and manipulation in environmental parameters (Pardo *et al*., 2010[11] Schroeder and Schisler, 1981[14], Singh and Kamal, 2011[17]). However, suitable strains were identified for cultivation in north Indian plains and use of vegetative mycelial characteristics likegrowth pattern, sector/zone formation, strandy/patchy growthand their correlations with the productivity of a strain. In present study the cultures of various strains were procured from the authentic old stocks, but some of them did not provide proper results, which may be due to continuous sub culturing and prolong storage, which resultedindecline of theirvigour.

In present study, it hasalso been observed that in general strains having fast to medium, appressed and strandy growth with sectors and zonationin agar medium, resulted in high productivity and well quality mushrooms and the strains with slow growth andappressedmycelium were low yielding with poor qualitymushrooms.Out of thirty three strains of *Agaricus bisporus* tested for their cultivation trials,thirteen strains,(ITCC-1924, 1927, 1931, 2074, 2075, 3554, 3607, 3608, 3611, 3618,3708, 3710 and 4004), provided best yield productivity and well quality mushrooms,followed by ten strains (ITCC-3609, 3616, 3617, 3697, 3707, 3709, 3616, 3696, 3706 and 4291),which provided satisfactory results. Remaining ten strains provided poor results which may be due todecline in their viability in prolonged storage and continuous sub-culturing. Therefore for getting proper results and high productivity, mushroom growers should always use fresh tissue/spore/ hybrid cultures for spawn preparation.

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