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**EFFECT OF DIFFERENT SUBSTRATES AND CULTURES ON
GROWTH, YIELD AND QUALITY OF PADDY STRAW
MUSHROOM (Volvariella diplasia Berk & Br.)**

By

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**DISSERTATION
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**DEPARTMENT OF HORTICULTURE
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PARBHANI**

1978

AFFECTIONATELY DEDICATED
TO MY PARENTS

CERTIFICATE I

Shri Shivaji Bhanudasrao Gaikwad has satisfactorily prosecuted his course of research for a period of not less than four semesters and that the dissertation entitled " EFFECT OF DIFFERENT SUBSTRATES AND CULTURES ON GROWTH, YIELD AND QUALITY OF PADDY STRAW MUSHROOM (V.diplasia BERK AND BR.)" submitted by him is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any University.

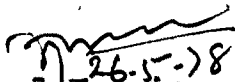
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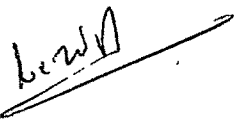

(D.A. Rane)
Guide

CERTIFICATE II

This is to certify that the dissertation entitled
" EFFECT OF DIFFERENT SUBSTRATES AND CULTURES ON GROWTH,
YIELD AND QUALITY OF PADDY STRAW MUSHROOM (V.diplasia
BERK AND BR.)" submitted by Shri Shivaji Bhanudasrao
Gaikwad to the Marathwada Agricultural University in
partial fulfilment of the requirements for the degree
of Master of Science (Agriculture) in the subject of
Horticulture has been approved by the student's advisory
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(S.B. Gaikwad)

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CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

Mushrooms are the kind of fleshy fungi which constitute a major group of the lower plant kingdom. They belong to fleshy Basidiomycetes but some of the fungi are Ascomycetous also.

From time immemorial people have been using mushrooms as vegetables and occasionally deaths resulted from their use either through ignorance or carelessness. Still, men persisted in using them and began to think of their cultivation under controlled conditions. France and England are the pioneer countries to raise mushrooms under controlled conditions. Mushroom was first grown in France in lime stone caves in and near Paris. The Japanese and Chinese learned several centuries ago the technique of cultivation of tree inhabiting mushroom called the "Shii-take". The cultivation of mushroom in U.S.A. was introduced in the later part of 19th century and Pennsylvania, Delaware and New York are the leading states in the mushroom cultivation.

Mushroom production has become of particular economic importance in countries with a high potential for agricultural production. For instance, in the Netherlands, which is famous the world over for production of vegetables

and ornamental flowers like tulips and begonias, mushroom production was 300 tons in 1959, which increased to 6,500 tons in 1964 and 9000 tons in 1973, a thirty times increase in 14 years. Similarly 5,000 tons of mushrooms were produced in Denmark in 1963. The world production of mushroom in 1963 was reported to be 1,93,000 tons of which U.S.A. alone produced 75,000 tons, France 48,000 tons, England 22,000 tons and Formosa 15,000 tons.

The successful attempts for mushroom growing have centered around some species which are not dependent for their growth on living tissue. Such species are saprophytic in nature e.g. species of *Agaricus*, *Volvariella* and *Lentinus*. The earliest record of cultivated mushroom appears to be the tropical species of *Volvariella* (Paddy-straw mushroom) and the *Lentinus edodes* while the first European species to be cultivated was *Agaricus bisporus*.

For many years, mushroom has been treasured for its flavour. Today however, the increased demand for it is not only for its flavour but also for its high food value. Among the many novel sources of protein to bridge the protein gap, mushrooms offer themselves as potential source. They have got the capacity to convert nutritionally valueless substances into high protein at comparatively low cost. Besides these, mushrooms contain a good amount

of valuable minerals like Fe, Ca, K, Mg and P_2O_5 and top the list among many vegetables in minerals, B-Vitamins and are possible source of antibiotics and anticancer agents (Mitchel, 1960). Mushroom contains 17 different carbohydrates and upon hydrolysis its protein yields 23 different amino acids.

The mushrooms are quite nutritious and may even be considered superior to vegetables like cauliflower, spinach and legumes. Their calorific value is comparable to that of apples. The protein value of mushroom is about one and half times that of asparagus and almost twice as that of cabbage and potatoes and four times that of oranges. Mushrooms play an important role as condiments of food accessories and as a flavouring agent add greatly to the palatability of many other foods. They are very popular as Pizza toppings in Western countries. These are an excellent source of riboflavin and nicotinic acid and a good source of pantothenic acid. They also contain appreciable amount of thiamin and biotin.

The importance of mushrooms in the food production should also be seen from another point of view. Due to saprophytic character, mushrooms grow on dead organic material. Mushroom production is nothing but the

utilization of energy of rotting material which otherwise is wasted. After growing the mushrooms the spent substrate can be utilized as a good compost and soil preserver for the field. Such compost contains about 2.5 per cent N and a high amount of P_2O_5 and K_2O (Mantel, 1969). Its main amount of organic material increases the humus content of the soil. In this way mushroom growing indirectly improves the field crops.

In spite of all the favourable points, mushrooms are not popular among the common people of Maharashtra, since they are being freshly introduced and their cultivation practices are also not worked out. With a view to study the performance of paddy straw mushroom, Volvariella duroii on different substrates and nutrients, an experiment was conducted in the Department of Horticulture, of Marathwada Agricultural University, Parbhani India.

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CHAPTER 2

REVIEW OF LITERATURE

The following review gives an account of the information available on various aspects of mushroom culture. But information is rather scanty on Volvariella diplasia the paddystraw mushroom, as compared to other species. The literature available is divided into suitable sub-headings.

2.1. Effect of substrates on growth and yield.

For growing mushrooms substrates like, wheat, oat or rye compost are used for temperate mushrooms and paddy straw is used for tropical mushrooms.

2.1.1. Paddystraw mushrooms.

* Volvariella diplasia called paddystraw mushroom, can be cultivated only on paddystraw (Krishnamurthy and Lalithakumari, 1968). However, Tu et al. (1971) found ✓ that the highest yield (486.87 kg per 100 m²) was obtained with fresh sisal tow covered with rice straw and polythene. This system developed the most suitable temperature for hyphal growth and fruit body production resulting in longest harvesting period of 16.5 days. A similar system without polythene produced 261.75 kg and other sisal tow

treatment produced lower yields compared with those produced on the conventional substrates of paddy straw covered with polythene.

* Shin et al. (1971) reported that in spring the highest mushroom yield was obtained from a combination of rice straw, poultry manure, rice bran, urea and gypsum. In autumn, the best yields were produced on a combination of rice straw, poultry manure, urea, K and gypsum. He further reported that out of eleven farm products tested, parilla meal, se-samum meal, wheat bran, poultry manure and rice bran were highly effective in increasing yields.

Yong and Graham (1973), however, grew successfully paddy straw mushrooms on fresh oil palm pericarp waste. Old waste subjected to long period of decomposition and leaching was not suitable. Fresh material composted for five days before spawning gave the highest mean yield of approximately 1.54 kg/100 kg of waste, compared with material composted for 1, 10 and 15 days. Paddystraw, according to him, was clearly superior to others giving a mean yield of 4.67 kg/100 kg of straw.

* Goh and Graham (1975) successfully grew paddy straw mushroom (Volvariella volvacea) on a compost made on air

dry basis of approximately 90 per cent oil palm pericarp waste and 10 per cent shredded waste paper supplemented with 0.6 per cent urea or 0.5 per cent NH_4OH . Out of the three pericarp paper combinations the one supplemented with urea gave the maximum yield per unit area.

2.1.2. Temperate mushrooms.

B. Els (1962) reported that average yield from compost of oat straw ranged from 8.9 to 12.5 kg per m^2 during 8-14 weeks and from composts of oat and rye straw mixture, average yield reached 19.24 kg/ m^2 in 13 week cropping period.

* Lemke (1963) prepared substrate by chopping wheat straw and mixing with peat, lime, marl, soybean meal and cotton seed meal and soaking it to 70 per cent water content and autoclaving it. Reasonable yields of rapidly growing mushrooms were obtained on this substrate by adding cotton seed meal alone or with soybean meal up to 10 per cent weight.

* Bryzgalov and Khalmirzaev (1976) reported that out of 8 substrates tested, the best results were obtained with 50 per cent pig manure + 50 per cent straw or 750 kg spent hops + 1,000 kg straw for temperate mushrooms.

* Reithus (1965) concluded from three tests with 5 composts from different sources, ranged in N content between 1.79 to 2.15 per cent, that the yield of mushroom varied between 4.5 to 10.5 kg / m² but there was no direct relationship between nitrogen content and yield.

- 2.1.3. *Pleurotus* mushrooms.

✓ Zakia and Shrivastava (1962) used various substrates like rice straw, sorghum straw, rice hulls, saw dust, horse dung and various combinations of these media for *pleurotus* species of mushroom and observed that the highest yield was obtained from rice straw inoculated with spawn at the rate of 40 g per 600 g of straw.

✓ * Zakia Bano (1972) obtained high yields of *Pleurotus flabellatus*, when grown in tapioca medium supplemented with cheap organic material rich in protein in a study of submerged liquid culture using water extract of different organic materials like oat meal, wheat bran, tapioca, jowar, pea shells, rice bran and pine apple waste.

- 2.2. Effect of culture on growth and yield of mushrooms.

Asthana (1947) concluded that the sporulation (Sporophore formation) was scanty when powdered dhal

(seed of pigeon pea or chick pea) was not added in the medium. Rangaswami (1956) also observed that adding of ground seed of pigeon pea (Cajanus cajan) or chick pea (Cicer arietinum L.) to the spawn resulted in the increased yield.

Zakia and Shrivastava (1962) used grain powder as a source of nutrient in which oat meal gave the highest yield as compared to all other cereal grain meals. When pulse powders were used as an organic source of nitrogen, red gram dhal powder gave the maximum yield followed by Bengal gram dhal. But the adverse effects on yield were observed when ammonium salts and urea were used as inorganic source of nitrogen.

- Krishnamurthy et al. (1968) indicated that a spoonful of powdered red gram (dhal) can serve as starter to grow spawn.

Yong and Graham (1974) obtained the fastest and most abundant growth of V. volvacea mushroom by addition of 1 g of urea and 10 g of rice bran to 200 g of oil palm pericarp waste.

- 2.3. Nutritive value of mushrooms.

The protein content of mushroom sporophores varies from 14 to 43 per cent on dry weight basis, 34 to 35 per cent

being recorded for *N. esculents* as reported by Singer (1961). He further observed that the nutritive value of mushroom is based on a relatively high percentage of protein especially in *A. bisporus* of which at least 72 per cent is digestible protein.

— *Pleurotus* spp. of mushroom approximately contains 2.78 per cent protein and 0.14 per cent non-protein nitrogen on fresh weight basis according to Zakia et al. (1963).

— Milagros et al. (1967) reported that mycelium of *V. volvacea* contains 45.3 per cent protein on dry weight basis and on hydrolysis its protein yielded all of the amino acids which are known to be essential in nutrition.

— From the trial to determine the composition of cultivated mushroom (*A. bisporus*) during the growing cycle as affected by nitrogen source introduced in composts, Angelo et al. (1968) reported the composition as moisture 90.50 per cent, dry matter 9.50 per cent, Nitrogen, 6.29 per cent, fat, 1.68 per cent, ash, 10.75 per cent, Ca, 0.18 per cent, K, 4.68 per cent, Na, 0.50 per cent, P, 1.50 per cent and Fe, 23.00 mg per 100 g of dry weight.

— Sheo and Birendra (1968) reported that edible mushroom contains water 92 per cent, protein 4 per cent, fat 0.3 per cent and minerals 2 per cent.

Shu and Kit (1973) found that basidiocarp protein content of mushroom (V. volvacea) is least in the volva and greatest in the pileus. Both the stipes and volva exhibit a more or less similar pattern in the protein content and electrophoretic spectra while the pileus possesses a unique pattern.

Zakia et al. (1971) determined the composition of mushroom species V. diplasia per 100 g of fresh weight as moisture 90.4 g , protein, 3.90 g, ash 1.10 g, Phosphorus 0.10 g K, 0.32 g, Fe, 1.70 mg and Ca, 5.60 mg.

— Charlempow et al. (1973) studied 10 edible mushroom species commonly growing in Poland for K and Ca composition. They contained 323 to 840 mg K and 151 to 306 mg Ca per 100 g of fresh weight.

— Munjal (1974) reported the following data on the food value of Agaricus bisporus on 100 g fresh weight basis. Water, 89.5 per cent, protein, 3.9 per cent, fat, 0.19 per cent, fibre, 1.1 per cent and ash, 1.26 per cent.

Volvariella diplasia species of mushroom contain, according to Angle and Tamhane (1974), water, 90.4 per cent, protein, 3.90 per cent, fat, 0.25 per cent, carbohydrate and fibre, 1.67 per cent and ash, 3.78 per cent.

— Hayes and Haddad (1976) studied the protein content in buttons, cups and flats from 1st to 3rd flush crop of cultivated mushroom and found them to contain crude and actual protein respectively as 1st break buttons, 38.52, 35.72 cups, 34.30, 31.58; flats, 31.80, 29.00 and 3rd break buttons, 39.33, 32.27; cups, 36.00, 28.70 and flats, 33.03, 26.83 on dry matter basis.

— Hayes (1976) reported the composition of mushroom (A. bisporus) in percentage as water, 91, carbohydrates, 2.4, protein, 3.3, fat, 0.4 and ash 0.9.

— Stanimirvic et al. (1976) reported that some of the mushroom proteins had a nutritional value higher than that of beef.

— 2.4. Effect of temperature humidity and other factors on the production and quality of mushroom.

A certain amount of work has been carried out on the temperature relation of higher basidiomycetes which also include a majority of edible mushrooms but most of this is scattered in the literature.

— Treschow (1944) observed that the mycelium of the cultivated mushroom (A. bisporus) was very sensitive to temperature and optimum growth was limited to a very narrow range of temperature.

* Rangaswami (1956) found paddy straw mushroom (V. diplasia) to have good growth in the nutrient medium at 35 °C temperature.

* Rath (1962) found that V. diplasia are cultivated in the tropics on paddy straw because of their suitability for high temperature and tropical climate.

• Flegg (1962) stated that at low rates of ventilation the initiation of primordia was delayed and the yield was reduced. The sporophores were more spindly than those given higher rates of ventilation. The number and total weight of sporophores were greater at high (80-90 per cent) than at low (40 to 50 per cent) relative humidity and at 65 °F (18.3 °C) than at 75 °F (23.8 °C) temperature. In his later work in 1968, Flegg observed that a temperature of 70 °F (21 °C) during the spawn running was most favourable for the mycelial growth and during the cropping stage a temperature of 57 °F (13.8 °C) to 62 °F (16.6 °C) had no effect on the weight of crop but at 67 °F (19.4 °C) the yield was reduced. The number of sporophores increased but average weight was less at lower cropping temperature.

* According to Ramkrishnan et al. (1968), 35.6 to 37 °C appears to be most favourable temperature for the maximum production of sporophores in case of V. diplasia.

. Huhnke (1969) observed that substrate temperature ranging from 14 °C to 30 °C was optimum for mycelial growth during the sterile phase and it was 27°C for the productive phase while the lethal temperature was 36 °C. Mycelial growth was retarded at temperature above and below optimum.

— Gupta et al. (1970) found optimum temperature and humidity for the production of good crop of mushroom to be 30 to 40 °C and 57.2 per cent respectively. The optimum temperature for development of mycelium was 25 °C while the growth of fruit bodies required an optimum temperature of only 16 to 18 °C.

— Lakhanpal (1976) stated that paddy straw mushroom favoured higher temperature range between 30 to 45 °C for its proper growth. The growth was checked at temperature lower than 25 °C.

— 2.5. Effect of watering the beds on production .

— Kindt (1968) subjected four mushroom strains to different rates of watering under conditions of low relative humidity in winter and high relative humidity in spring under stress and delayed watering conditions. Watering given too late or too small an amount caused a lower moisture content of casing soil (40-50 per cent below saturation point) and had negative

influence on yield, average weight and earliness of crop.

— Flegg (1965) observed that plots watered by capillarity produced a greater total weight of sporophores than plots watered by hand.

— Vedder (1973) observed the average total water consumption to be 2 litres per kg mushroom harvested, of which 1 litre is lost by evaporation.

② ✕ Very wet compost (over 76 per cent water) in the stack heated more slowly but reached a higher temperature than drier stacks, as observed by Gerrits (1973). It tended to produce less. However, the best yields came from compost with 70-72 per cent water content at filling and 65 per cent at spawning. Because of variation in the water content of the original manure, the addition of water needed and compost produced per ton of manure varied widely. The water content at spawning depended mainly on heat production during pasteurization.

. Flegg (1974) observed that the amount of water applied was positively correlated with crop weight from about second week of cropping and increasing the amount of water applied reduced the drying of compost and casing during cropping. Watering affected the character of mushroom mycelium development in the casing layer. The amount of water required to maintain

the per cent of water content of compost and casing remained unchanged throughout cropping and can be calculated from an equation representing the overall balance of water applied to and lost from the mushroom trays.

Yield was optimum when water was sprayed regularly and evenly throughout the pre-cropping and cropping. Cased trays which were not watered produced in six weeks yield of mushroom about 2/3rd of that from trays watered regularly, thus showing that there is a considerable reserve of water in the compost and casing on which the crop can grow as observed by Flegg (1975).

2.6. Effect of polythene film on production and germination.

* Ramakrishnan et al. (1968) observed that paddy straw mushroom beds when covered entirely with transparent or black polythene, which was removed only for watering, reduced the growing time by 9 days and increased the number and weight of mushroom by over 500 per cent as compared with uncovered beds. The black polythene treatment was not significantly superior to control.

Thus from the above review it can be seen that the research work on the use of various substrates and cultures

to suit the local needs and the availability of material is very scanty especially on paddy straw mushroom. Similarly conflicting yield figures and some nutrient element contents have been reported, which prompted to take-up the present study.

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CHAPTER 3

MATERIAL AND METHODS

The details of the materials used and methods followed in conducting the present investigation are given in this chapter.

Details of the experimental material.

3.1. Experimental site.

The present investigation was carried out at the Department of Horticulture, Marathwada Agricultural University, Parbhani in the green house during the summer season of 1977.

3.2. Climate and weather conditions.

Parbhani falls in the sub-tropical region, geographically 19° - $16'$ N latitude and 76° - $47'$ E longitude at a height of 409 meters above mean sea level. The average maximum temperature varies from 28°C in winter (December) to 40.9°C in summer (May), whereas, mean minimum temperature varies from 12.1°C to 24.9°C during winter and summer respectively. The climate of Parbhani is characterised by cold and humid winter and hot and dry summer weather conditions.

From the data presented in Appendix I, it is seen that during the period of experimentation the mean maximum and minimum temperatures which ranged between 32.33 to 41.50 °C and 23.00 to 26.90 °C respectively were suitable for the growth of tropical mushroom as this is the range of temperatures when paddy-straw mushrooms are said to grow well (Gupta et al., 1970).

3.3. Preliminary trial .

A preliminary trial was conducted in the third week of April and a regular replicated trial was conducted in the first week of June, 1977 and ~~continued~~ in the second week of July, 1977.

In order to determine the suitability of some substrates, a preliminary trial with paddy straw, wheat straw and dried banana leaves as substrates was undertaken in the month of April, 1977. All the substrates were individually tied into bundles of 50 cm long and about 16.5 cm in diameter weighing approximately 1 kg each. Beds of 100 cm x 50 cm x 75 cm size, by placing the bundles alternately length-wise and breadth-wise, were prepared. Spawning was done on the second and third layers. The culture used was red gram powder at the rate of one gram

at each place at the periphery of the bed at a distance of 10 cm on all sides. On this culture, spawns grown on paddy straw received from Head, Department of Pathology, Tamil Nadu Agricultural University Coimbatore, were put at the rate of 4-5 paddy straw bits. On these spawns, the culture was again placed at the rate of one gram. On this layer again a layer of substrate was placed on which the second spawning was done in the same manner as first. This was again covered by another layer of substrate and the bed was completely covered with white polythene film of 150 gauge thickness. It was observed from the preliminary results that the wheat straw was not useful for growing tropical mushrooms. Hence it was replaced by dried grass collected after weeding and a regular replicated trial was laid out in the month of June, 1977.

3.4. Selection of culture.

3.4.1. Red gram.

Red gram powder is the recommended culture for the growth of paddy straw mushroom. So it was taken as the check culture.

3.4.2. Bean (*Dolichos lablab*).

Bean is grown at low cost of production in Marathwada region and as such is available at cheap rate. In order to

determine if it can replace the red gram, it was taken as one of the cultures.

3.5. Selection of substrates.

For this experiment three substrates were selected. As the wheat straw did not produce any mushroom buttons in the preliminary trial conducted in April, 1977, it was rejected and was replaced by dried grass which was nearer to paddy straw.

3.5.1. Paddy straw.

The crumpled, freshly harvested and completely dry straw was used for this purpose.

3.5.2. Banana leaves.

Banana leaves which were cut after the harvesting of banana crop were collected and dried in the sun and were used as substrates. Only the disease or mould free leaves were used for this purpose.

3.5.3. Dried grass.

The grass which was removed by weeding was collected, dried and was used as the third substrate as this grass is generally available in abundance and is mostly wasted.

3.6. Preparation of substrate bundles .

The bundles were manually prepared by tying the substrate at both ends into about 16.5 cm diameter. The tapering ends of the bundles were cut at both ends to measure 50 cm in length and approximately 1 kg in weight.

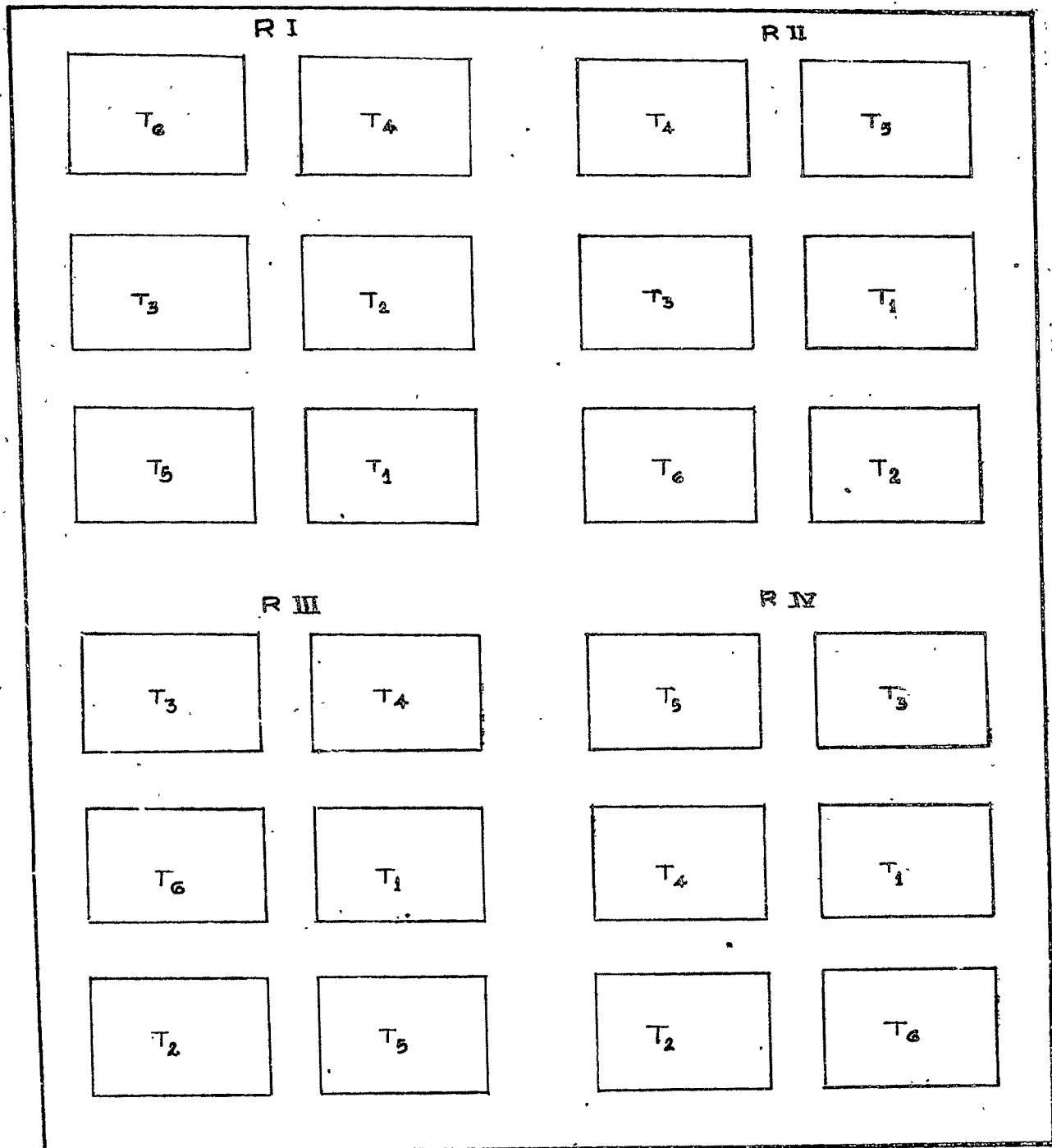
The prepared bundles of paddy straw, dried grass and banana leaves were immersed in separate water tanks. They were tied with stones, so that the entire bundles remained completely submerged. Subsequently the bundles were taken out of the tanks after 12 hours of soaking.

The soaked bundles were washed with clean water and were placed on the sloping surface in order to drain away the excess water. Thereafter, these bundles were placed on shahabadi stone floor in such a way that the butt ends of three bundles each were on either side of each layer in alternate rows. Over this layer the second layer was placed across by placing butt ends in opposite direction in alternate rows. The same pattern was followed for further alternate layers.

3.7. Treatments .

The treatments taken for the study are given below. Six combinations of 3 substrates and 2 cultures as individual treatments in a factorial randomised block design with four replications as shown in the layout plan in Fig.1.

PLAN OF LAY-OUT



DESIGN : F.R.B.D
 REPLICATIONS : FOUR
 TREATMENTS : SIX
 BED SIZE : 100 X 50 X 75 cm³

<u>Sr.No.</u>	<u>Treatments</u>	<u>Symbol</u>
1.	Banana leaves + Red gram powder	T ₁
2.	Banana leaves + Bean powder	T ₂
3.	Dried grass + Red gram powder	T ₃
4.	Dried grass + Bean powder	T ₄
5.	Paddy straw + Red gram powder	T ₅
6.	Paddy straw + Bean powder	T ₆

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3.8. Spawning.

After placing the second layer of substrate the culture powder was put along the periphery at 10 cm apart at the rate of one gram powder spread into a circular manner. Over this were placed 4-5 paddy straw pieces of 1.00 to 1.25 cm length, which contained the spawns (the myceliar growth on paddy-straw bits). Over the spawn again a layer of one gram of the culture powder was spread uniformly and two more layers of the substrate were placed over it.

Over these layers of substrate also the spawning was done as above. This was covered by two more layers of substrate and the entire bed was covered with white polythene film of 150 guage thickness as in the filler trial.

The spawning was done on 3-6-1977 and the buttons were harvested between 22-6-1977 to 7-7-1977.

3.9. Watering.

The beds were watered twice a day in the morning and evening with one can of water (approximately 15 litres) for the first 10 days and then watering was done only once in a day in the evening upto the complete harvest of buttons. At the time of watering, polythene film was removed and again covered after watering.

3.10. Picking.

The buttons of mushroom started appearing after 16 days of spawning and they were ready for harvest on the 18th day after spawning. Picking was done twice a day (before the buttons opened out) by gently twisting the upper end of each fruiting body.

3.11. Observations recorded.

3.11.1. The following growth observations were recorded.

a) Total length of buttons

Total length was measured from the base to the cap in cm as shown in Fig. 2C.

LEGEND:

LS - LENGTH OF STALK
 DC - DIAMETER OF CAP
 DS - DIAMETER OF STALK
 LC - LENGTH OF CAP
 TL - TOTAL LENGTH
 OF BUTTON

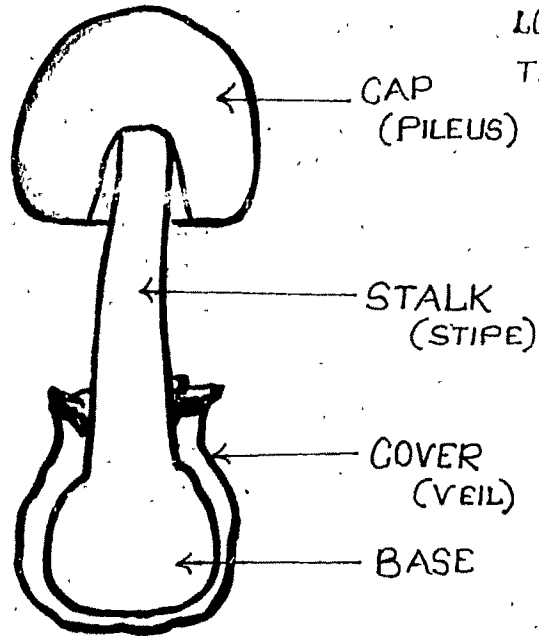


Fig. 2 a

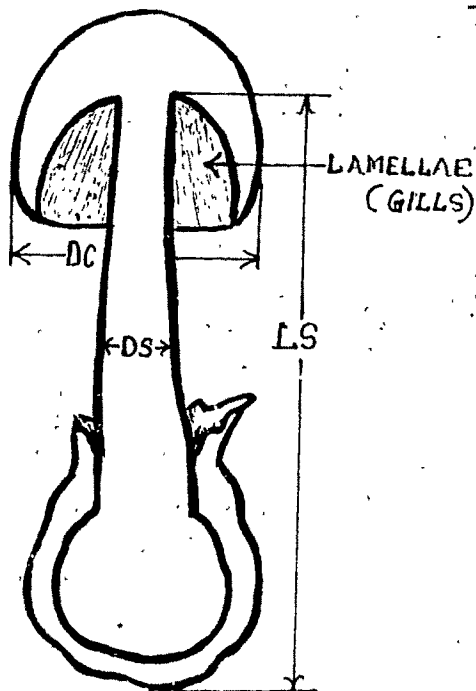


Fig. 2 b

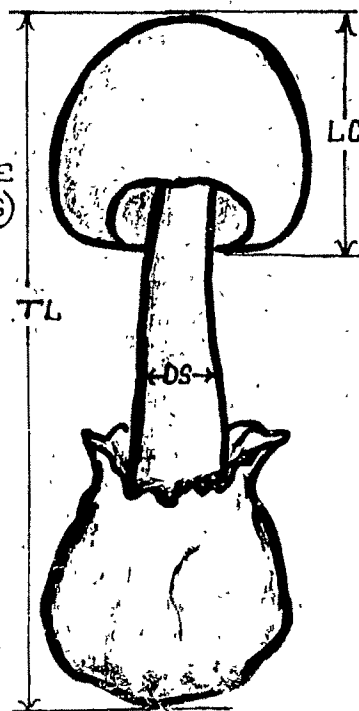


Fig. 2 c

LS OF A MUSHROOM BUTTON

b) Length of stalk.

Length of stalk was measured in cm from the base to the attachment of cap as shown in Fig. 2b.

c) Diameter of stalk.

Diameter of stalk was measured in cm in the centre of stalk by vernier caliper as shown in Fig. 2b.

d) Length of cap.

Total length of cap was measured in cm as shown in Fig. 2c.

e) Diameter of cap.

Diameter of cap was measured in cm by vernier caliper as shown in Fig 2b.

f) Weight of buttons.

The weight of individual buttons was recorded in grams and total number of buttons produced and their weight were recorded.

3.11.2. Other observations recorded were as follows.

a) The dry matter percentage was determined by drying the known weight of buttons in the oven until a constant weight was obtained. Similarly the average dry matter content of the cap, stalk, cover and base were calculated individually and expressed as per cent of fresh weight.

- b) The dried parts were used for determining the following.
 - i) Total proteins
 - ii) Phosphorus
 - iii) Potash
 - iv) Calcium
 - v) Magnesium
 - vi) Iron
- c) The substrates were analysed before and after the crop for the following.
 - i) Nitrogen
 - ii) Phosphorus
 - iii) Potash
- d) The cultures were analysed for N, P and K content before use.

3.12. Collection of climatological data.

Daily maximum and minimum temperatures and relative humidity were recorded for the period of experimentation and are presented in Appendix I.

3.13. Temperature of bed.

The temperature of each treatment bed was recorded at 9 a.m. every day at a depth of 10 cm from above in the centre of bed and the data are presented in Appendix II.

3.14. Methods adopted for chemical estimation.

3.14.1. Total nitrogen content.

This was estimated by Kjeldahl's method as given by A.O.A.C. (1965).

3.14.2. Total P_2O_5 content.

This was estimated by 'Vando-molybdophosphoric yellow colour method' in nitric acid system Jackson(1967).

3.14.3. Total K_2O content.

This was estimated in tri-acid extract of plant using 'Parkin Elmer Flame Photometer as adopted by Jackson(1967).

3.14.4. Ca and Mg content.

These were estimated by the Versenate titration method as described by Jackson(1967).

3.14.5. Iron content.

This was determined colorimetrically as O-phenon-throline red ferrus complex as described by Jackson(1967).

3.14.6. Protein percentage.

The nitrogen percentage in mushroom per treatment was estimated replication-wise by Kjeldahls method. The percentage of protein was worked out by multiplying nitrogen

percentage by a factor of 6.25.

3.15. Statistical analysis.

The data recorded were subjected to statistical analysis (Panse and Sukhatme, 1967) wherever possible. The treatments in which no growth was observed were transformed by square root transformation method in order not to violate assumptions of analysis of variance as described by Quenouille (1950) and are given in bracket in the experimental findings.

[illegible]

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840.

CHAPTER 4

RESULTS

The experimental findings recorded in the present study are presented in this chapter.

4.1. The number of days taken for first appearance of buttons and the average period of harvest days are given in Table 1.

Table 1: Number of days taken for first appearance of buttons and duration of harvest days for different treatments

| Treatments | No. of days taken for first button to appear | No. of days during which the harvesting period was spread |
|--|--|---|
| T ₁ (Banana leaves with red gram) | 21.2 | 12.00 |
| T ₂ (Banana leaves with beans) | 21.5 | 12.25 |
| T ₃ (Dried grass with red gram) | No growth | - |
| T ₄ (Dried grass with beans) | No growth | - |
| T ₅ (Paddy straw with red gram) | 24.2 | 7.00 |
| T ₆ (Paddy straw with beans) | 25.7 | 7.00 |

It is clear from the Table that the dried grass failed to sustain the mycelial growth of paddy straw mushroom and produce the fruiting bodies. It is also seen that the banana leaves as substrate produced the



FIG. 3a.



FIG. 3b.



FIG. 3c.

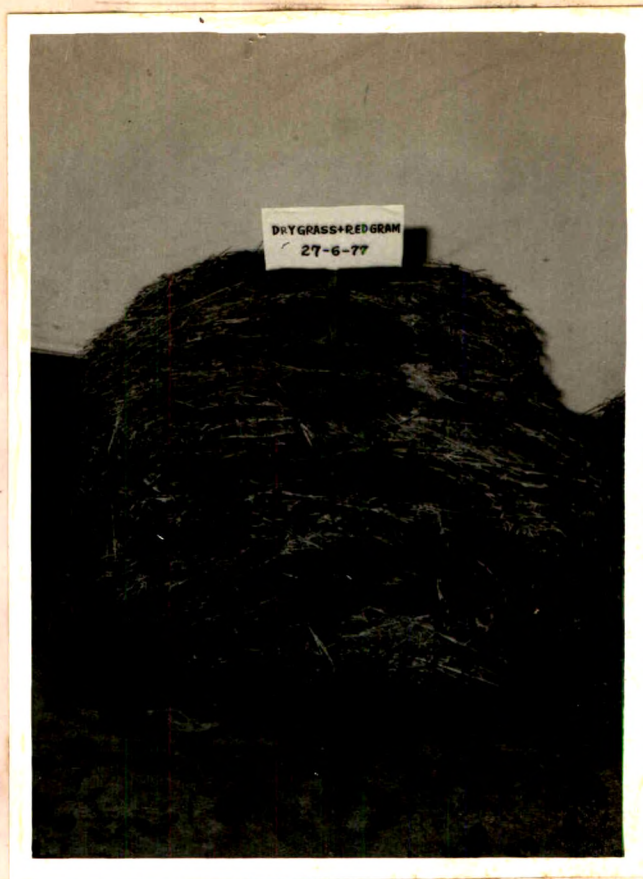


FIG. 3 d.

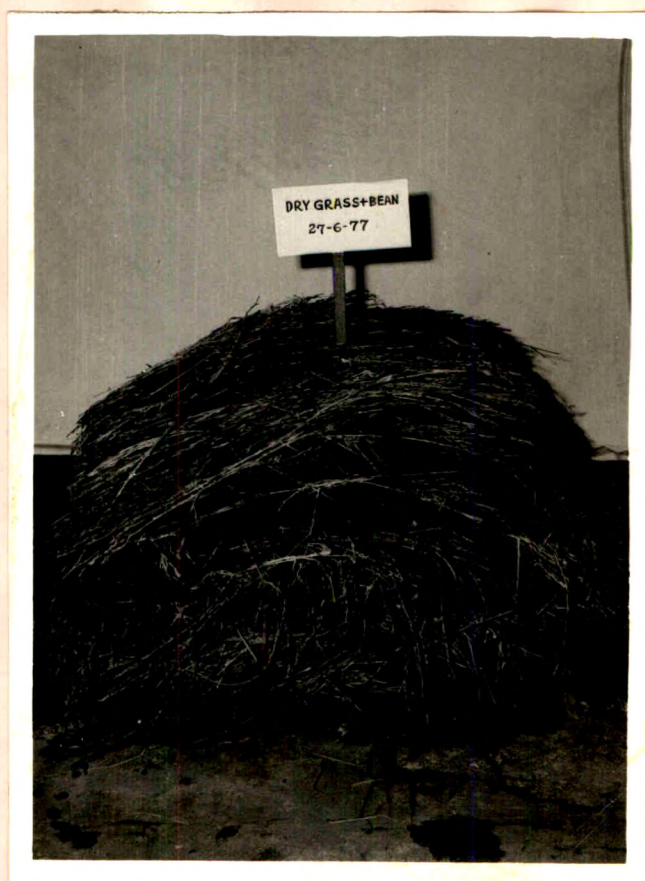


FIG. 3 e.

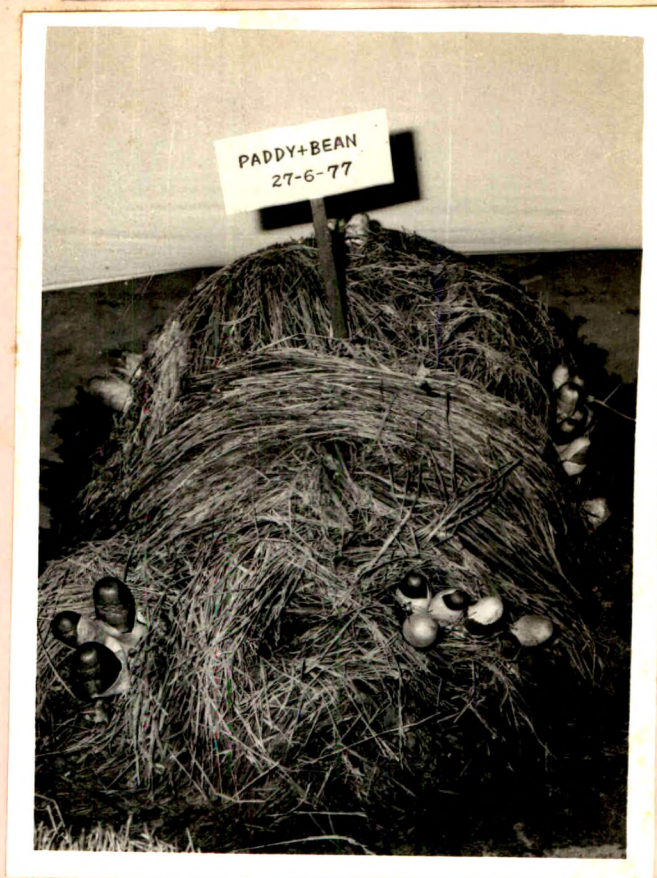


FIG. 3 f.



FIG. 3 g.

mushroom buttons about 3 to 4 days earlier than paddy straw substrate. Similarly the period of harvest was longer by about 5 days with banana leaves as substrate as compared to paddy straw.

4.2. Yield of mushroom.

The yield was recorded in terms of number of buttons produced per bed and weight of total number of buttons per bed during the entire cropping period. The general performance of the crop is represented in Fig. 3 (a to g).

4.2.1. Total number of buttons produced per bed are given in Table 2 and graphically represented in Fig. 4. The figures in bracket in this and in all the subsequent Tables are the transformed values taken for statistical analysis on the basis of which the inferences are drawn. Similarly figures denoted by same letters are not significantly different from each other.

It is seen from the data presented in Table 2 that there was significant increase in number of buttons produced per bed among the substrates. Banana leaves produced on an average 53.750 buttons as compared to 34.125 on paddy straw. However, there was no significant difference between the two cultures as regards the number of buttons produced per bed. The interaction between the substrates and cultures was significant indicating a better combination

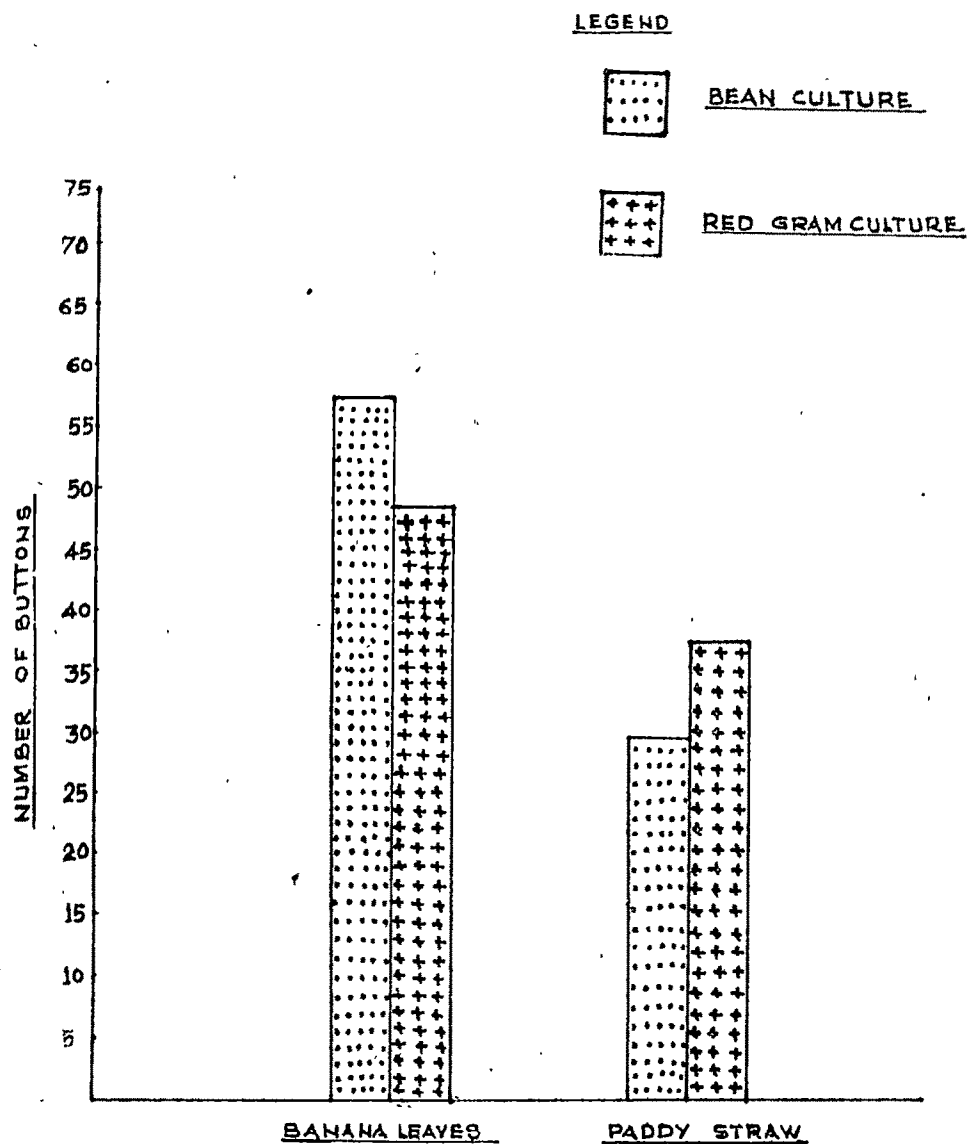


FIGURE:4 NUMBER OF PADDY STRAW
MUSHROOM BUTTONS AS AFFECTED BY SUBSTRATES
AND CULTURES.

Table 2. Total number of buttons per bed as affected by different substrate and cultures.

| Cultures | C ₁ | C ₂ | |
|--------------------------------|--------------------|--------------------|-----------------------|
| Substrates | (Red gram) | (Beans) | Mean |
| S ₁ (Banana leaves) | 49.00
(14.02) | 58.50
(15.30) | 53.750
(14.659)a |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00)c |
| S ₃ (Paddy straw) | 38.25
(12.42) | 30.00
(10.73) | 34.125
(11.571)b |
| Mean | 43.625
(9.146) | 44.250
(9.010) | |
| | Substrate | Culture | Interaction |
| S.E. ± | 0.552 | 0.451 | 0.781 |
| C.D. at 5% | 1.664 | N.S. | 2.350 |

of substrate and culture. The combination of banana leaves with bean culture gave the maximum number of buttons (58.5) as compared to only 30.0 produced by paddy straw with bean culture.

4.2.2. The yield of buttons per bed is recorded in Table 3 and graphically presented in Fig. 5.

The yield in terms of weight of buttons also significantly differed among the substrates. The maximum yield of 1928.625 g per bed was produced on banana leaves as compared to 1308.25 g on paddy straw. There was no

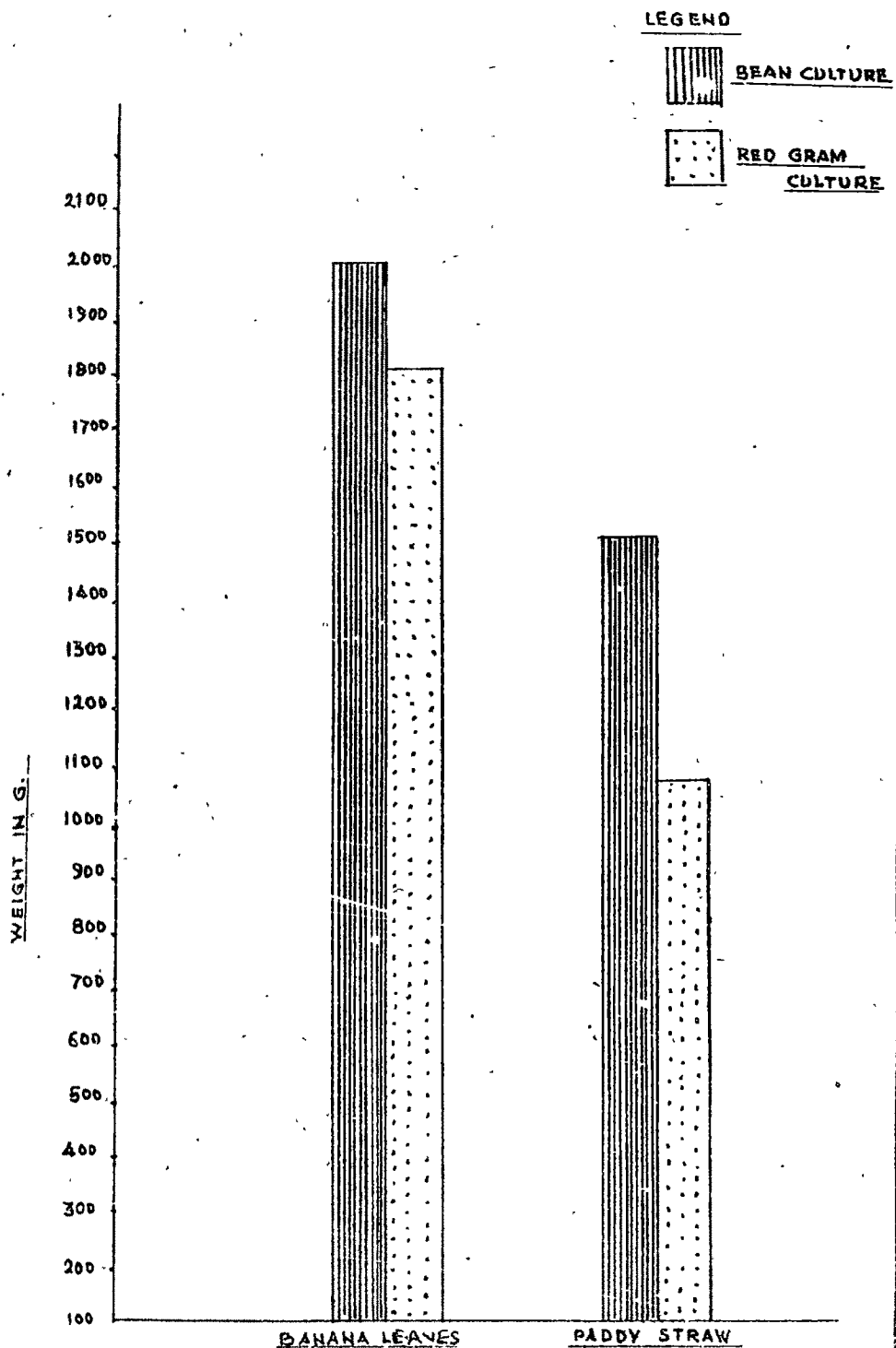


FIGURE: 5. WEIGHT OF PADDY STRAW MUSHROOM BUTTONS AS AFFECTED BY SUBSTRATES AND CULTURES.

Table 3. Total weight of buttons in g per bed as affected by different substrates and cultures.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|----------------------------|-----------------------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 1833.50
(85.58) | 2024.75
(89.84) | 1928.625
(87.71) _a |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00) _c |
| S ₃ (Paddy straw) | 1532.75
(78.17) | 1083.75
(65.26) | 1308.250
(71.712) _b |
| Mean | 1708.125
(54.916) | 1554.250
(52.033) | |
| | Substrate | Culture | Interaction |
| S.E. $\pm$ | 1.844 | 1.506 | 2.60 |
| C.D. at 5 % | 5.557 | N.S. | 7.83 |

significant difference between the cultures. The interaction between substrates and cultures was significant. The combination of banana leaves with bean culture gave the maximum yield (2024.75 g /bed) as compared to paddy straw (1083.75 g/bed) with bean culture.

4.3. The ancillary data about the yield contributing factors are presented below.

4.3.1. The data on individual weight of buttons per treatment are given in Table 4 and presented in Fig. 6.

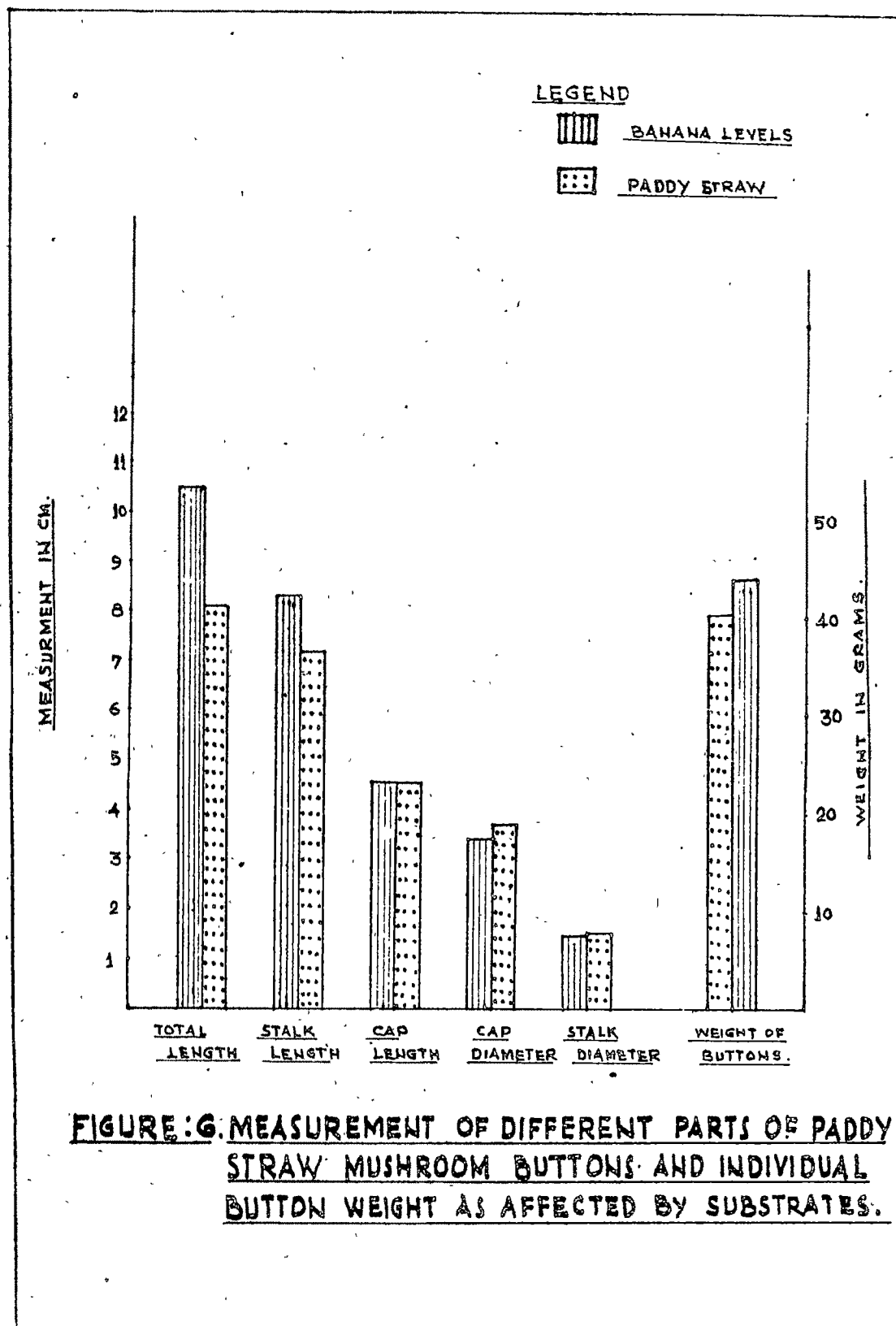


Table 4. Individual weight of buttons in g as affected by different substrates and cultures.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|---------------------------|---------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 46.08
(13.63) | 42.44
(13.09) | 44.260
(13.363)a |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00)b |
| S ₃ (Paddy straw) | 41.69
(12.90) | 40.15
(12.56) | 40.920
(12.735)a |
| Mean | 43.885
(9.176) | 41.295
(8.883) | |

| | Substrate | Culture | Interaction |
|------------|-----------|---------|-------------|
| S.E. $\pm$ | 0.475 | 0.388 | 0.675 |
| C.D. at 5% | 1.433 | N.S. | 2.020 |

It is evident from Table 4 that the individual weight of buttons significantly differed among the substrates. But this was because of the non-productive substrate as there was no significant difference between the other two productive substrates, though buttons on banana leaves were slightly heavier than those on paddy straw. There was no significant difference among the cultures also as regards the weight of buttons. The interaction between the substrates and cultures however, was significant which indicated that a particular combination was better suited for production of bigger buttons. The combination of banana leaves with

red gram culture gave the maximum weight (46.08) as compared to the least weight of only 40.15 g produced by paddy straw with bean culture.

4.3.2. The data on total length of buttons are given in Table 5 and graphically represented in Fig. 6.

Table 5. Total length of buttons in cm as affected by different substrates and cultures.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|---------------------------|--------------------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 11.85
(6.26) | 9.17
(6.21) | 10.510
(6.234) _a |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00) _b |
| S ₃ (Paddy straw) | 8.14
(5.86) | 8.13
(5.92) | 8.135
(5.890) _a |
| Mean | 9.995
(4.373) | 8.650
(4.376) | |

| | Substrate | Culture | Interaction |
|------------|-----------|---------|-------------|
| S.E. $\pm$ | 0.120 | 0.098 | 0.170 |
| C.D. at 5% | 0.363 | N.S. | 0.512 |

It is seen from the above Table that there was significant increase in total length of buttons among the substrates. Banana leaves produced longer buttons measuring 10.51 cm as compared to 8.1 cm long buttons on paddy straw. And in case of cultures, there was no significant difference

between them. However, the interaction between the substrates and cultures was observed to be significant. The combination of banana leaves with red gram culture gave the maximum length (11.85 cm) as compared to 8.13 cm produced by paddy straw with bean culture.

4.3.3. Data pertaining to the length of stalk of the buttons are given in Table 6 and graphically represented in Fig. 6.

Table 6. Length of stalk in cm as affected by different substrates and cultures.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|----------------------------|-------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 8.4
(5.96) | 8.27
(5.91) | 8.335
(5.932)a |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00)c |
| S ₃ (Paddy straw) | 7.15
(5.51) | 7.34
(5.61) | 7.245
(5.559)b |
| Mean | 7.775
(4.156) | 7.785
(3.873) | |

| | Substrates | Culture | Interaction |
|------------|------------|---------|-------------|
| S.E. $\pm$ | 0.088 | 0.072 | 0.124 |
| C.D. at 5% | 0.266 | N.S. | 0.373 |

The length of stalk in cm was significantly different among the substrates. Banana leaves produced 8.3 cm long

stalk length as compared to 7.2 cm on paddy straw. However, there was no significant difference between the cultures as regards the length of stalk. But the interaction between the substrates and cultures was significant. The combination of Banana leaves with red gram culture gave the highest length of 8.4 cm as compared to 7.15 cm in paddy straw with red gram culture.

4.3.4. The data on the stalk diameter of buttons are presented in Table 7 and graphically represented in Fig. 6.

Table 7. Diameter of stalk in cm as affected by different substrates and cultures.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|---------------------------|-------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 1.52
(2.82) | 1.50
(2.80) | 1.510
(2.809)a |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00)b |
| S ₃ (Paddy straw) | 1.62
(2.89) | 1.52
(2.81) | 1.570
(2.849)a |
| Mean | 1.570
(2.236) | 1.510
(2.203) | |
| | Substrates | Culture | Interaction |
| S.E. $\pm$ | 0.05 | 0.041 | 0.070 |
| C.D. at 5% | 0.151 | N.S. | 0.213 |

The diameter of stalk in cm also significantly differed among the substrates. But these differences were due to the non-productive substrate, the dried grass, as there was no significant difference between the productive substrates.

There was no significant difference between the two cultures. Though the interaction was significant for stalk diameter, it was due to the non-production of buttons on dried grass as the differences between the productive substrates were not significant.

4.3.5. Data pertaining to the length of cap in cm are given in Table 8 and graphically represented in Fig.6.

Table 8. Length of cap in cm as affected by different substrates and cultures

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|---------------------------|-------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 4.92
(4.64) | 4.30
(4.36) | 4.610
(4.503)a |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00)b |
| S ₃ (Paddy straw) | 4.55
(4.47) | 4.67
(4.53) | 4.610
(4.506)a |
| Mean | 4.735
(3.370) | 4.485
(3.296) | |
| | Substrates | Culture | Interaction |
| S.E. $\pm$ | 0.073 | 0.060 | 0.100 |
| C.D. at 5% | 0.221 | N.S. | 0.300 |

From the data presented in Table 8 it can be seen that the length of cap significantly differed among substrates.

But these differences were due to the non productive substrates as the other two productive substrates were at par. There was no significant difference between the two cultures. Through the interaction among the substrates and cultures was significant the effective combinations of productive substrates and cultures were at par.

4.3.6. Data on diameter of cap are given in Table 9 and graphically presented in Fig.6.

Table 9. Diameter of cap in cm as affected by different substrates and cultures.

| Cultures | | | |
|--------------------------------|------------------------------|---------------------------|-------------------------------|
| Substrates | C ₁
(Red gram) | C ₂
(Beans) | Mean |
| S ₁ (Banana leaves) | 3.62
(4.05) | 3.35
(3.91) | 3.485
(3.986) _a |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00) _b |
| S ₃ (Paddy straw) | 3.67
(4.07) | 3.85
(4.15) | 3.760
(4.115) _a |
| Mean | 3.645
(3.040) | 3.600
(3.020) | |
| | Substrates | Culture | Interaction |
| S.E. $\pm$ | 0.043 | 0.036 | 0.061 |
| C.D. at 5% | 0.131 | N.S. | 0.186 |

From the data given in Table 9 it is observed that the significant differences among the substrates pertaining to cap diameter were due to non-productive dried grass substrate

as the other two productive substrates were at par. There was no significant difference between the two cultures also. But the interaction gave the significant differences in cap diameter. Paddy straw with bean culture gave the broadest cap diameter of 3.85 cm as compared to 3.35 cm in banana leaves with bean culture.

4.4. The mushroom buttons were analysed for their nutrient element content in their various parts and the data are presented here.

4.4.1. Protein content.

The protein content was calculated on the basis of nitrogen content estimated on dry weight basis. The data are presented in Table 10 and represented in Fig. 7.

4.4.1.1. Protein content of cap.

It is seen from the Table 10 that there were significant differences in protein content of mushroom produced on different substrates. But these differences were due to non-productive substrate and as such the banana leaves and paddy straw, the productive substrates were at par. However, there was significant difference between cultures. The bean culture produced button caps with more protein content than the red gram culture. The interaction was also significant as can be seen from Table 10a. The combination of paddy straw with bean culture was the best among all the

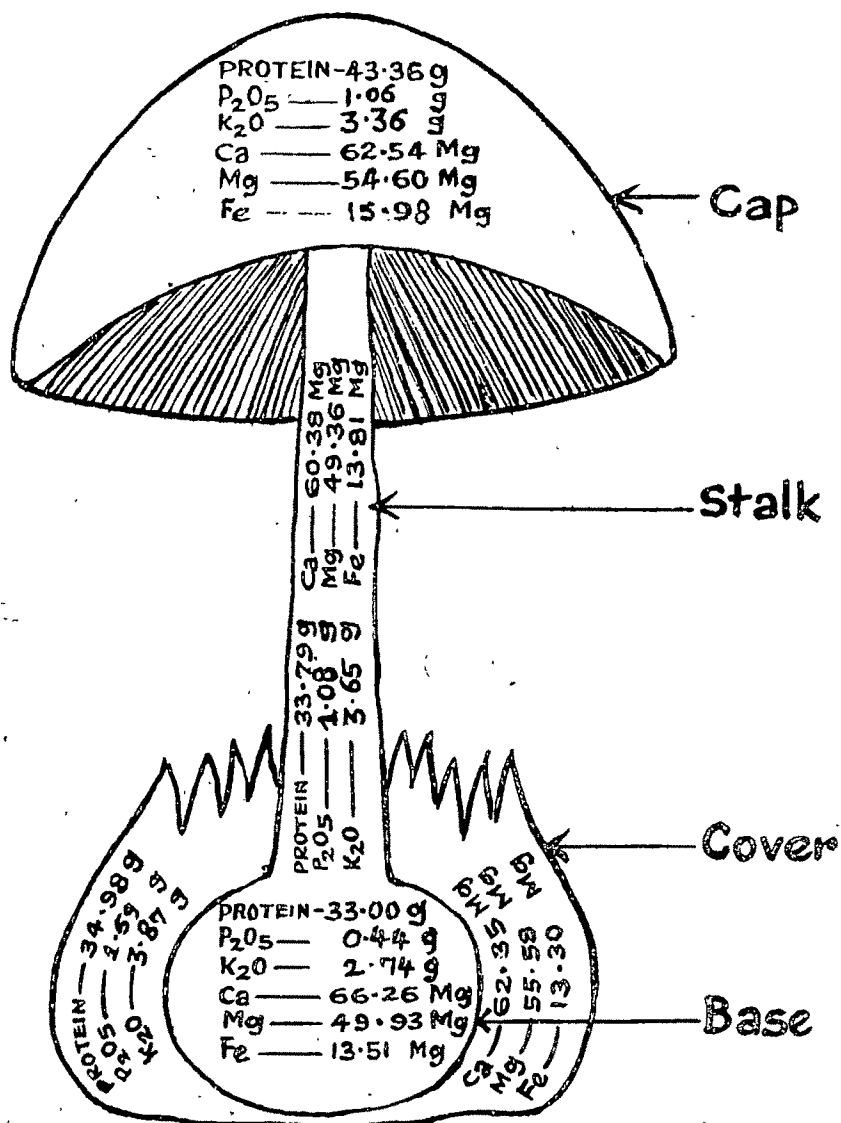


Fig 7. Nutrient content in different parts of mushroom buttons.

Table 10: Protein content of different parts of paddy straw mushroom (*Volvariella diplasia*) buttons in g / 100 g dry weight.

| Substrate | Button part | | | |
|---------------------------------|---------------------|----------------------|---------------------|---------------------|
| | Cap | Stalk | Cover | Base |
| S ₁ (Banana leaves) | 43.610
(13.279)a | 33.765*
(11.690)a | 34.925
(11.900)a | 33.000
(11.576)a |
| S ₂ (Dried grass) | 0.000
(1.000)b | 0.000
(1.000)b | 0.000
(1.000)b | 0.000
(1.000)b |
| S ₃ (Paddy straw | 43.660
(13.288)a | 33.815
(11.709)a | 35.045
(11.920)a | 32.985
(11.567)a |
| Mean | 43.635
(9.189) | 33.780
(8.133) | 34.985
(8.273) | 32.992
(8.047) |
| S.E. $\pm$ | 0.008 | 0.092 | 0.012 | 0.020 |
| C.D. at 5% | 0.024 | 0.276 | 0.035 | 0.061 |
| <u>Culture</u> | | | | |
| C ₁ (Red gram) | 43.245
(9.150)b | 33.410
(8.085) | 35.350
(8.313)a | 32.475
(7.985)b |
| C ₂ (Bean) | 44.025
(9.227)a | 34.170
(8.180) | 34.620
(8.233)b | 33.535
(8.110)a |
| S.E. $\pm$ | 0.007 | 0.075 | 0.010 | 0.017 |
| C.D. at 5 % | 0.020 | N.S. | 0.029 | 0.052 |

* Figures in brackets are the transformed values used for statistical analysis from which valid inferences are drawn.

Table 10 a. Protein content of cap.

| Cultures | | | |
|--------------------------------|------------------------------|---------------------------|--------------------|
| Substrates | C ₁
(Red gram) | C ₂
(Beans) | Mean |
| S ₁ (Banana leaves) | 43.32
(13.23) | 43.90
(13.32) | 43.610
(13.275) |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00) |
| S ₃ (Paddy straw) | 43.17
(13.21) | 44.15
(13.36) | 43.66
(13.285) |
| Mean | 43.245
(8.813) | 44.025
(9.266) | |
| S.E. ± | 0.010 | | |
| C.D. at 5% | 0.030 | | |

combinations producing the protein content of 44.15 g/100 g dry matter of cap as compared to the least quantity of 43.17 g/100 g in paddy straw with red gram culture .

4.4.1.2. Protein content of stalk.

From the data presented in Table 10 it is evident that there were significant differences in protein content but were only due to non productive substrates, while the productive substrates were at par. There was no significant difference between the cultures. The interaction was also nonsignificant.

4.4.1.3. Protein content of cover.

It can be seen from Table 10 that there were significant differences in protein content of cover of different substrates.

But banana leaves and paddy straw were at par as the significant differences are due to nonproduction of buttons on dried grass substrate. There was significant difference between the cultures. The red gram culture produced button covers with more protein content than bean culture. The interaction was also significant as is clear from Table 10 b.

Table 10 b. Protein content of cover

| Cultures | | | |
|--------------------------------|------------------------------|---------------------------|--------------------|
| Substrates | C ₁
(Red gram) | C ₂
(Beans) | Mean |
| S ₁ (Banana leaves) | 35.32
(11.96) | 34.53
(11.83) | 34.920
(11.895) |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00) |
| S ₃ (Paddy straw) | 35.38
(11.97) | 34.71
(11.86) | 35.045
(11.915) |
| Mean | 35.350
(8.310) | 34.626
(7.963) | |

S.E. $\pm$ 0.0170

C.D. at 5 % 0.051

The combination of paddy straw with red gram culture was the best among all the combinations thus producing protein content of 35.38 g/100 g dry matter of cover as compared to 34.53 g/100 g in banana leaves with bean culture.

4.4.1.4. Protein content of base.

From the data recorded in Table 10, it is observed that there were significant differences in protein content of mushroom base produced on different substrates but these differences also were due to non-productive substrate. There was significant difference between the cultures. The bean culture produced button base with more protein content (33.535 g/100 g) than red gram culture (32.475 g/100 g). The interaction was also significant as can be seen from Table 10c.

Table 10c. Protein content of base.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|-----------------------------|---------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 32.50
(11.48) | 33.55
(11.67) | 33.025
(11.575) |
| S ₂ (Dried grass) | 00.00
(1.00) | 00.00
(1.00) | 00.00
(1.00) |
| S ₃ (Paddy straw) | 32.45
(11.47) | 33.52
(11.66) | 33.985
(11.565) |
| Mean | 32.475
(7.983) | 33.535
(8.110) | |
| S.E. $\pm$ | 0.028 | | |
| C.D. at 5% | 0.084 | | |

The combination of banana leaves with bean culture produced more protein i.e. 33.55 g/100 g as compared to 32.45 g /100 g in paddy straw with red gram culture.

4.4.2. Phosphorus content in different parts of mushroom buttons.

The phosphorus was calculated on dry weight basis.

The data are prescribed in Table 11 and represented in Fig.7.

Table 11 Phosphorus content of different parts of paddy straw mushroom (*Volvariella diplasia*) buttons in g/100 g dry weight.

| Substrate | Button part | | | |
|--------------------------------|-------------------|-------------------|-------------------|-------------------|
| | Cap | Stalk | Cover | Base |
| S ₁ (Banana leaves) | 0.828
(2.261)b | 1.424
(2.709)a | 1.355
(2.699)b | 0.332
(1.731)b |
| S ₂ (Dried grass) | 0.000
(1.000)c | 0.000
(1.000)c | 0.000
(1.000)c | 0.000
(1.000)c |
| S ₃ (Paddy straw) | 1.299
(2.648)a | 0.742
(2.164)b | 1.825
(3.024)a | 0.550
(1.965)a |
| Mean | 1.063
(1.700) | 1.083
(1.957) | 1.590
(2.241) | 0.441
(1.565) |
| S.E. $\pm$ | 0.044 | 0.024 | 0.024 | 0.024 |
| C.D. at 5% | 0.131 | 0.074 | 0.0738 | 0.0738 |
| <u>Culture</u> | | | | |
| C ₁ (Red gram) | 1.121
(2.000) | 1.525
(2.200)a | 1.450
(2.179)b | 0.581
(1.669)a |
| C ₂ (Bean) | 1.005
(1.939) | 0.641
(1.715)b | 1.730
(2.303)a | 0.301
(1.457)b |
| S.E. $\pm$ | 0.036 | 0.020 | 0.020 | 0.020 |
| C.D. at 5% | N.S. | 0.060 | 0.060 | 0.060 |

4.4.2.1. Phosphorus content in cap.

From the data recorded in Table 11, it is evident that there were significant differences among substrates. Paddy straw gave the maximum phosphorus content of 1.299 g/100 g as compared to 0.828 g /100 g on banana leaves. The dried grass failed to produce any buttons. There was no significant difference between the cultures and also the interaction was non-significant.

4.4.2.2. Phosphorus content of stalk.

It is seen from Table 11 that significant differences existed among the substrates for phosphorus content of button stalks. Banana leaves gave the maximum production of phosphorus in stalk i.e. 1.424 g/100 g as compared to 0.742 g/100 g on paddy straw. There was significant difference in cultures also. The red gram culture produced stalk with more phosphorus content than bean culture. The interaction was also significant as seen from Table 11a. The combination of banana leaves with red gram gave the highest phosphorus content in stalk viz. 2.04 g/100 g while it was as low as 0.474 g/100 g in paddy straw with bean culture.

4.4.2.3. Phosphorus content of cover.

Significant differences in phosphorus content of cover were observed in different substrates.

Table 11a. Phosphorus content of stalk.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|---------------------------|------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 2.04
(3.175) | 0.809
(2.243) | 1.424
(2.709) |
| S ₂ (Dried grass) | 0.000
(1.00) | 0.000
(1.000) | 0.000
(1.000) |
| S ₃ (Paddy straw) | 1.010
(2.426) | 0.474
(1.902) | 0.742
(2.164) |
| Mean | 1.525
(2.200) | 0.642
(1.715) | |
| S.E. $\pm$ | 0.033 | | |
| C.D. at 5% | 0.099 | | |

Table 11b. Phosphorus content of cover.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|---------------------------|------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 1.40
(2.734) | 1.31
(2.665) | 1.355
(2.700) |
| S ₂ (Dried grass) | 0.000
(1.000) | 0.000
(1.000) | 0.000
(1.000) |
| S ₃ (Paddy straw) | 1.500
(2.804) | 2.150
(3.243) | 1.825
(3.123) |
| Mean | 1.450
(2.269) | 1.730
(2.302) | |
| S.E. $\pm$ | 0.034 | | |
| C.D. at 5% | 0.104 | | |

Paddy straw substrate produced 1.825 g P_2O_5 /100 g as compared to 1.355 P_2O_5 /100 g on banana leaves as substrates. There was significant differences between the cultures also. The bean culture produced more phosphorus in cover as compared to red gram culture. There was significant difference between the interactions as can be seen from Table 11b. Paddy straw with bean culture gave the highest phosphorus (2.15 g/100 g) in cover as compared to the least (1.31 g/100 g) on banana leaves with bean culture.

4.4.2.4. Phosphorus content of base.

It is seen from Table 11 that there were significant differences in phosphorus content of base produced in different substrates. The paddy straw gave 0.552 g/100 g phosphorus in base as compared to 0.332 g/100 g on banana leaves as substrate. There were significant differences between cultures. The red gram culture produced more phosphorus in base than the bean culture. There was significant interaction as can be seen from Table 11c. The combination of paddy straw with red gram culture produced more phosphorus content of 0.772 g/100 g dry matter as compared to 0.275 g /100 g in paddy straw with bean culture.

Table 11c Phosphorus content of base

| Cultures | | | |
|--------------------------------|------------------------------|----------------------------|------------------|
| Substrates | C ₁
(Red gram) | C ₂
(Beans) | Mean |
| S ₁ (Banana leaves) | 0.390
(1.799) | 0.275
(1.651) | 0.332
(1.725) |
| S ₂ (Dried grass) | 0.000
(1.000) | 0.000
(1.000) | 0.000
(1.000) |
| S ₃ (Paddy straw) | 0.772
(2.209) | 0.328
(1.721) | 0.550
(1.965) |
| Mean | 0.581
(1.666) | 0.301
(1.462) | |
| S.E. $\pm$ | 0.036 | | |
| C.D. at 5% | 0.107 | | |

4.4.3. Potash content.

The potash content was calculated on the dry weight basis. The data are presented in Table 12 and represented in Fig.7

4.4.3.1. Potash content of cap.

From the data recorded in Table 12 it is evident that there were significant differences in potash content of mushroom produced on different substrates.

Table 12. Potash content of different parts of paddy straw mushroom (*V.diplasia*) buttons in g per 100 g dry weight .

| Substrates | Button part | | | |
|--------------------------------|-------------------|-------------------|-------------------|-------------------|
| | Cap | Stalk | Cover | Base |
| S ₁ (Banana leaves) | 3.342
(3.906)a | 3.468
(3.972)b | 3.770
(4.121)b | 2.658
(3.538)b |
| S ₂ (Dried grass) | 0.000
(1.000)b | 0.000
(1.000)c | 0.000
(1.000)c | 0.000
(1.000)c |
| S ₃ (Paddy straw) | 3.386
(3.801)a | 3.847
(4.156)a | 3.990
(4.229)a | 2.840
(3.637)a |
| Mean | 3.364
(2.902) | 3.666
(3.042) | 3.880
(3.116) | 2.749
(2.725) |
| S.E. $\pm$ | 0.071 | 0.017 | 0.020 | 0.024 |
| C.D. at 5% | 0.213 | 0.052 | 0.060 | 0.074 |
| <u>Culture</u> | | | | |
| C ₁ (Red gram) | 3.350
(2.858) | 3.540
(3.006)b | 3.880
(3.116) | 2.745
(2.724) |
| C ₂ (Bean) | 3.370
(2.946) | 3.770
(3.079)a | 3.875
(3.116) | 2.750
(2.725) |
| S.E. $\pm$ | 0.057 | 0.014 | 0.017 | 0.020 |
| C.D. at 5 % | N.S. | 0.043 | N.S. | N.S. |

But these differences were only due to non-productive substrate of dried grass and as such the banana leaves and paddy straw, the productive substrates, were at par. Similarly there was no significant difference between the cultures and various combinations of the substrates and cultures.

4.4.3.2. Potash content of stalk.

It was observed that there were significant differences among the substrates (Table 12).

Table 12a. Potash content of stalk.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|---------------------------|------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 3.54
(4.01) | 3.39
(3.93) | 3.465
(3.970) |
| S ₂ (Dried grass) | 0.00
(1.00) | 0.00
(1.00) | 0.00
(1.00) |
| S ₃ (Paddy straw) | 3.54
(4.01) | 4.15
(4.30) | 3.845
(4.155) |
| Mean | 3.540
(3.006) | 3.770
(3.076) | |
| S.E. $\pm$ | 0.023 | | |
| C.D. at 5% | 0.069 | | |

The paddy straw gave higher potash content in stalk i.e. 3.847 g/100 g on dry weight basis as compared to 3.468 g/100 g on banana leaves. There were significant differences between the cultures also. Bean culture gave higher potash content of stalk i.e. 3.770 g/100 g dry matter as compared to 3.540 g/100 g on red gram culture. The interaction was also significant as can be seen from Table 12a. The combination of paddy straw with bean culture gave the stalk potash content of 4.15 g/100 g as compared to 3.39 g/100 g on banana leaves with bean culture.

4.4.3.3. Potash content of cover.

It is seen from Table 12 that there were significant differences in potash content of cover in different substrates and paddy straw was significantly superior to banana leaves. No significant differences between the cultures were observed and also there were no significant differences in interaction.

4.4.3.4. Potash content of base.

It is evident from the data recorded in Table 12 that there were significant differences among the substrates on the production of potash content in base. The paddy straw gave high potash content of base i.e.

2.840 g/100 g as compared to 2.658 g/100 g on banana leaves. However, there was no significant difference in cultures and the interactions also were not significant.

4.4.4. Calcium content.

Calcium content was determined on dry weight basis in mg/100 g dry weight. The data are prescribed in Table 13.

4.4.4.1. Calcium content of cap.

It is seen from Table 13 that there were significant differences among the substrates for calcium content in cap which were only due to the unproductive dried grass substrate and as such the banana leaves and paddy straw, the productive substrates, were at par.

4.4.4.2. Calcium content of stalk.

Although there were statistically significant differences among the substrates for calcium content of stalk, the differences were due to the non-production of crop on dried grass. There were no significant differences between cultures and the interactions also were non-significant.

Table 13. Calcium content of different parts of paddy straw mushroom (*V. diplasia*) buttons in mg/100 g dry weight.

| Substrate | Button part | | | |
|--------------------------------|---------------------|---------------------|---------------------|---------------------|
| | Cap | Stalk | Cover | Base |
| S ₁ (Banana leaves) | 61.840
(15.765)a | 61.381
(15.702)a | 58.297
(15.473)b | 63.225
(15.946)b |
| S ₂ (Dried grass) | 00.000
(1.000)b | 00.000
(1.000)b | 00.000
(1.000)c | 00.000
(1.000)c |
| S ₃ (Paddy straw) | 62.982
(15.919)a | 59.387
(15.431)a | 65.148
(16.187)a | 69.225
(16.701)a |
| Mean | 62.411
(10.895) | 60.384
(10.711) | 61.723
(10.886) | 66.225
(11.216) |
| S.E. $\pm$ | 0.247 | 0.307 | 0.212 | 0.184 |
| C.D. at 5% | 0.745 | 0.925 | 0.638 | 0.554 |
| <u>Culture</u> | | | | |
| C ₁ (Red gram) | 61.685
(10.829) | 59.870
(10.669) | 61.070
(10.779) | 68.220
(11.373) |
| C ₂ (Bean) | 63.180
(10.960) | 60.890
(10.753) | 63.620
(10.995) | 64.310
(11.058) |
| S.E. $\pm$ | 0.064 | 0.250 | 0.173 | 0.150 |
| C.D. at 5% | N.S. | N.S. | N.S. | N.S. |

4.4.4.3. Calcium content of cover.

From the data recorded in Table 13 it is clear that there were significant differences among the substrates for calcium content of cover. Paddy straw gave higher calcium content in cover (65.148 mg/100 g) than the banana leaves (58.277 mg/100 g). There were no significant differences between the cultures and interaction also was non-significant.

4.4.4.4. Calcium content of base .

It is seen from Table 13 that significant differences existed in calcium content of base produced on different substrates. The paddy straw gave the maximum calcium content in base (69.225 mg/100 g dry weight) which was significantly higher than 63.225 mg/100 g on banana leaves. However, there was no significant difference between cultures and also the interaction was not significant.

4.4.5. Magnesium content.

Magnesium content was calculated on dry weight basis as mg /100 g. The data are presented in Table 14 and represented in Fig. 7.

Table 14. Magnesium content of different parts of paddy straw mushroom (*V.diplasia*) buttons in mg/100 g dry weight.

| Substrate | Button parts | | | |
|--------------------------------|---------------------|---------------------|---------------------|---------------------|
| | Cap | Stalk | Cover | Base |
| S ₁ (Banana leaves) | 53.672
(14.704)a | 48.441
(13.939)a | 52.517
(14.519)a | 47.894
(13.785)b |
| S ₂ (Dried grass) | 0.000
(1.000)b | 0.000
(1.000)b | 0.000
(1.000)b | 0.000
(1.000)c |
| S ₃ (Paddy straw) | 55.401
(14.916)a | 50.287
(14.210)a | 58.675
(15.251)a | 51.193
(14.467)a |
| Mean | 54.536
(10.206) | 49.364
(9.716) | 55.596
(10.256) | 49.544
(9.751) |
| S.E. $\pm$ | 0.356 | 0.301 | 0.294 | 0.139 |
| C.D. at 5 % | 1.073 | 0.907 | 0.886 | 0.418 |
| <u>Culture</u> | | | | |
| C ₁ (Red gram) | 55.740
(10.295) | 48.315
(9.595) | 55.510
(10.195) | 52.265
(9.937)a |
| C ₂ (Bean) | 53.445
(10.117) | 50.405
(9.836) | 50.675
(10.318) | 47.560
(9.564)b |
| S.E. $\pm$ | 0.291 | 0.246 | 0.240 | 0.113 |
| C.D. at 5% | N.S. | N.S. | N.S. | 0.341 |

4.4.5.1. Magnesium content of cap.

From the data recorded in Table 14 it is seen that significant differences in magnesium content in cap of mushroom produced on different substrates were due to non-productive substrate of dried grass. The other two substrates viz. paddy straw and banana leaves were not significantly different from each other. There were no significant differences between the cultures and the interaction between substrates and cultures was not significant.

4.4.5.2. Magnesium content of stalk.

From the data recorded in Table 14 it can be seen that the significant differences among substrates for magnesium content in stalk were due to non-productive dried grass as substrate. Banana leaves and paddy straw substrates were at par. There were no significant differences between the cultures and the interactions also were not significant.

4.4.5.3. Magnesium content of cover.

It is evident that magnesium content in cover did not significantly differ between the productive substrates and there was no significant difference between the cultures. The interactions were also not significant.

4.4.5.4. Magnesium content of base.

The paddy straw produced significantly higher quantity of mg in mushroom button as compared to banana leaves (Table 14). Between cultures, red gram culture produced significantly higher mg content (52.265 mg) than bean culture (47.56 mg). The interaction was also significant as can be seen from Table 14a.

Table 14a. Magnesium content of base.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|----------------------------|--------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 51.11
(14.14) | 44.67
(13.42) | 47.890
(13.780) |
| S ₂ (Dried grass) | 00.00
(1.00) | 00.00
(1.00) | 0.00
(1.00) |
| S ₃ (Paddy straw) | 53.42
(14.66) | 50.45
(14.28) | 51.935
(14.460) |
| Mean | 52.155
(9.933) | 47.560
(9.560) | |
| S.E. $\pm$ | 0.113 | | |
| C.D. at 5% | 0.341 | | |

The combination of paddy straw with red gram gave maximum magnesium content (53.42 mg/100 g) as compared to 44.67 mg/100g on banana leaves with bean culture.

4.4.6. Iron content.

The iron content was determined on the dry weight basis as mg/100 g dry weight. The data are presented in Table 15 and represented ⁱⁿ Fig. 7.

Table 15. Iron content of different parts of paddy straw mushroom (V.diplasia) buttons in mg/100 g dry weight.

| Substrate | Button parts | | | |
|--------------------------------|--------------------|--------------------|--------------------|--------------------|
| | Cap | Stalk | Cover | Base |
| S ₁ (Banana leaves) | 17.020
(8.335)a | 13.475
(7.455)a | 14.058
(7.589)a | 15.864
(8.046)a |
| S ₂ (Dried grass) | 00.000
(1.00)b | 00.000
(1.000)b | 0.000
(1.00)b | 00.000
(1.000)c |
| S ₃ (Paddy straw) | 14.870
(7.810)a | 14.156
(7.642)a | 12.541
(7.184)a | 11.166
(6.797)b |
| Mean | 15.945
(5.715) | 13.815
(5.365) | 13.299
(5.257) | 13.515
(6.734) |
| S.E. $\pm$ | 00.187 | 00.134 | 00.145 | 00.216 |
| C.D. at 5% | 00.564 | 00.405 | 00.437 | 00.651 |
| <u>Culture</u> | | | | |
| C ₁ (Red gram) | 15.740
(5.680) | 14.090
(5.414) | 11.703
(4.971)b | 13.875
(5.370) |
| C ₂ (Bean) | 16.210
(5.765) | 13.535
(5.317) | 14.890
(5.543)a | 13.145
(5.191) |
| S.E. $\pm$ | 0.153 | 0.110 | 0.118 | 0.176 |
| C.D. at 5% | N.S. | N.S. | 0.356 | N.S. |

4.4.6.1. Iron content of cap.

From the data recorded in Table 15 it is seen that there were significant differences in iron content of cap produced on different substrates. But the differences were due to non-productive substrate and as such the banana leaves and paddy straw, the productive substrates, were at par. There were no significant differences between the cultures and interaction between substrates and cultures.

4.4.6.2. Iron content of stalk.

It is evident from Table 15 that there were significant differences in iron content of stalk produced on different substrates, but these differences were due to non-productive substrates and the productive substrates were at par. There were no significant differences between the cultures in respect of iron content in stalk and also the interactions were not significant.

4.4.6.3. Iron content of cover.

It is seen from Table 15 that the significant differences in producing iron in cover existed but they were due to un-productive dried grass as the substrate. However, there were significant differences between the cultures. Bean culture produced significantly more iron content in cover (14.89 mg) as compared to red gram culture (11.703 mg).

Also, there were significant differences in interaction as seen from Table 15a.

Table 15a. Iron content of cover.

| Substrates | Cultures | | Mean |
|--------------------------------|------------------------------|---------------------------|-------------------|
| | C ₁
(Red gram) | C ₂
(Beans) | |
| S ₁ (Banana leaves) | 12.83
(7.27) | 15.28
(7.90) | 14.055
(7.585) |
| S ₂ (Dried grass) | 00.00
(1.00) | 00.00
(1.00) | 00.00
(1.00) |
| S ₃ (Paddy straw) | 10.58
(6.64) | 14.50
(7.47) | 12.540
(7.055) |
| Mean | 11.765
(4.970) | 14.890
(5.456) | |
| S.E. $\pm$ | 0.204 | | |
| C.D. at 5% | 0.617 | | |

Banana leaves with bean culture produced more iron i.e. 15.28 mg/100 g as compared to 10.88 mg/100 g on paddy straw with red gram culture.

4.4.6.4. Iron content of base.

The data recorded in Table 15 reveal that there were significant differences among substrates in respect of iron content in base. The banana leaves produced more iron

content i.e. 15.864 mg/100 g as compared to 11.166 mg/100 g on paddy straw. However, there were no significant differences between the cultures. Also there were no significant differences in the interaction.

4.5. Nutrient content of whole mushroom button.

On the basis of the nutrient content of different parts of mushroom buttons, treatment-wise and replication-wise, the nutrient content of the mushroom button as a whole was computed substrate-wise and culturewise and the data are presented in Table 16.

Table 16. Content of protein and other elements in whole paddy-straw mushroom buttons as affected by different substrates and cultures.

| | Substrates | | | | Mean | On fresh wt. basis |
|--------------------------------------|---------------|-------|-------------|-------|-------|--------------------|
| | Banana leaves | | Paddy straw | | | |
| | Red gram | Beans | Red gram | Beans | | |
| Protein g/100g | 36.11 | 36.54 | 36.13 | 36.63 | 36.35 | 3.08 |
| P ₂ O ₅ g/100g | 1.16 | 0.81 | 1.18 | 1.03 | 1.04 | 0.088 |
| K ₂ O g/100g | 3.30 | 3.31 | 3.46 | 3.57 | 3.41 | 0.289 |
| Ca mg/100g | 61.70 | 61.30 | 63.73 | 64.71 | 62.86 | 5.331 |
| Mg mg/100 g | 50.48 | 50.78 | 55.44 | 52.77 | 52.37 | 4.441 |
| Fe mg/100 g | 14.97 | 15.27 | 12.74 | 13.62 | 14.15 | 1.200 |

It is evident from the data presented in Table 16 that there was no much variation in the protein content of mushrooms grown on different substrates with different cultures. Except for Fe content, the paddy straw with both cultures produced on an average, mushroom having more of P_2O_5 , K_2O , Ca and Mg. The substrate of banana leaves produced more Fe than the paddy straw with both the cultures. On an average the paddy straw mushrooms, Volvariella diplasia contained 36.35 g protein, 1.04 g P_2O_5 , 3.41 g K_2O , 62.86 mg Ca, 52.37 mg, Mg and 14.15 mg Fe per 100 g dry weight. When converted on fresh weight basis the corresponding values were 3.08, 0.088, 0.289, 5.331, 4.441 and 1.200 respectively.

4.6. The dry matter content of whole mushroom.

The dry matter content was computed on the basis of moisture content in various parts of the mushrooms at the time of drying for analytical work and the data along with the moisture content in various parts are given in Table 17. On an average the mushroom as a whole contained 91.52 per cent moisture and 8.48 per cent dry matter and there was no much difference in moisture content of various parts except that the cap seems to have slightly more dry matter content than the other parts.

Table 17. Average moisture and dry matter content of different parts of mushroom

| | Moisture
% | Dry matter
% |
|---------|---------------|-----------------|
| Cap | 90.97 | 9.03 |
| Stalk | 91.92 | 8.08 |
| Base | 91.50 | 8.50 |
| Cover | 91.70 | 8.30 |
| Average | 91.52 | 8.48 |

4.7. Nutrient content of substrates and cultures.

The substrates as well as the cultures were analysed for their N,P,K content before conducting the trial. The spent substrates were analysed treatment-wise after the crop was completely harvested, with a view to find out if the spent substrates were enriched in N,P,K content as a result of mushroom growth. The data on these aspects are presented in Table 18. It is evident from Table 18 that there was increase in N and P content of the banana and paddy straw after the crop was harvested, whereas, there was little reduction in K_2O content of the spent substrates.

Table 18. Nutrient content of pre-trial substrates and cultures and post-trial substrates.

| Nutrient elements | Pre-trial content of nutrient elements in sub-strates and cultures | | | | Post-trial content of nutrient elements in substrates | | | |
|--------------------------------------|--|-------------|----------|-------|---|----------------|----------------|----------------|
| | Banana leaves | Paddy straw | Red gram | Beans | Banana leaves | | Paddy straw | |
| | | | | | C ₁ | C ₂ | C ₁ | C ₂ |
| N g/100g | 0.546 | 0.420 | 2.60 | 2.55 | 1.04 | 0.95 | 1.01 | 1.05 |
| P ₂ O ₅ g/100g | 0.137 | 0.112 | 0.225 | 0.375 | 0.234 | 0.159 | 0.325 | 0.309 |
| K ₂ O g/100g | 2.20 | 4.00 | 0.750 | 0.680 | 1.70 | 1.85 | 3.87 | 3.40 |

On an average the spent paddy straw substrate was richer in N,P,K content as compared to banana leaves. Although the banana leaves were originally containing slightly higher quantity of N and P₂O₅, there was slightly lesser quantity in the spent material as compared to paddy straw. Both substrates were enriched in N and P₂O₅ content after the crop but both reduced the K₂O content.

4.8. Cost of production.

Cost of production has been worked out and is presented in Appendix III. It is observed that the mushroom production is more profitable on banana leaves (Rs 1820.00 net profit per 100 m²) than on paddy straw (Rs 1100.00 net profit per 100 m²).

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CHAPTER 5

DISCUSSION

Mushroom, the fruiting bodies of fleshy fungi are rich source of easily digestable proteins. They can be easily grown over farm waste and the yields per unit area are quite high. Generally the stalk and cap are consumed after discarding the base and cover from tropical mushrooms. In order to determine the best substrate and suitable culture for maximum production of paddy straw mushroom the trial was conducted with three substrates and two cultures.

In order again to see if all the parts including the base and cover could be used for consumption, all these parts were analysed separately for their nutrient content and the experimental findings, presented in earlier chapter are discussed here.

5.1. Substrate.

The dried grass could not sustain the mycelial growth of the paddy straw mushroom indicating that it could not host the Volariella diplasia fungus. It is just possible that it needs some other treatment so that the mycelial growth can take place and produce the fruiting bodies.

Between the other two substrates, paddy straw is the usual substrate, on which this tropical mushroom

species is grown. The yield per bed of $\frac{1}{2}$ m² area was on an average 1.308 kg (261.60 kg/100 m²) which is rather low as compared to 486.87 kg/100 m² obtained by Tu et al. (1971) on fresh sisal tow covered with rice straw. However, it (4.36 kg/100 kg straw) is almost equal to the yield (4.67 kg /100 kg straw) obtained by Yong and Graham (1973). But the yield of mushroom buttons on banana leaves was much higher both in number of buttons per bed and weight of total number of buttons (Tables 2 and 3). This higher yield on banana leaves was due to higher number of buttons per bed produced on banana leaves and slightly higher weight of individual buttons (Table, 4) which were slightly lengthier (Table 6) than those on paddy straw. There are no references available about the successful use of banana leaves for the production of paddy straw mushroom. The banana leaves as substrate has thus come up as a new substrate for higher production of mushroom, with other successful substrates like oil palm pericarp waste (Goh and Graham, 1975), fresh oil palm paricarp (Yong and Graham, 1973) and sisal tow (Tu et al., 1971). The banana leaves produced the crop earlier by about 3-4 days than paddy straw and the harvesting period was also lengthened, by about 5 days (Table 1).

5.2. Cultures.

As regards the cultures, both red gram and beans were equally good for the production of mushroom buttons, although the red gram produced slightly higher quantity by weight per bed. Asthana (1947), Rangaswami (1956) and Krishnamurty et al. (1968) have recommended the use of either pigeon pea or chick pea powder for good yield of mushrooms. Zakia and Shrivastava (1962) also observed that red gram powder as organic source of nitrogen gave higher yield as compared to oat meal and Bengal gram. But according to them the use of ammonium salt and urea as inorganic source of nitrogen had an adverse effect on yield. On the contrary Yong and Graham (1974) got abundant growth of V.volvacea mushroom by adding one gram of urea and 10 gram of rice bran to 200 gram of oil palm paricarp waste. Under the circumstances, the successful use of bean as culture is a welcome addition to the list of cultures.

The observation that the bean powder gave equally good yield proves that any organic source of nitrogen as culture is useful for the production of buttons.

5.3. Nutritive value of mushroom.

5.3.1. Protein content.

The mushroom cap contained the maximum quantity of proteins as compared to other parts. Stalk, cover and base^{contained}

almost equal quantity of proteins in them in both substrates and cultures indicating that even the cover and base which are generally thrown out are as rich in protein content as stalk and cap thus be used for consumption. On an average the mushroom buttons as a whole contained 3.08 per cent of protein on fresh weight basis and 36.35 per cent on dry weight basis, which is slightly less than that of 45.3 for V. volvacea as reported by Milagros et al. (1967) and 3.9 per cent on fresh weight basis for V. diplasia and fairly compares with those reported by Zakia et al. (1971) and Angle and Tamhane (1974). However, no reported data for protein content of different parts are available. The higher protein content of cap (pileus) and lower in stalk (Volva) as observed in the present investigation tallie with the findings of Shu and Kit(1973). It seems that the percentage protein reported by different workers was estimated for the cap and the stalk which are generally the edible parts and this accounts for the lower protein content observed in the present investigation because it includes the protein content of base and cover which was much lower than that of the cap.

5.3.2. Phosphorus content.

Except for stalk all the three other parts contained more phosphorus on paddy straw than on banana leaves.

The cover contained the maximum P_2O_5 while the base contained the minimum. Between the cultures red gram gave higher phosphorus content except for cover. The phosphorus content observed in the present investigation calculated on fresh weight basis (0.088 per cent) is slightly lesser than 0.1 per cent as reported by Zakia et al. (1971). This may be because it is the average of all the four parts as against the cap and stalk, which have been analysed by other authors. There was maximum content of phosphorus in stalk portion in the button grown on banana leaves with red gram as culture, whereas, phosphorus content of cover was maximum with paddy straw with bean culture. In the base of buttons grown on the paddy straw with red gram culture, it was much higher than on banana leaves. This shows that there is no consistency for the increase of phosphorus content in different parts with a particular combination of substrate and culture and as such no valid conclusions can be drawn.

5.3.3. Potash content.

The potash content was quite high and almost equal in all the parts except the base. Paddy straw on an average had significantly more potash content in all the parts of the buttons. The buttons grown on paddy straw contained more potash than those grown on banana leaves. This accounts for reduction in potash content in both in banana leaves and paddy straw (Table 18). The potash



content observed in present investigation (0.289 per cent) on fresh weight basis (Table 16) is almost equal to the 0.32 per cent reported by Zakia et al. (1971). It is slightly low because potash content of the base was lesser than that of other parts of button. Between the cultures there was no much variation for different parts except the stalk, which had more potash on bean culture than on red gram.

5.3.4. Calcium, magnesium and iron content.

The calcium content in cap and stalk was the same in banana leaves and paddy straw substrates, whereas, it was significantly higher in paddy straw than on banana leaves in the other two components of the button. The value of Ca content tallies with that observed by Zakia et al. (1971) for the same species.

As regards magnesium the mushroom buttons contained as much as 52.32 mg/100 g on dry weight basis which is pretty high. No reported literature is available on the magnesium content of paddy straw mushroom.

As regards iron content, paddy straw mushrooms grown on banana leaves as substrate produced more iron in all the parts except stalk as compared to paddy straw.

As regards the cultures, bean culture produced significantly more iron in cover than the red gram. The banana leaves with bean culture gave the maximum iron content in cover. The iron content as reported by Zakia et al. (1971) is little higher than that obtained in the present investigation. This is possible because of inclusion^{of} cover and base portion of button for analytical purposes.

From the above findings regarding the nutrient content of different parts of the mushroom buttons it is quite evident that all the parts including the base and cover are equally nutritious and can thus be used for consumption. Further efforts should be made to explore the possibility of using these parts for edible purposes.

5.3.5. Nutrient content of whole mushroom buttons.

On the whole the paddy straw mushroom contained almost the same quantity of nitrogen when grown on either banana leaves or paddy straw in combination with either red gram or bean, indicating that banana leaves can effectively be used for the maximum production of mushroom with either red gram or bean as culture.

5.3.6. Nutrient content of substrates.

It was observed that both the banana leaves and paddy straw were enriched in nitrogen and phosphorus content

indicating that the spent straw can be effectively used as a good compost. Although the potash content was reduced in the spent straw, it is high enough to be considered as a rich manure. The figure of 2.5 per cent nitrogen content of compost as reported by Mantel (1969) is higher than the observed value in the present investigation. It may be because Mantel might have prepared complete compost before analysing it for nitrogen content.

It can, thus, be concluded that growing of paddy straw mushrooms during summer season with banana leaves can be an economically good proposition as the net profit, even at a moderate rate of Rs 6/- per kg, comes to Rs 1820/- for a short period of about one month during agriculturally idle period of summer season, as can be seen from Appendix III.

CHAPTER 6

SUMMARY

CHAPTER 6

SUMMARY

An experiment entitled " Effect of different substrates and cultures on growth, yield and quality of paddy straw mushroom V. diplasia Berk and Br. was conducted during summer season of 1977 in the Department of Horticulture, Marathwada Agricultural University, Parbhani.

The object was to find out a suitable substrate and culture for high production and quality of paddy straw mushroom under Marathwada conditions. Different combinations of three substrates viz. banana leaves, dried grass and paddy straw and two cultures viz. red gram and bean were used.

The salient features of the experimental findings are summarised below.

- 1) The substrate banana leaves produced the mushroom buttons three to four days earlier than paddy straw and harvesting period also was longer by about five days on banana leaves.
- 2) The dried grass as a substrate was found to be unsuitable for the mycelial growth and production of paddy straw mushrooms.
- 3) Banana leaves with bean culture gave both the higher number of buttons (58.50) and button weight(2.025 kg)

per bed of half square meter area (1170 and 405 kg per 100 m² respectively).

4. Both the cultures, red gram and beans, were found to be equally good for the production of mushroom buttons indicating that red gram can be substituted with a cheaper culture like bean without affecting the yield and the quality.
5. The mushroom cap contained the maximum quantity of protein than other parts while stalk, cover and base contained almost equal quantity of protein in both the substrates and cultures.
6. Cover contained higher quantity of phosphorus than the other parts on paddy straw than on banana leaves while the base contained minimum phosphorus.
7. The buttons grown on paddy straw contained more potash than those grown on banana leaves.
8. The calcium content in cap and stalk was higher in paddy straw than banana leaves.
9. Iron content was more in banana leaves as a substrate than paddy straw.
10. The nitrogen and phosphorus content of both the substrates after the crop increased considerably while

the potash content was reduced to a little extent.
Thus the nutrient enriched substrates can be used
as a rich source of organic manure.

11. The cap portion of the button contained the maximum dry matter (9.03 per cent) while the stalk contained the least dry matter (8.08 per cent).

It can thus be concluded that the paddy straw mushroom Volvariella diplasia Berk and Br. can successfully be grown on banana leaves with bean as a culture without much imparing the quality thus replacing the conventional substrate paddy straw with red gram as culture.

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* Originals not seen.

APPENDIX

APPENDIX I

Meteorological observations during the cropping
period from April to July, 1977

| Months | Meteoro-
logical
week | Temperature | | Relative Humidity % | |
|--------|-----------------------------|-------------|-------|---------------------|-------|
| | | Max. | Min. | A.M. | P.M. |
| April | 16-4-77 to
22-4-77 | 36.03 | 23.30 | 40.3 | 17.70 |
| | 23-4-77 to
29-4-77 | 38.70 | 25.10 | 39.80 | 18.00 |
| May | 30-4-77 to
6-5-77 | 41.50 | 24.70 | 33.02 | 16.00 |
| | 7-5-77 to
13-5-77 | 39.60 | 26.13 | 41.00 | 15.00 |
| | 14-5-77 to
20-5-77 | 41.03 | 26.30 | 53.00 | 13.04 |
| | 21-5-77 to
27-5-77 | 39.01 | 26.90 | 48.40 | 25.40 |
| June | 28-5-77 to
3-6-77 | 39.30 | 26.06 | 59.04 | 21.50 |
| | 4-6-77 to
10-6-77 | 40.80 | 26.90 | 60.30 | 20.10 |
| | 11-6-77 to
17-6-77 | 36.08 | 24.90 | 70.00 | 35.00 |
| | 18-6-77 to
24-6-77 | 34.70 | 23.00 | 87.80 | 49.30 |
| July | 25-6-77 to
1-7-77 | 26.34 | 23.75 | 81.00 | 52.08 |
| | 2-7-77 to
8-7-77 | 32.33 | 23.63 | 76.70 | 40.30 |
| | 9-7-77 to
15-7-77 | 33.23 | 23.90 | 80.80 | 48.10 |
| | | | | | |

APPENDIX II

Bed temperature at a depth of 10 cm in the centre of bed

| Date | Banana leaves | | Dried grass | | Paddy straw | |
|---------|------------------------------|--------------------------|------------------------------|--------------------------|------------------------------|--------------------------|
| | C ₁
(Red gram) | C ₂
(Bean) | C ₁
(Red gram) | C ₂
(Bean) | C ₁
(Red gram) | C ₂
(Bean) |
| June 17 | 36.5 | 36.7 | 36.0 | 36.00 | 37.00 | 37.5 |
| 18 | 36.5 | 36.5 | 36.5 | 35.5 | 37.00 | 37.2 |
| 19 | 36.2 | 36.5 | 36.5 | 36.00 | 36.5 | 37.0 |
| 20 | 36.5 | 36.5 | 36.5 | 36.2 | 36.0 | 37.5 |
| 21 | 36.0 | 36.5 | 35.7 | 35.7 | 36.5 | 37.0 |
| 22 | 36.0 | 36.0 | 35.0 | 36.0 | 36.2 | 37.5 |
| 23 | 36.0 | 36.0 | 34.5 | 36.0 | 36.2 | 36.5 |
| 24 | 36.0 | 35.5 | 33.5 | 35.7 | 36.2 | 36.5 |
| 25 | 35.0 | 36.0 | 32.5 | 35.5 | 36.0 | 36.0 |
| 26 | 35.0 | 35.0 | 32.5 | 35.5 | 36.2 | 36.5 |
| 27 | 35 | 35.5 | 32.5 | 35.5 | 35.5 | 36.0 |
| 28 | 35.0 | 35.5 | 32.5 | 35.0 | 35.2 | 35.0 |
| 29 | 35.0 | 35.5 | 32.0 | 32.0 | 35.0 | 35.0 |
| 30 | 32.5 | 33.5 | 32.0 | 31.5 | 32.5 | 33.0 |
| July 1 | 31.7 | 33.0 | 31.5 | 31.5 | 32.5 | 33.0 |
| 2 | 31.0 | 33.0 | 31.0 | 31.5 | 31.5 | 31.5 |
| 3 | 30.5 | 31.5 | 31.2 | 30.5 | 31.5 | 31.0 |
| 4 | 30.5 | 30.7 | 31.0 | 30.5 | 30.5 | 31.0 |
| 5 | 30.5 | 30.0 | 30.5 | 30.5 | 30.0 | 35.0 |
| 6 | 30.0 | 30.0 | 30.5 | 30.5 | 30.0 | 30.0 |
| 7 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 | 30.0 |

APPENDIX III

Cost of production of paddy straw mushrooms on different substrates

| I t e m
(1) | Amount in Rs/100 m ² | | Remarks
(4) |
|---|---------------------------------|----------------------|---|
| | Paddy straw
(2) | Banana leaves
(3) | |
| 1) Cost of substrate
(six tonnes each) | 180.00 | 60.00 | Cost of substrate Rs 30.00/
tonne for paddy straw and Rs
10/ for banana leaves. |
| 2) Cost of tying bundles
immersing in water and
preparation of beds | 60.00 | 60.00 | 15 women for one day
at Rs 4.00 /day |
| 3) Cost of spawn (1 per
packet for 3 beds) | 250.00 | 250.00 | Total 70 packets of spawn
required at Rs 35.50 per
10 packets including
postage |
| 4) Cost of culture at
100 g/bed | 50.00 | 50.00 | Total 20kg/100 m ² at
Rs 2.50 /kg |
| 5) Cost of polythene
(3 m x 2 m, 150 gauge
film per bed) | 200.00 | 200.00 | Cost calculated at Rs 10/-
per piece of 3x2 m ² which
can be used for at least
10 times (Cost calculated
for one use). |
| 6) Cost of watering
every day for the first
15 days | 60.00 | 60.00 | Watering twice a day (one
labour per day) |

contd..

APPENDIX III contd..

| (1) | (2) | (3) | (4) |
|--|--|--|--|
| (8) Cost of watering and harvesting for 20 days after the first 15 days | 80.00 | 80.00 | Watering once a day and harvesting twice a day (one labour per day) |
| I. Total cost of production | -----
880.00
----- | -----
760.00
----- | |
| (8) Gross income | | | |
| (i) Cost of mushroom buttons produced at the rate of 105 kg/bed on paddy straw (300 kg /100 m ²) and 2kg/bed on banana leaves (400 kg/ 100 m ²) at Rs 6/per kg | 1800.00 | 2400.00 | Modest rate of Rs 6/kg taken because of inclusion of the weight of base and cover in the weight of buttons |
| (ii) Cost of compost at Rs 3/ tonne for 6 tonnes
(I + II) | Rs 180=00

1980=00
----- | Rs 180=00

2580=00
----- | |
| II. Gross income | | | |
| Less cost of production (I) | Rs 880=00
----- | Rs 760=00
----- | |
| (9) Net income (II-I) per 100m ² (200 beds) | Rs 1100=00
----- | Rs 1820=00
----- | |