The Mushroom Journal

MAY 1989
Number 197
ISSN 0144-0551

CONTENTS

Official Journal of the Mushroom Growers' Association

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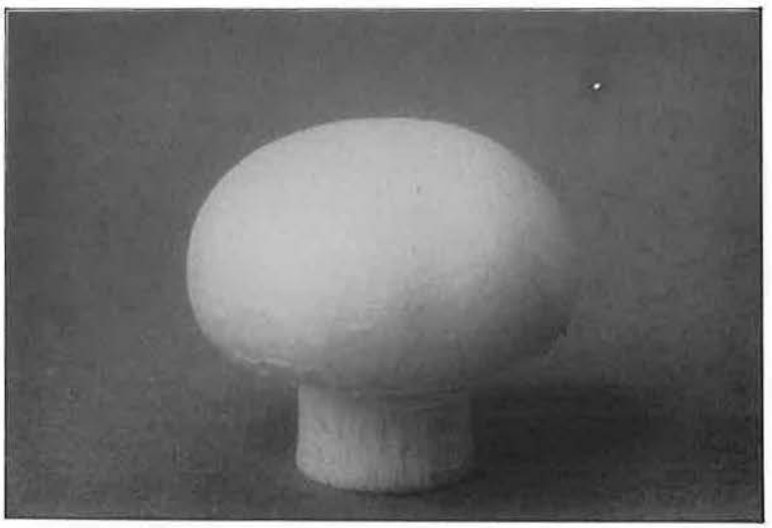

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Ken James

An Industry of infinite variety and continuous development

In the past month I have visited growers who are involved in exciting developments - from dramatically increased yields using a new technique within traditional growing methods, - to marketing, some with pharmaceutical potential.

On a visit to Scotland for an area meeting, many Scottish growers were made aware of the resources and expertise at the West of Scotland College, Auchincruive, which will make a contribution to the industry's R & D and training needs. At the area meeting, members were told of the agreement for the MGA to link with the NFU of Scotland, which has offered Scottish members similar services to those enjoyed by members in England and Wales for many years.

Whilst in Scotland I took the opportunity to visit the Glasgow wholesale market to see something of the wide variety of quality and presentation, coming from local - but also N and S Irish producers. Ostensibly first quality mushrooms with price tags as wide as £1.50 to £2.60 x 3lb. It was suggested to me that it would pay more mushroom growers 'to come out of the dark' and see their crops at the market and in comparison with others available - in the wholesale market and in many other direct outlets.

These visits prompt the comment that in my short span so far as Director of the MGA, the most significant factors which predominate the UK industry are:

- The apparently infinite number of different quality and presentation standards adopted by growers.

- The numerous development projects being carried out. Many are exciting in concept, some could have fundamental effects on the industry.

Some of these differences and developments can be assumed to gain commercial advantages for individuals or companies. As an Industry Association, the MGA will often be aware of, but respect the independence of its members commercial activities.

It must also be aware of and pose questions, when through collaboration - imposed or voluntary - competing countries use the technical and commercial benefits of shared resources, to offer a better, or more consistent supply to UK customers. The threat to sales volume and profitability, in direct and wholesale outlets, is one which has already been made apparent, in the past from Dutch imports - in the present from fresh mushrooms out of Ireland and processed from mainland Europe.

Several of the largest growers have the resources to combat this competition. Many smaller growers do - and increasingly can - gain similar advantages in their local and regional outlets. Some, but not many, have picked up the opportunity to develop more profitable outlets, through participation at the International Fresh Produce Fair at Birmingham. More could have done, if their availability and information had been extended by collaboration. The resolution on collaboration from Peter Munns, accepted at the AGM, could give wider opportunities for growers in all size categories to pick up sales in the higher net price brackets. Information will

The Mushroom Journal
MAY 1989
No. 197

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Articles submitted for inclusion in the Journal *are always welcome. Whilst the Editor cannot undertake to publish all the copy received, submissions will be acknowledged. Originals, wherever possible, will be returned to the contributor, who will also be notified as to if and when the article will appear.*

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come out to growers, with the opportunity for follow up discussions in any area where interest is expressed.

MGA month of activity

The past month has been one of more serious discussions with MAFF and the Horticultural Development Council, following Harold Linfield's report on 'the years of discussion and inaction', at the AGM. The R & D committee met in the last week in April to make a start on identifying the research needed and preparing a 'prospectus' for a poll of growers in the Autumn, to decide if growers will meet the cost alongside Government fundamental research support.

The Education and Training committee has reached the second stage of their programme to design a training and qualifications scheme within the industry. The video on the National Council for Vocational Qualifications is being shown at area meetings, so that members have some background to the scheme. The Committee's April meeting was held at the West Sussex College, Brinsbury, which has the facilities to provide day release and block mushroom training, in conjunction with training groups from any part of the country.

By the time that members receive this issue of the Journal, one of the busiest periods in a very full PR programme will have passed. Stands at the Hyde Park and Fresh Produce Fair Exhibitions within a week, early in May, will need much stamina, as well as PR skills. The launch of the new logo at Birmingham, will simply signal the start of a follow up campaign aimed at increasing regional and catering sales.

At the Marketing and Promotion committee in April, the PR report included reference to yet another editorial coup by Victoria Lloyd Davies - some £35,000 of advertising value, a four page feature in Womens Realm, for the £20 cost of mushrooms and telephone calls - plus Victoria's contacts and skills.

This and many other magazine features, highlight the value of our PR in extending the range of members sales.

Issues of 1989

When discussing R & D at the AGM, it was suggested from the floor that consideration should be given to the start of a European growers' R & D link with Holland. David Bird in his April Journal letter, included all of Europe in such a proposal. S Ireland already contributes to the promotional activities of the MGA. Would similar joint action be valuable to Mushroom Growers in Europe?

Do members have views on the value of cross border links - which could be for R & D, promotion and maybe other technical and marketing activities? Responses from the other side of both channels, as well as MGA grower members will be welcome.

Peter Baker - MGA Chairman

For those of you that I have not yet had a chance to meet and for others that I do not know that well, I felt it would be worthwhile taking a few lines of this month's Journal to tell you a little of my background.

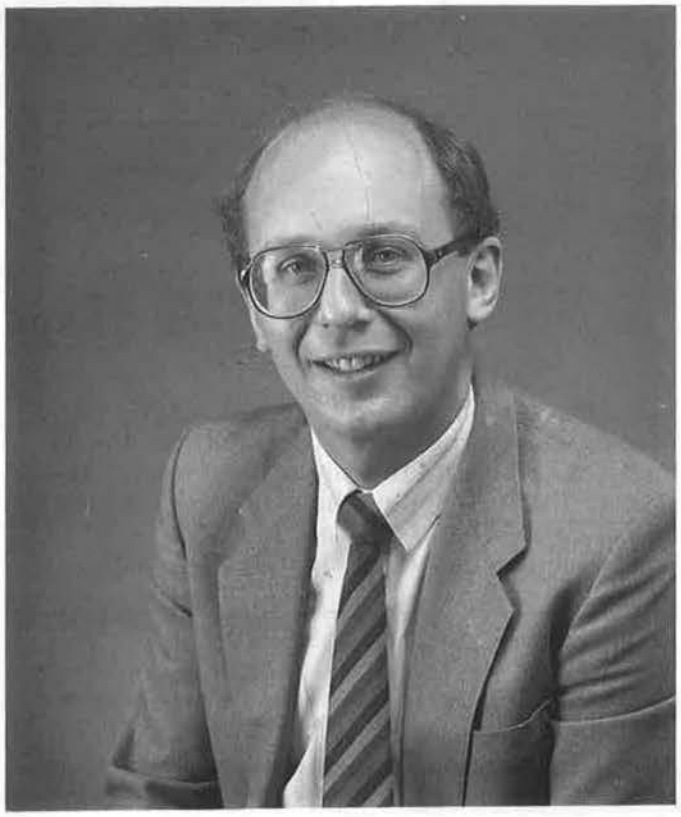
I am 36 years old (but look older!), married to Lydia who is 21 again this year, we have two children, the eldest a girl Gemma is 7 years old and the youngest is 5 years old and is definitely a boy. We live just outside Pulborough in West Sussex in a place called West Chiltington, close to where the mushroom farm is located.

I am Managing Director of Chesswood Produce Ltd, which is an amalgamation of the old A G Linfield Ltd and Shepherds Grove Mushrooms Ltd. As a group we grow 30 million pounds per annum of mushrooms for the fresh market, with the only diversion from this an 8000 pig herd in Sussex whose presence is beneficial for the compost!

I have worked with mushrooms at Sussex for five-and-a-half years and joined the company via Ranks Hovis McDougall Plc., Chesswood's parent company. I was first employed by RHM as a 21 year old Graduate Production Trainee in their Flour Milling Division, and after training held a number of Production and Distribution Management roles culminating in being appointed in 1982 as General Manager of Birkenhead Flour Mill. Throughout this time I lived in a variety of different locations from as far apart as Southampton to Edinburgh in Scotland, so I have a working knowledge of most accents!

I enjoy working with mushrooms and find their constant challenge intellectually stimulating but somewhat - on occasions - frustrating. I look forward to the coming year, one in which the MGA has a number of different challenges to overcome and problems to solve, not least of all future Research and Development funding, N.C.V.Q., Marketing ..... need I go on!

Please do not hesitate to contact myself or any member of the MGA Staff or Executive if you require help or advice, - that is what the Association is there for. In the meantime I look forward to seeing you at the many events planned in the coming year and in particular at our Conference in York.



Peter Baker

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Area Meetings in April

It has been a very full and successful month for area meetings. The support and interest has been very encouraging, and this helps to make the meetings very worthwhile and stimulating.

At all the meetings, Ken James, MGA Director, gave an update on the current issues facing growers and action being taken, and Lucy Unwin, MGA Public Relations Officer, said a few words about the PR activities in the months ahead.

South-East 1 Region

The meetings started in the South-East 1 region held in Reigate. Cathal MacCanna, the Managing Director, of Carbury Mushrooms, Co. Kildare, Eire, gave a most interesting talk on CACing Training for the Uninitiated. He is the pioneer of spawn casing and illustrated, very convincingly, the advantages and few disadvantages of spawned casing. Spawned casing produces even colonisation, surface pinning, reduced clumping, earlier cropping and easier management control. The casing does not carry a severe disease risk, however green mould, *Trichoderma*, attacks have been a problem in the past.

It is important to use the same mushrooms strain in both the casing and compost to obtain the full benefits. Spawned casing does produce earlier cropping, but there is no extra yield. Spawned casing method of growing mushrooms is used extensively in the Irish production.

The talk created a great deal of interest and discussion about the methods of growing in Ireland and the market place there.

East and West Midlands Region

The meeting was held in Tamworth, Staffordshire, where Aoife O'Brien, Darmycel UK Ltd, gave a very interesting talk on the Phase II method of growing mushrooms on blocks and bags. She concentrated on the bag-growing system which was of particular interest to the growers in this region; the majority of the mushroom farms are on the Phase II system.

This meeting was very well attended and hope that it will remain so. The NCVQ (National Council for Vocational Qualifications) video was shown and created interest and comments.

Scottish Region

The Scottish meeting was held at the Scottish Agricultural College at Auchincruive, Ayrshire. It was a very successful meeting, mainly due to the hard work and organisation of the Horticulture Department and the mushroom unit headed by Professor Geoffrey Dixon and Ian Maxwell, respectively.

The meeting was a mini Conference held at Oswald Hall in the grounds of the College. In the foyer there were trade and information stands about the mushroom unit for growers to observe. The programme of speakers was very comprehensive and informative.

Jim Dumbreck, the Area Chairman, introduced all the speakers and thanked the College for allowing the Association to hold the meeting there. Professor Dixon welcomed everyone to Auchincruive and explained how the department operates. The Scottish Agricultural Services work in three sections however they operate solely as a unit. The sections are Educational, Advisory, and Research and Development. There are facilities and resources at Auchincruive to assist specialised areas of agriculture and horticulture.

Dr Robin Szmidt followed this with a comprehensive summary of the mushroom R & D during the 20 years it has been at Auchincruive. He stressed that there is a core of specialised scientists working in the department and the approach to mushroom R & D is multi-disciplinary.

The analytical services at Auchincruive were explained by Dr Jim Dixon, he pointed out that a great deal of work is being done on raw materials in composts and casing.

Ian Maxwell, the Mushroom Specialist in Scotland, spoke about the education and training offered at the mushroom unit. He started his talk with a very amusing story about the use of camel manure for Phase II compost! He then said a few words on the history of the mushroom unit. Mushroom tunnels were built 15 years ago, and head-filling machinery was supplied by Monomech at that time. *Agaricus* and *Pleurotus* production was studied and developed by the students. In addition, all aspects of the mushroom industry are researched from production factors, to packaging requirements, and market research. Ian stressed it is a very active mushroom unit in the horticulture development.

All the growers were taken on a guided tour of the unit, even though it had been raining all day and was still raining!

Everyone was delighted to welcome the MGA Chairman, Peter Baker, to the meeting. He stressed how important the area meetings were to make the Association stronger, with local growers and MGA staff. The NCVQ video was shown.

After the meeting, the majority of growers stayed for a 3 course meal at Oswald Hall. It was an ideal end to a most successful meeting.

Northern Area Meeting

The Northern Area Meeting attracted a well attended gathering with Cathal McCanna repeating his talk to the growers on his discoveries and research with

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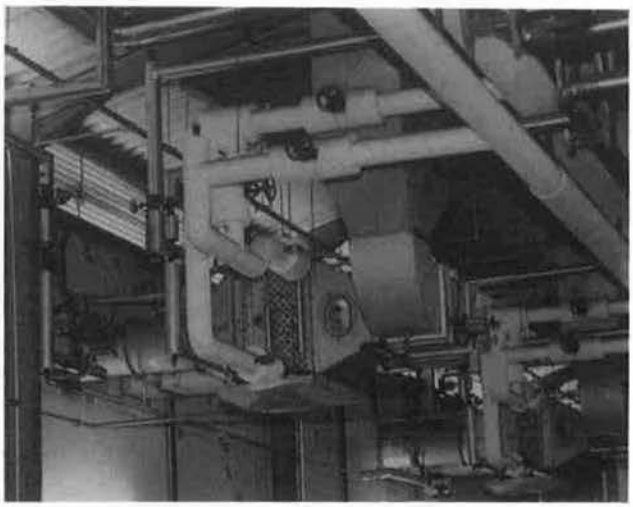

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INVEST IN THE BEST ~ BUY BRITISH

CONFERENCE IN YORK
27 - 29 SEPTEMBER 1989

by Sharon Brook

The history of York, capital of the north and second city of the realm, is the history of England. It is one of the world's most fascinating cities. York is a walled city which houses a vast array of medieval and Georgian architecture together with the beautiful (pictured below) Minster Cathedral.

The conference programme is very near to being finalised. The general outline to date is as follows:

WEDNESDAY 27/09/89

Golf, Clay Pigeon Shoot,
Registration.

THURSDAY 28/09/89

0900 Chairman's Introduction
0915 Changing Patterns in Supply & Demand - Ben Wragg
1000 Improved Efficiency through Staff Development - Tony Davey
1045 Coffee Break
1100 Mushroom Enzymes - Past, Present & Future - David Wood
1145 Sinden Award Lecture
1230 Lunch/Trade Exhibition
1700 Finish

FRIDAY 29/09/89

0915 How we overcame a Virus Problem..... Jeff Green/ Aoife O'Brien
1000 Filter Selection & Applications - David Stephens
1045 Coffee Break
1100 The latest developments in Environmental Control - Geoff Robins
1145 A Confrontation with High Technology??? - Ron Jones
1230 Lunch/Trade Exhibition
1600 Finish

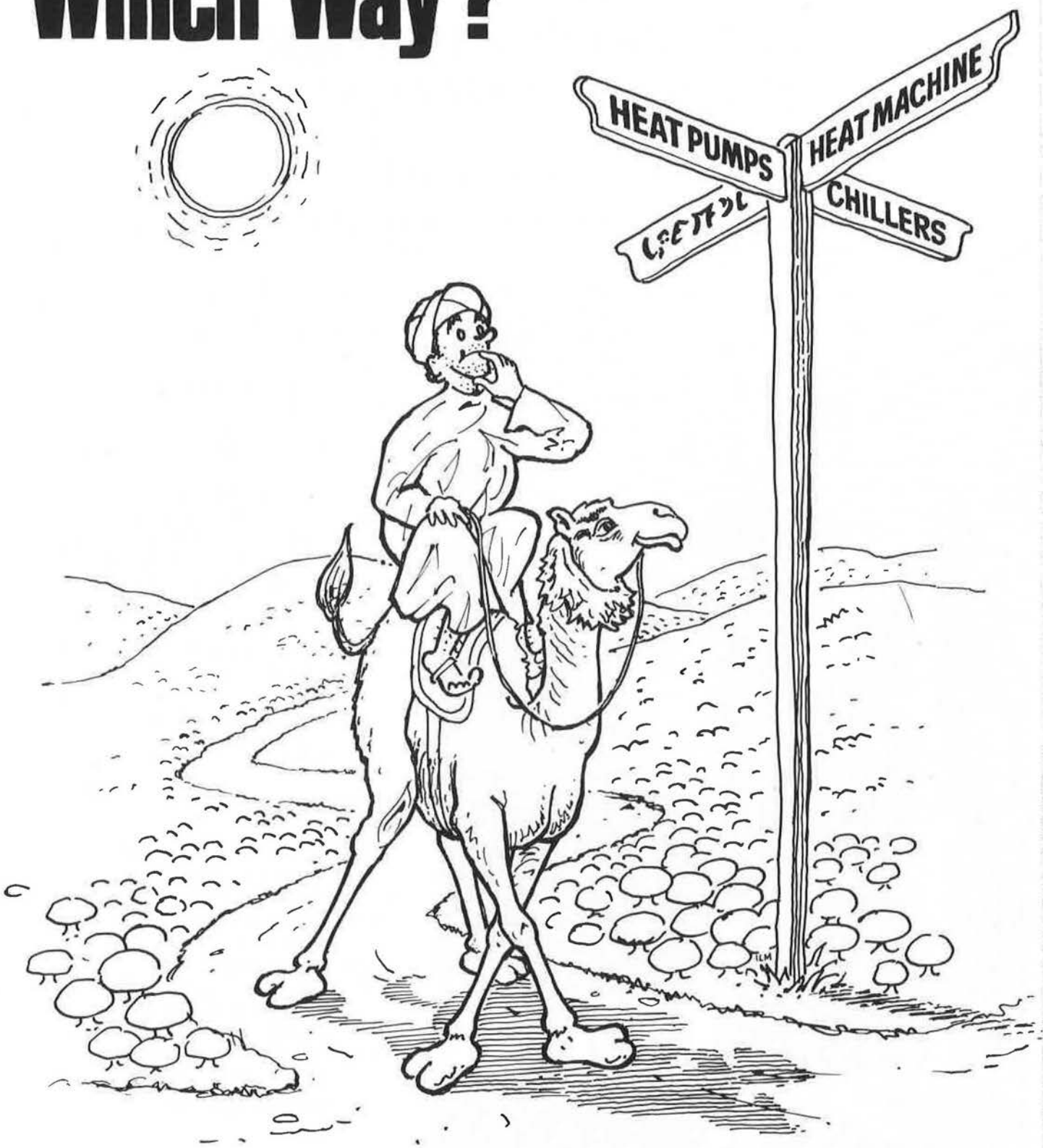
SATURDAY 30/09/89

Farm Walk - Middlebrook Mushrooms
Minskip Mushrooms

Details of sporting and social activities will appear in further issues of the Journal.

You will find enclosed in this issue of the Journal the booking form for the Viking Hotel. I strongly advise that you fill this in and send as soon as possible directly to the hotel. Please do not hesitate to contact me on 01-235 5077 ext: 363 if you need further information.

Which Way?



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Further observations on *Trichoderma*

by **D.A. Seaby**, Department of Agriculture Northern Ireland, Belfast.

Introduction

Beginning in the spring of 1985 increasingly frequent attacks of green mould caused by *Trichoderma harzianum* were first noted in Northern Ireland. These mainly affected satellite bag growers, a system whereby a central compost maker supplies 100 or more growers. The disease spread throughout Ireland in 1986 and has been troublesome since then. Novel stringent hygiene precautions have reduced the incidence of infection among those originally affected to a low level. The disease is now found in several areas in England and Scotland and has affected block, shelf and tray growers with initial reductions in yield of 30% or more. The outbreak among bag growers was described in detail (Seaby, 1987; Staunton 1987). Since then four lectures to mushroom growers in England plus the experience of advising in cases of severe attack on tray and shelf farms and continuing investigations with bag growers in Ireland have provided further information.

The *Trichoderma* life cycle

The vast majority of outbreaks have been caused by what appears to be a unique, possibly mutant strain of *Trichoderma harzianum* designated Th2. This fungus is particularly well adapted to colonising spawned mushroom compost and grows alongside the mushroom mycelium. Because *Trichoderma* also has white mycelium the spawn run usually appears normal till after casing, when large green spore masses are produced. Sporing often coincides with increased illumination of the house.

Individually the green spores are microscopic. They can infect the mushroom compost most easily just after spawning. They are transmitted to freshly peak heated compost by the wind, attached to spent compost dust particles, by mites which have fed on *Trichoderma* mycelium in infected compost, on the hands and clothing of mushroom workers and especially on tray farms, by the machinery. The spores, and the mites which carry them, are both produced in very large quantities and consequently can get almost anywhere on a farm. This has meant that a wide variety of different infection routes are possible and almost anything or anybody which has direct or even indirect contact with spawn-run compost or mushrooms and then freshly spawned compost is a potential carrier. A list of known carriers was outlined previously (Seaby, 1987). This paper enlarges the list and highlights some dangers on tray and shelf farms by giving case-history examples.

Trichoderma strain characteristics

It is important to be able to identify the strain of *Trichoderma* which has caused a disease outbreak because the strain often indicates the source of infection. When Th2 is found, experience on more than 10 large farms indicates that particularly stringent long-term hygiene precautions are required in order to contain it.

Many green-spored *Trichoderma* species are very similar in appearance and some confusion exists in the literature concerning their identification. The latter is made difficult because it is recognised that most species-descriptions in fact, cover groups of species with very similar imperfect or asexual *Trichoderma* states, but which are known to be different species because they have dissimilar perfect or sexual ascomycete states. Unfortunately, it is difficult, as an aid to positive identification, to make the imperfect state produce the perfect state. Individual species usually comprise a variety of strains which can have differences between them almost as large as those found between species. The method of culturing isolations affects the appearance of the colony and even the proportions of different types of sporing structures. It is thus important to follow a precisely similar method of culture for each new isolate. The method outlined below showed up consistent differences between species/strains and Th2 was characterised clearly. Isolations were made on antibiotic 2% malt agar (C.M.I.). For identification a needle stab of spores was made 1 cm from the edge of the Petri dish. Dishes should not be taped up as this reduces aeration. They were incubated at 27°C in the dark in an incubator free of bacterial cultures (these sometimes produced gases such as ammonia which affected the growth rate). After 2 days the cultures were briefly illuminated in artificial light for no more than 10 min and a scratch was made on the back of each dish to indicate the position of the edge of the colony and notes made as to whether it was smooth or wavy in outline. Sporing colonies were also noted. After 24 h this examination and marking was repeated. After a further 24 h another examination was made and the presence and morphology of sporulation was noted. The growth rate was also calculated. Using this method, 9 distinct groups of *Trichoderma* species and strains have been found on mushroom farms. Isolates grouped by this method had similar spore-bearing structures as described by Rafai (1969).

The main types found were as follows:-

1. *Trichoderma viride*, was common in the lagoon water used for wetting the raw materials and very common on casing, particularly after the third flush. However, it was found causing green mould in batches of compost on only 4 occasions in 3 years. It was usually associated with

patches of infected spawn and, in one case, contamination of bags appeared to have been from an infected bag of spawn.

In culture it was slow to spore and grew very slowly at 27°C (0.3-0.5 mm/h), but faster at 20°C. It formed cushions of sporulation after removal from the incubator and spore-masses in Petri dishes were typically jade (blue green) for several days and smelled of coconut. Spores were relatively large, round or oval and rough walled, unlike all other *Trichodermas* which have smooth walled spores.

2. *Trichoderma harzianum* (Th1) was very common in the lagoon water. However, it has not been found to cause damage in compost. It grew rapidly in culture at 27°C (c 1.0 mm/h) and spored within 2 days producing much aerial mycelium. It had two bands of heavier sporulation corresponding to the two periods when the incubator was opened, elsewhere on the aerial mycelium an even dusting of sporulation occurred. Spore masses rapidly turned dark green (spinach) and spores were small and almost spherical.

3. *Trichoderma harzianum* (Th2) spores were uncommon on the compost raw materials but very common in and around infected mushroom houses, stores, mushroom packing sheds, on clothing, and on trailers, especially their load covers. In culture it grew rapidly 0.9-1.1 mm/h at 27°C, produced a fluffy layer of white aerial mycelium around a central bare disc free from aerial mycelium and normally cultures did not spore for at least 4 days, this made them show up very clearly among other groups of isolates. Sporulation was mainly as cushions of spores in the central area with some light sporulation on the aerial mycelium at the edge of the dish. Sporulation often remained white for a day or more and turned spinach green via blue green (jade). Spores were slightly larger and more oval than those of Th1.

4. *Trichoderma harzianum* (Th3) was common on the compost raw materials and in the lagoon water. It caused severe attacks in spawned compost which became contaminated from the raw-compost yard. For example, when peak heating nets broke and compost was removed partially by hand, heavy infection by Th3 usually followed. In another case, a series of heavy infections occurred after peak heated trays of compost were habitually stacked near the compost yard for several hours prior to filling a house. However, trays, which had been covered with new plastic sheet, remained uninfected.

Where compost bagging areas were in close proximity to the compost yard and not very well sealed off from it, regular green mould outbreaks due to Th3 occurred. Similarly, in overwet compost that has been partially peak heated, avenues for infection may be created due to sections of compost remaining unpasteurised (Fermor, 1985). In culture, a wide variety of Th3 strains showed growth rates ranging between 0.5-1 mm/h at 27°C. Colonies often had a wavy margin and the mycelium was distinctly striate in a radial pattern. Sporulation normally occurred as coalescing cushions. These often formed a central disc plus a scatter of sporulation elsewhere, sometimes broken up into blocks by radial striations. Spore masses were jade green and usually smelled of coconut. Spores were noticeably larger and usually slightly more spherical than those of Th2.

5 *Trichoderma pseudokoningii*, *T. koningii* and *T. longibrachiatum* were commonly found in the lagoon water and were very prevalent on tray farms often sporing densely, particularly on the wood of new trays. However, no growth into compost was noted. In culture, spores germinated faster than those of other species and growth rate was 1-1.2 mm/h. Very little aerial mycelium was produced and spore masses formed cushions with white margins or granular masses scattered over the surface of the agar. Spore masses were in shades of yellow olive to olive green. Spores were small to large, but always narrow to elongated oval. The name *T. hammatum* has not been used here because the type specimen described by Rifai grew very slowly and this species description was so variable that almost any *Trichoderma* species can be encompassed. It could include *T. harzianum* Th2 or Th3.

Symptoms of attack

Green patches of sporulation, the main symptom of attack by *Trichoderma*, were very clearly visible in bags, slightly less so with blocks and often invisible in trays. In shelves, patches of sporulation were often visible on the undersides of the net 2-3 weeks after filling. When mature, these spore-masses were dark green and less visible. They were then often washed off onto the casing below and the mushrooms emerging through this casing were very badly spotted, often distorted and had a very short shelf- life. In one case investigated, 24 blemished mushrooms yielded 24 pure cultures of Th2. Other species/strains of *Trichoderma* also caused spotting (Fletcher. J. personal communication).

On tray farms, straws of compost protruding between the bottom boards may be covered with spores: but this was often hard to see except in the beam of a strong torch. One of the first symptoms noted was a drastic fall in yield, to a mean as low as $^1/_2$ lb per sq. ft. Also, blank patches occurred in the trays and the casing was often densely covered in pepper mites and/or heavily contaminated by eelworms. Mushrooms in the trays below were usually spotted and distorted. Those developing near an infection were sometimes cinnamon in colour due to a dense covering of pepper mites. Pickers found the mites irritating and occasionally refused to pick the crop.

Some case histories

Mites carry *Trichoderma* spores and can be transferred by the pickers' clothing and by trolleys to other areas around the farm. On one farm the pickers kept the milk for their tea in the spawn store. This was perhaps the most sensitive area on the farm as regards recycling of infection. A particularly severe outbreak not attributable to wind-borne infection could have been caused by mites from the pickers' clothing infecting spawn in the store.

Origin of infection in bagged compost

With compost in bags, infections may appear to start mainly at the bottom of the bags, and the inference was made that the infection came with the compost from the manufacturer. On the other hand, infection also occurred mainly at the top of the bags or only on the casing. In these cases, infection by the grower, possibly at levelling, was considered more likely. Surface spawning, besides aiding infection, also concentrated sporulation near the surface, Seaby, 1987. In severe cases, nearly the entire casing of many bags was found to be covered in green spore-masses. On two small farms where this type of attack was seen, farm hygiene was low. On one of these farms, bags were

placed in old trays which were used as 4-storey racking. In between crops these trays were washed with a power hose. They were found to be heavily contaminated with 5 *Trichoderma* species including Th2. Soon after the house was filled, mites carrying *Trichoderma* were caught on agar plates as they dropped from the trays above. The growing houses had open vents, without filters, these allowed mushroom flies to move freely from older, visibly infected, houses to new 'clean' ones. On another farm, every surface tested inside the house and on the forecourt yielded Th2 spores. The clothing of the hired helper was very heavily contaminated and he was known to 'help' on two or three other farms, without a change of clothing. During the investigation a young child ran up and down the narrow aisles brushing against infected bags which were visibly covered in mites. On another farm 2 large dogs did the same thing. A line of infected green bags sat just outside the doorway and the wind blew straws from them around the gravel forecourt. Any vehicle, eg delivering compost, would be likely to become contaminated, as would the large cover used to retain the load, if it had touched the ground.

In a subsequent investigation seventeen covers from three compost producers were sampled by just touching a few cm^2 of each of the covers against the surface of two replicate agar plates, this yielded a 63% infection rate for *Trichodermas* including Th2. Even covers kept very 'clean' in appearance by regular washing were found to be contaminated on 75% of their surface area. In these instances 15 x 15 cm squares were tested by swabbing and plating. Covers also harboured mites and in use came into direct contact with exposed compost in the bags.

Three infection routes on a shelf farm

On one shelf farm visited, cooking out was not possible and formaldehyde prills were used prior to emptying. Th2 became more prevalent in each of the succeeding crops until cropping became uneconomic due to reduced yields and blemished mushrooms. The nets had been carefully sterilised, but several other sources of infection were suggested. For example, it was found that mites could gain access at the ends to the hollow tubing making up each of the shelf sections. Inside these narrow tubes restricted air movement would have protected the mites from the formaldehyde vapour generated by the prills and also from the subsequent washing, so that they could later emerge to cause infection. During house filling, dust from the yard could not be prevented from blowing into the trailer delivering the compost and also onto the filling hopper. A plentiful source of dust was found in large fissures in the concrete surface of the adjoining yard, every test swab from these yielded *Trichoderma* isolates.

Four infection routes on a tray farm

On a tray farm visited, the compost was peak heated in bulk and filled into trays which moved under a hopper and along a tray conveyor-line. The line was not cleaned between casing one batch of trays and filling the next. The rollers and guides were found to be heavily contaminated by contact with the boxes of spawn run compost. On the following day these parts of the machinery came into contact with freshly steamed boxes containing spawned, peak-heated compost. This provided an ideal transfer mechanism for *Trichoderma*. The species transferred were mainly *T. koningii*, *T. pseudokoningii* and *T. longibrachiatum*. However, mites and Th2 were also transferred. Two pickers wearing their picking clothes helped to shape the compost into the boxes and compost brushed against their clothing. Over-filled boxes were stacked for several hours close to a doorway, the other side of which was a ramp where spent compost was emptied. On this farm, (due to building design), cooking-out was not possible. The conveyor-line area was thus heavily contaminated by Th2. The route for the filled boxes to the spawn running houses was the same as that for the pickers trolley and the 'spent' trays. It was observed that the tyres of the fork-lift threw spray from the wetted concrete along this route into the trays it was carrying. As expected, the concrete was heavily contaminated with *Trichoderma*, so an infective spray was created. The fact that this farm had been very successful for many years with relatively few disease problems became irrelevant after Th2 arrived and it was only after weeks of hard work and a complete rethink of farm hygiene that the outbreak was brought under control.

Steps and ladders can cause infection

On several compost producers' premises the staging or steps used by the spawner did not have a handrail. As a result the spawner touched parts of the ladder or staging with his hands, which his boots had previously touched. His hands thus became contaminated just before he touched the mushroom spawn.

Infection due to workers entering the peak heat

On some farms the peak heat thermometers could not be removed from the outside. This meant that men had to clamber over the freshly pasteurised compost in order to retrieve them before emptying. On one farm, the peak heat fan-inlet was protected by a pre-filter only. This was obviously inadequate to keep out mites and the finest dust particles.

Protection of farms by virtue of their isolation

On a number of mushroom farms isolation from other farms is only geographical, a number of potential infection carriers regularly move between them. These include large re-usable bags for transporting casing, vehicles, personnel, trays, borrowed equipment and even batches of compost. The latter, or the vehicles carrying them, appeared to be the initial source of infection in several very damaging outbreaks. In another case bought-in second-hand trays not sterilized before arrival were blamed for introducing Th2 to a farm.

Additional control recommendations

1. Formaldehyde is not an ideal sterilant for use against *Trichoderma* because it has little residual effect and may kill bacterial and fungal competitors. Similarly, steaming trays or nets renders them liable to enhance growth by *Trichoderma* if infection can occur after sterilization.

2. Dipping trays in fungicide uses up the active ingredient in the solution which is further neutralised by the accumulating organic sludge. Optimum concentration

of fungicide must be maintained by regular checking of the concentration.

3. Load covers should be sprayed with a persistent fungicide and acaricide.

4. Foot-dips should be provided for workers building bags on trailers.

5. Plastic sheeting used for blocks, bags or for screening attracts dust and should be stored carefully.

6. Insecticides incorporated into compost must be stored with similar care to that used for spawn or for compost supplements.

7. Fork-lifts should be provided with splash-guards for the front wheels to prevent contamination of the trays they are carrying.

8. The peak heat air intake must have a filter, such as a box filter, with sufficiently fine pores to retain fungal spores c 2 microns in diameter.

9. The staging at the spawn hopper should have an easily-cleaned handrail.

10. Care should be taken to reduce the possible infection routes from other mushroom farms.

11. If possible, all houses should be cooked-out prior to emptying so as to minimise the build-up of inoculum in, or around, the farm.

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Oops!

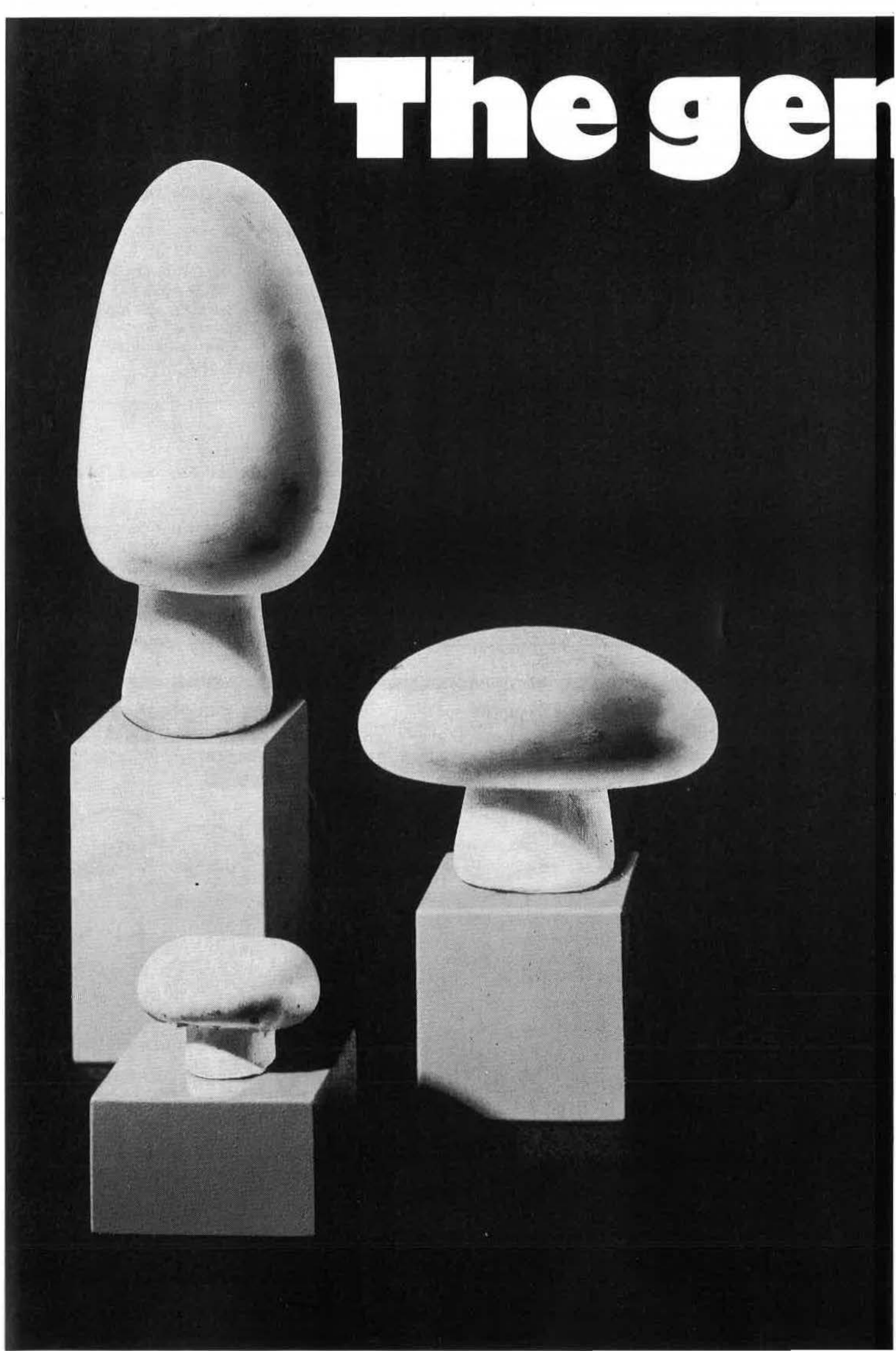
Did you spot our deliberate mistake last month? Well, we're saying it was deliberate ..... the page of photographs taken at the Annual General Meeting didn't have their captions printed.

Two of the photographs showed our outgoing chairman Frank Stewart-Wood and Peter Baker taking over from him. The third was of Hugh Barton presenting a cheque for the John Stewart-Wood Memorial Fund. The fourth was of the top table speakers.

Please help us get out of this embararrasing situation before the new chairman notices. Send us your (humorous) idea of how we should have captioned the fourth photograph.

A magnum of champagne - from our printers - for the most appropriate caption sent to the MGA director by 9th June.

The gen



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GEOFF GANNEY'S

GROWING PAINS

April Fools Day

Grower magazine tells me that Womens Farming Union' are to run a surveillance scheme monitoring mushrooms in multiples and in department stores at the request of the M.G.A. A daily diary on fresh fungi.

Fresh Produce Journal tells me that the market was inundated with mushrooms, which consequently made a poor showing at 150p/pound for low quality cups and buttons and 230p for good quality flats and opens. Also that the enormous growth in demand for mushrooms was not only being taken up with expansion in Eire, Holland, Belgium, France, Spain, Italy, Greece, Portugal, Poland, but also $^1/_2$% growth in home production. No shortages of cheap money or materials was envisaged by producers and current over supply of top quality labour would add to the already high profitability.

2nd April

Was asked about supplying mushrooms in mixed grade packs and mixed edible fungi packs. Must be another 'Mushroom Fools Day'!

3rd April

Secondary fermentation shot bed temperature up into the mid 40°C. This looked to be a result of deep litter chicken manure with over 7% nitrogen. Due to having to use loads on an immediate basis it has been impossible to get analysis back in time to relate to current loads. Worked out a system of holding loads until analysis results are back but not storing for more than 3 weeks in a covered barn. Next thing to do is to introduce a method of feeding material through a shredder to minimise lumps.

4th April

Delays in first flushes going to push too many mushrooms into the weekend which in turn means late second flushes next week. Investigation revealed deeper casing with a subsequent 36 hours lateness in airing. **Accountability.**

5th April

Had a purge on Pickers Knives. Well what is there to get excited about with Pickers Knives. Well in the first place we identified eight different types some long, some short, some thin, some fat but *all blunt*. Secondly, some had plastic handles, some had wooden handles, some no handles at all. *All were dirty*. Some were bent or twisted, none was straight.

Result, variably trimmed mushrooms with poor symmetry and gill damage to large flats. Has anyone studied the best weight, length, blade shape, handle material and degree of sharpness for the most important tool a picker has?

6th April

Completed Supermarket and Anglian Water Authority questionnaire on chemicals used on the farms. *Basically it took up two lines*. Be happier when it is a *single line*. There is certaintity of certain types of chemicals being removed from growing practice and as the more toxic persistent materials go, those in the lower ranges become more vulnerable.

7th April

Reflecting on Agricultural Wages Board Pay Increase for this June and how to implement this without changing the total annual wage bill. Having made labour cuts where possible during the last six months it is going to be far from easy. Removing people from a labour intensive system without affecting productivity or quality is a tight rope operation. Maybe the starting place is to analyse the work practices.

8th April

Open Learning is now established in the Mushroom Training Curriculum and with many credits to it. However, it is unlikely to be a totally commercial success without firstly being carefully evaluated for its effect in its current format and then updating to meet the constant needs of a changing industry.

10th April

Rises in oil prices and the constant need to make any possible savings has resulted in cursory examination of energy wastage. It is alarming. Even simple things such as cutting fans and heat on crops going out in a couple of days is being missed. The overkill on after crop sterilisation, no wonder the trays break! Actual simple vain cleanliness seems a thing of the past. Questions raise the same two answers; 'we don't know when it was changed?' 'We don't have enough time?'

11th April

Discussing spawned casing with Tony Claxton and Aoife O' Brien in relation for the need to match up the strain in the casing and compost. Recalling some years ago a practice of mixing two white strains prior to spawning to gain the vigour of one and the quality of the other, *which I was never sure if it did work*! Is there a relationship that could be used with hybrid strains to advantage? After 3 hours discussion we had no answer! I suppose like many areas of mushrooms production it will be a case of trying a shed to assess potential or otherwise. Although today innovation is less likely due to economic forces.

12th April

Charles and Edward Spencer visited Marigold and we discussed how was it possible to get people to produce quality on trays? Looking at our Marigold crops the mushrooms certainly had a brightness on the beds not quite Dutch White. The boys thought this more likely to be a result of the new fluorescent lighting being used in the sheds!! Interestingly bringing in a crop in one small shed, which had what was termed a difficult compost i.e. no spawn growth, without any watering of the casing after ' airing up' produced extremely white caps.

13th April

Using far more air to initiate the first breaks dropping CO_2 levels down to 6-700 p.p.m. instead of 11-1200 p.p.m., which is puzzling. Maybe the warmer ambient conditions are having an effect? Generally compost activity is far greater which will lead to greater CO_2 evolution, or whatever else may be around. I have no doubts we will hit a period of over pinning.

14th April

Debating the costs and advantages of preparing a totally synthetic (straw based) compost as to using a mixture or light racing stable manure. Room to handle the prewetting material has to be a major consideration as would be the efficiency of straw ton conversion? Would you get a total of 2.5 or 3 tons of made compost from each ton of raw material? Probably the answer to that question would be a result of the condition of material at baling. The thought of more accuracy of formulation in terms of dry matter fill and nitrogen computation must be a plus. Maybe it simply comes down to how much you pay for straw or horse manure. Also today the question of volume and economics of scale with the costs of replacing equipment is a major factor in *how much compost you need* to be making to be economical in the first place. That might be a surprise.

16th April

End of crop killing off is all done through water tanks and hand propelled watering trees. It is successful but can use a greater volume of raw source chemicals which does tend to put more chemical onto concrete floors or to block walls. This I do not like if phenolic based chemicals are used. Have, therefore, used chlorinated water at high levels to give a surface coverage. Can't really trust that this would kill all 'foes' but so far it has been used with common sense and appears to do an acceptable job. The common sense being if there is a specific problem then a chemical is selected to suit that problem. **Anyway who knows what kills what?**

17th April

Reading a copy of the *Irish Mushroom Review* and hopefully it will be possible to get copies for the Fred Atkins Library. Certainly the energy going into mushroom projects in Eire leaves one breathless and one *hopes not pennyless!*

18th April

Virus tests from samples of crops sent with cased spawning have come back negative once again. But the eelworm samples proved positive. Why? Spent time checking phase II kill temperature and decided although these seem in the right range it is likely there are cold spots. If not cold, there could be wet spots. Reading the notes of the Electron Microscope test result one sentence could give rise to a whole conference on the subject of mushroom viruses. *'By reference to previous tests and associated yield losses the significance of virus in mushrooms can be estimated'.*

19th April

Shortage of prochloraz-manganese threw us into a panic! A panic of realisation that while using the chemical on a selective basis its efficiency had led us to drop diseasing teams. Now we need to reconsider the training requirements of personnel to undertake such a necessary discipline. Not an easy task for individual farms and more appropriate to a training group approach.

21st April

Preparing a paper for the South African Conference next month led me to realise 'Growing Pains' was now 15 years old and as an Australian Lady put it to me at the Braunsweig International Conference; *'are you the poor man who has all those problems every month? Jesus, I feel sorry for you!'* Or if you like as a growers friend said, *'Its about bloody time you get sorted!!'* Or more subtly put, *'I'm surprised you're still around....'*

22nd April

Reading this month's *Journal* proved more difficult than normal no doubt the 'press' had a touch of the 'DT's. The nameless MGA Officers are no doubt part of the next Xmas quiz, *find a caption!!*

Aoife O'Brien seems to be dashing from one area to another which brought back memories of the days spent doing the same many years ago! In some ways if formal papers are given it might be that they are best printed in their entirety. **Extracts of facts can be misleading.**

23rd April

Talking with Sue Jones, Tesco Mushroom Technologist about the role of a Q.C. on a traditional mushroom farm and the difficulties of developing such a position in a hostile environment. When work practises have been followed along very traditional lines it is by no means easy to implant change. The philosophy of 'Quality Implementation' in every aspect of a business has to begin with the Directors and flow at every opportunity in every direction through all concerned with that business. Not an easy task and one where the slightest faltering will set you back at the beginning. Some times systems and methods negate the possibility of progress. Often I wonder if you need to reduce in size to 'where small is beautiful'.

24th April

An apparent sudden outbreak of orange cecid (*Mycophylla sp.*) at Catfield led the close investigation back to possibly one load of peat. This prepared as usual up to enough casing for $3\frac{1}{2}$ sheds and cecid could be found in each area cased for this single batch. Due to what? In probability to a very mild winter and no hard penetrating frosts to curb larvae or fly movement, or the possiblity of a new bag being cleared off with some natural population being present. With weed growth also occuring from root debris of perennial weeds, perhaps this is more than likely. Introduced 'Sudol' foot-dips, invigorated general hygiene and cleared and cleaned cold stores, vehicles and packing area. Re-infection is more than often from infection in older crops.

25th April

Continual damage by fork lift trucks and vehicles to equipment and buildings illustrates yet another modern phenomena!! Always believed in relating net wage to performance with a discount for damage. All explantations start with 'He didn't mean to, or, He is new, or He couldn't see' Never that he was negligent. Maybe it is the nature of this business where due to economics people are under pressure so mistakes occur. But whatever, it is still a **'People Problem'.**

26th April

Met up with Iain Hensby to travel down to the Institute of Horticulture (G.C.R.I.) to attend a Research and Development Committee Meeting. Having been invited I was not too sure as a member or guest. But with all the changing political positions that have occured in the past two years it is by no means easy to asses where the 'ball' actually is. *Certainly not in the net!* Harold Linfield to my way of thinking has done a most excellent job for the membership in holding the thing together in some co-ordinated way. Now it appears a proposal is required to raise an amount of money to go towards the increasing shortfall between government finance and the total required for near market and basic research. No money is probably a nil programme. At a time when the industry is more than a little economically stressed, producers will be asked two things; *if they endorse a need to continue with a research and development programme, for money.* A carefully formulated case will be needed so there are two other things that is sure; money will not be easily obtained and many will see priorities differently.

29th April

Introduced dichlorvos treatment of the spawn growing rooms for the rest of the Summer. We have managed many months with no necessary fly control treatments with considerable success.

30th April

Warm humid weather brought it's usual problems of too many open mushrooms, opening in cold stores and during transportation and up in the steamy 'Broadlands' the usual coverage of bacterial blotch. Again the Catfield site being on a white hybrid and the other farms on off-white hybrids where even though picking is behind, there is no bacterial blotch!

Amazingly the crops that experienced secondary fermentation are now at the airing up stage and looks good. So what do we really know about this tantalisingly variably crop?

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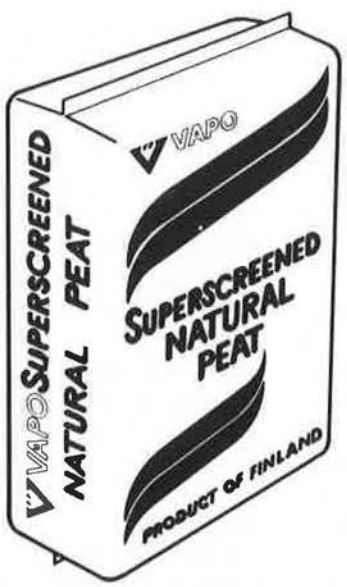

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Crop Production

by **Peter Flegg**

The casing layer

After spawning the compost and encouraging a good run of mushroom mycelium, the next major job is to case the beds. Why? What is the casing layer for? What does it do?

In commercial mushroom production it is essential to put a layer of soil, peat or similar material over the spawned compost. Without such a layer, few, if any, mushrooms will grow.

Soon after the casing layer has been put on, the mushroom mycelium begins to grow into it in much the same way as it grows into the compost. As the mycelium reaches the top of the casing layer, the fine, hair-like growth changes. Thickened strands of mycelium form, a network of strands develops and 'knots' or 'lumps' of mushroom tissue appear. Eventually some of these knots of white tissue take on a more definite shape, more or less round and about the size of a pinhead. These 'pinheads', as they are called, are the early stages of the development of a mature mushroom. How this change in type of growth occurs is still something of a mystery. One possible explanation is that the mushroom mycelium produces a substance (or substances) which does not normally allow fruit bodies to develop. However, certain bacteria, commonly present in the casing layer, destroy this substance and the mushroom mycelium is then free to produce fruit bodies. Although it is not certain if that explanation is correct, the important thing for mushroom growers is to know how to produce the right conditions in the compost and casing for fruiting to take place.

One of the most important requirements in the casing layer is for a plentiful supply of water. Mushrooms contain a lot of water and much of it is supplied from the casing layer. So, a material used for casing mushroom beds kept under well ventilated conditions must be able to hold a lot of water. It must also be able to withstand frequent watering without losing its structure. Another important characteristic for a casing material is that it will allow an easy passage for air into the compost and for carbon dioxide to escape. A casing mixture which disintegrates into a structureless sludge when watered will not allow oxygen and carbon dioxide (CO_2) gases to pass freely.

The casing material must also be neither too acid, nor too alkaline. To ensure this we usually add chalk to the mixture which then has a pH of around 7 to 8.5.

The pH scale is a way of measuring acidity and alkalinity of moist materials, a pH of 7 is the neutral mid-point with pH 1 being at the extreme acid end of the scale and 14 at the alkaline end. Mushrooms seem to prefer a casing layer somewhere between pH 6.5 to 8.5.

While growing and fruiting best in a neutral to slightly alkaline casing layer, the mushrooms will not fruit well if there are high levels of soluble salts present. The compost usually contains large amounts of salts and these will slowly move upwards into the casing. This does not usually do any harm, especially if the casing material is not used for mushroom growing more than once and if there is little or no salt present in the first place. Well fertilised garden and horticultural soils and composts are usually not suitable for casing mushroom beds.

Many types of peat have the physical characteristics to make a good casing material. Peat alone, however, is not an ideal casing medium. Usually it is acid and has to be mixed with chalk to counteract its acidity. The exact quantities of peat and chalk are not too important. A typical mixture might be:-

Peat	1000 litres or 220 gallons
Chalk	170 kg or 375 lb
Water	170 litres or 35 gallons

Usually more chalk is added than is strictly needed to neutralise the acidity of the peat. The extra chalk will do no harm, it will probably reduce the total cost of the mixture and a lumpy chalk may help to keep the mixture 'open' and more porous to gases. The type of peat used is important. Sphagnum peats are very popular, but whichever type of peat is used, it should not contain a high proportion of dust, nor should it have too many large lumps in it. A medium grade is often the one to aim for and, as with most materials used in mushroom growing, the quality from one batch to the next should be consistent. The cheapest material may not be the most suitable.

Casing the beds

Having decided on the types of peat and chalk and the proportions of each to use, they can be mixed either by hand or by machine. A variety of machines is available, but it is important to get the time taken to mix the ingredients right. A casing mixture kept in the mixer for too long, and it may need only seconds rather than minutes, can resemble over-wet porridge and be quite useless for growing mushrooms.

Mixing peat and chalk by hand or by tractor and bucket is quite possible. It is important that the peat is wetted carefully and thoroughly. Dry peat is not easy to wet. Just turning a hose on a pile of dry peat will not do. You may need to soak the peat in a pit or bin.

Many growers find that their casing mixture, if prepared under hygienic conditions, is free from mushroom pests and diseases. However, if experience has shown that the casing mixture is likely to be contaminated, then treatment with formaldehyde, methyl bromide or steam may be needed. These aspects will be discussed in the next article on 'Farm Hygiene'.

The best time to case the beds is usually decided by the farm schedule. Altering the day on which casing is done according to the stage of development of the crop may be desirable but usually is not practicable. On many farms the beds are cased 13 days after spawning and, if all has gone well, at this time the compost will be almost completely colonised by the mushroom mycelium. With hybrid

strains it does seem to be more important that the compost is fully 'run' when cased than with some other strains.

However, it is quite possible to case mushrooms beds at the same time as mixing in the spawn. The two operations can be carried out on the same day, which saves time and labour, and the casing layer will help to keep the compost moist and protect it from diseased spores which may be in the air. On the other hand, management of the crop is more difficult. It is not so easy to see what is going on in the beds, the compost is more likely to overheat, because of the cover of casing material, and watering the beds can be more difficult. Unless watering is done with great care, water can easily trickle through into the compost. In the early stages, the casing does not have the benefit of the water-repelling effect of mushroom mycelium. If care is taken, casing and spawning at the same time can result in an earlier first flush, but the overall yield is not likely to be any greater. Most growers case their beds (trays, shelves or bags) about two weeks after spawning. The casing should be 'wet', but not too wet! There should be no loose water running from the casing into the compost. The casing can be applied by hand, so many buckets full per tray or shelf, or by using the spawning line. Whatever method of application is used, the surface of the compost should be levelled before-hand and the casing mixture applied in a uniform layer. Bags are probably best cased by hand. The optimum depth of casing is about 40mm (1.5in). If the casing layer is not the same depth all over the beds, then it is not going to be easy to maintain a uniform water content throughout the casing later on. Pinhead formation will not occur evenly and the mushrooms will come up in clumps. One consequence of clumping will be reduced picking rates, as clumps of mushrooms are not always easy to pick, and another will be poor quality resulting from irregularly shaped mushrooms caused by them growing together in tightly packed clumps.

Pinning up

This part of mushroom growing, getting the mushroom mycelium to grow into the casing layer evenly and to develop pinheads just on the surface of the casing layer, is sometimes regarded as the most difficult.

At first the job is rather like spawn running. To get the mycelium to grow evenly and as fast as possible into the casing layer, a temperature of around 24°C (75°F) is needed. Care must be taken that the temperature in the compost does not rise too much and so kill the mushroom mycelium. This means that air temperatures may have to be kept lower than 24°C. A compromise may be needed to get the fastest growth of mycelium and yet avoid compost temperatures reaching danger levels (30°C, 85°F). Cooling may be done with chillers or with fresh air. Although fresh air is cheaper it must be filtered to remove pests and disease spores. It is important that the mushroom mycelium is not allowed to develop into pinheads before it reaches the top of the casing layer. Mushrooms which develop deep in the casing layer emerge covered in peat. Such mushrooms are difficult to pick cleanly and both quality and cash returns suffer. The way to prevent premature pinhead development is to maintain a CO_2 level in the air and in the casing of 0.2% (2000 vpm) or more. At this level mushroom fruiting is inhibited and only mycelial growth can occur. Obviously excessive use of fresh air to lower compost temperatures will most likely reduce CO_2 levels also and result in pinheads forming too soon. Chillers allow temperatures to be reduced without letting in fresh air, but sometimes it becomes impossible to achieve both aims of high CO_2 levels and avoiding compost over heating. When this position arises, keeping bed temperatures below danger level has priority. Do remember that people are also affected by CO_2. The maximum limit in working environments is 0.5% (5000 vpm).

During the first week or so after casing, the relative humidity of the air will tend to be high anyway and only if drastic measures are taken to lower compost temperatures, such as prolonged use of chillers or letting in large quantities of fresh air, will there be a need to raise the relative humidity. A humidistat controlling a steam or water droplet humidification system, if set at around 90-95% RH, should be sufficient. Without such technical back-up frequent watering of walls and floors may be needed.

While keeping a watchful eye on temperature, humidity and CO_2 levels, a high-priority job is to keep the casing layer moist. The aim should be to raise the water content of the casing material as high as practicable without water running through, and maintaining it at that level. Once the casing is as wet as it can be with safety, then the aim of watering should be just to replace losses from evaporation. After a few days, the mushroom mycelium will have grown into the casing layer and will help to minimise the danger of water running through into the compost.

Even with the greatest care, it is not possible to achieve an absolutely uniform run of mycelium into the casing. To even out irregularities in mycelial growth, some growers find it of benefit to break up the casing layer gently and redistribute the mycelium. This practice is often known as 'ruffling'. There are machines, developed for use with the shelf system of growing, which perform this job.

Otherwise a flat board with downward pointing nails worked with a back and forth or circular motion over the beds may suffice. The casing surface should be levelled off after ruffling and no water applied for a couple of days while the mycelium is reuniting.

The best time to ruffle depends on the spawn strain and the rate of growth of the mycelium into the casing, probably around 6-10 days after casing is best.

Some 10 to 14 days after casing the mycelium should have reached the top of the casing layer, hopefully, more or less evenly throughout the cropping house. It is now time to persuade the mushroom to change its mode of growth from vegetative mycelial growth to the reproductive development of fruit bodies. The most important change in cultural conditions is to lower the CO_2 level from around 0.2% to about 0.06% to 0.08% (600 to 800 vpm) by increasing the amount of fresh air entering the house. At the same time, the temperature will also drop and the thermostat can be set to give an air temperature of around 16-17°C (61-63°F). Compost temperatures will also drop and overheating is now much less of a danger. It does not matter too much at this stage if the air temperatures do not drop as low as 16-17°C. However, it is expensive to attempt to maintain high temperatures when the fresh air input is probably near to maximum.

Relative humidities are also likely to drop as the amount of fresh air is increased and care is needed to see that the beds and any developing mushrooms are not subjected to excessive drying.

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Great British Mushroom Structures

It can be helpful on the day that the fresh air input is raised (airing the beds) to water the beds. This will not only help reduce drying out, but will also wash away any fluffy mushroom mycelium which may have grown up and over the surface of the casing. Too dense a development of mushroom mycelium over the surface of the casing layer can seriously hold up the absorption of water by the peat. After this 'knock-back' watering, avoid further heavy waterings at least until the developing pinheads have reached a diameter of 6mm ($^1/_4$ in).

The first and later flushes

When the crop has developed mushroom pinheads, it is time to concentrate on encouraging the development of a first flush of good quality and high yield. Mushrooms are produced in a succession of batches or 'flushes' over a period of several weeks. The flushes are usually about 6-10 days apart with the first one ready to pick about 18 to 22 days after casing. These times can vary somewhat with the strain of spawn used, the stage of maturity at which the mushrooms are harvested and the cropping conditions.

Some growers find that the heavier yielding hybrid strains begin cropping just a little later than other strains. Each flush will probably take some 3 to 5 days to harvest and sometimes the small mushrooms are already showing on the beds as harvesting of the previous flush is completed. Picking crops tightly, say, as buttons to small cups, will speed the arrival of the next flush, whereas leaving the mushrooms on the beds until they are open cups or flats will delay it. Raising the temperatures slightly (or in warm weather) also reduces the time between flushes.

As a flush of mushrooms develops, there is a lot of biological activity in the beds. Extra heat is generated and more carbon dioxide produced. Both ventilation and air movement over the beds must be adequate to remove the additional heat and CO_2. At this time of rapid development of, hopefully, a great weight of mushrooms, the needs of the crop must be carefully watched. Skill and past experience can be of great help in ensuring that the crop receives the right treatment. Not everything about mushroom growing can be learnt from books and from articles like this.

As a flush develops the air temperature is usually kept at around 16-18°C (60-63°F). Slightly higher temperatures will speed up growth, slightly lower will slow it. Beware of fluctuating temperature, as this can lead to excessive drying or the formation of condensation. Either will lead to a reduction in crop quality. Not only will air temperature affect the rate of growth of the developing mushrooms, but it will also affect the amount of carbon dioxide being produced by the compost, mycelium and mushroom fruit bodies. Carbon dioxide levels in the air immediately over the beds should be kept down below 0.1% (1000 vpm). Try to aim at 0.06% to 0.9% (600 - 900 vpm), remembering that the lower the level of CO_2 achieved, the greater the amount of fresh air needed. In winter, this can mean higher fuel bills and, in summer, increased cost of cooling. It is well worth while to monitor the levels of CO_2 in the air regularly. Equipment is now available to do this automatically and even to adjust ventilator flaps as necessary.

Mushrooms contain a lot of water (about 90%) and as the fruit bodies grow, a lot of water is being removed from the casing and compost. It is important to supply the beds with sufficient water to replace losses from evaporation and to supply enough water for the developing crop. You may find it necessary to water the beds on several successive days, but do be careful not to overwater at any one watering. Do not give 'two days' worth of watering at one time. Probably no more than 200 litres per 100 sq. meter (300 pints per 1000 sq. ft) should be given in any one day. It is certainly worth while practicing how to water beds evenly. However important it is to keep the beds moist, watering must stop a day or two before harvesting begins. Do not water just before the crop is to be picked, the pickers will not appreciate it and the mushrooms will more easily be damaged and become dirty.

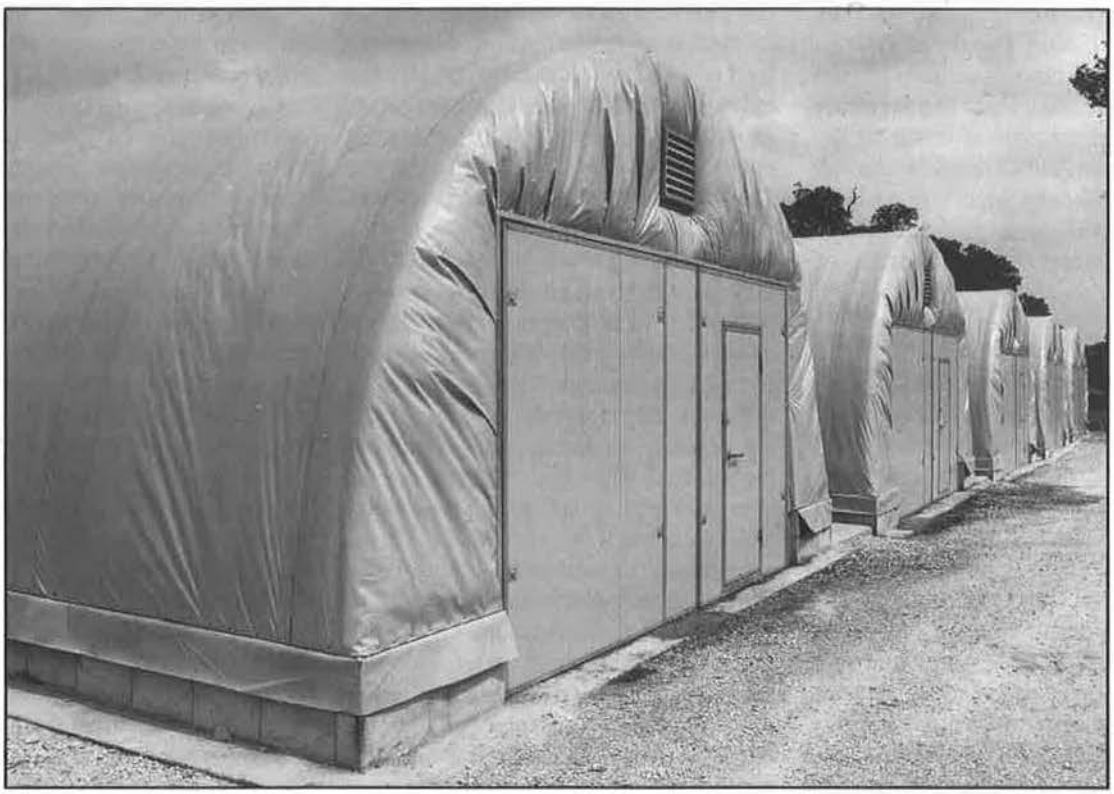
To avoid the possibility of bacterial blotch (and many other diseases) developing on the mushrooms after watering, it is important to make sure the mushroom caps dry off within three to four hours. To do this, raise the temperature a little, or increase the ventilation rate, or increase the rate at which air circulates. Perhaps a little of all three may be needed, but be careful not to overdo it. Mushrooms which dry too rapidly or too much will have a smooth and shiny surface, possibly with some scaling. When mushrooms are in this state, watering them to counteract the problem can also cause the tissues to burst and the mushrooms will first turn slightly pink and then brown. Easy does it. Try to avoid extremes of either hot and cold or wet and dry.

During cropping the relative humidity will generally be fairly high. At high relative humidities, say 90% and above, the air movement over the beds can be much faster than if the relative humidity is below 80%. A combination of low relative humidity and high air speed will lead to excessive drying of the beds and cracking and scaling of the mushrooms. On the other hand, when the relative humidity is high, it may be necessary to speed up the movement of air to avoid the development of bacterial blotch. A wet mushroom surface is ideal for the development of bacterial and fungal diseases of the mushroom.

The number of flushes which make up a full crop of mushrooms will vary somewhat depending on the spawn strain and conditions on the farm. Most farms will harvest at least four flushes and some continue cropping for six. A few, perhaps growing on deeper beds, may find it worthwhile to pick seven or eight. Try to use the period between flushes to tidy the beds, remove or otherwise deal with patches of diseases and to catch up with the watering.

While care is being given to the crop as it passes through the various stages, it is important that records are kept for later reference. Many items can be recorded, but one of the dangers is to record so much that it will never be read. Obviously important details to record include daily air and compost temperatures, CO_2 levels, relative humidity readings, times of watering and amounts given, pest and disease sightings, applications of chemicals and of course the daily pick. Records can be useful when things go wrong or when things seem 'not quite right'. Questions such as, 'Have the temperatures been kept at the right level? Has enough (or too much) water been given? What about CO_2 levels? Did we notice a similar problem with this strain at this time last year?, can usually only be answered from carefully maintained records. A wide range of equipment is available to help with making measurements and recording them. Many growers are turning to

The All Purpose Growing House



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computers to help with recording and controlling several environmental factors.

Further information about, and discussion of, the mushroom cropping house and its regulation is available in the MGA-ATB Open Learning Module No 4.

Having grown the crop to the best of ones ability, it is important that the effort is not wasted by poor picking and packing. Mushroom harvesting and quality control must be given a high priority and the MGA-ATB Open Learning Module No 7 gives a lot of useful information on this subject.

Hygiene is important at all stages of mushroom production. During cropping many people have access to the mushroom houses. Pickers, waterers, disease teams and supervisors are in close contact with the beds and in their work move from house to house. Unless they are all aware of the hygiene requirements to prevent the spread of pests and diseases around the farm, crop losses from the effects of pathogens can be very great. The next article in this series will deal with 'Mushroom Farm Hygiene' including the end-of-crop 'clean up'.

Previous articles in this series were published in the Mushroom Journal Numbers 185, 189 & 190.

Diary Dates 1989

22nd-26th May: Dutch Short Course, Horst Holland.
15th June - Growers/Allied Trades Golf Match, Newmarket.
Growers contact: Paul Maxwell 0992 22482
Trades contact: Barry Woodcock 0692 82100
16th-19th July - 8th North American Conference Calgary, Alberta
13th-16th September: 16th National Mushroom Industry Conference, Adelaide, S. Australia.
27th-29th September - MGA Annual Conference Viking Hotel, York
6th-7th October - HERE Exhibition, Concorde Sports Centre, Sheffield.
6th-10th November - ISMS International Symposium on Mushroom Biotechnology, Nanjing China
1990
22nd February - ADAS Conference, Cairn Hotel, Harrogate.

Electrical controls aid mushroom grower

by **A. Edwards**

At Monterey Mushrooms, in Madisonville, Texas, electrical controls maintain consistent growing atmosphere and operate assembly lines. This mushroom facility produces a consistently high yield, one that will total 20 million pounds of mushrooms last year.

In nature, mushrooms sprout overnight after a rainstorm — a low-pressure system drops rain, moves on, and a high-pressure system moves in to trigger growth; and Monterey duplicates Mother Nature.

This is made to happen in growing rooms (each 51,000 cubic feet) by lowering the air temperature and reducing the carbon dioxide levels with electrical controls. Humidity and oxygen levels are also carefully maintained.

Electrical controls also move the large wooden trays that mushrooms grow in through assembly-line operations that subject the controls to repeated impact and moisture. Tray movement through compost filling lines and subsequent operations, for example, depends on actuation of limit switches, relays and proximity switches made by Telemecanique Inc., of Westminster, Maryland. The same firm makes the pushbuttons that operate the equipment which maintains the growing room atmosphere.

In the filling line, trays move by activating a heavy-duty precision limit switch that features a sturdy diecast zinc alloy housing. It employs positive snap-action contacts; if the NC contact welds or the spring breaks, the positive snap-action design actually shears welded contacts open.

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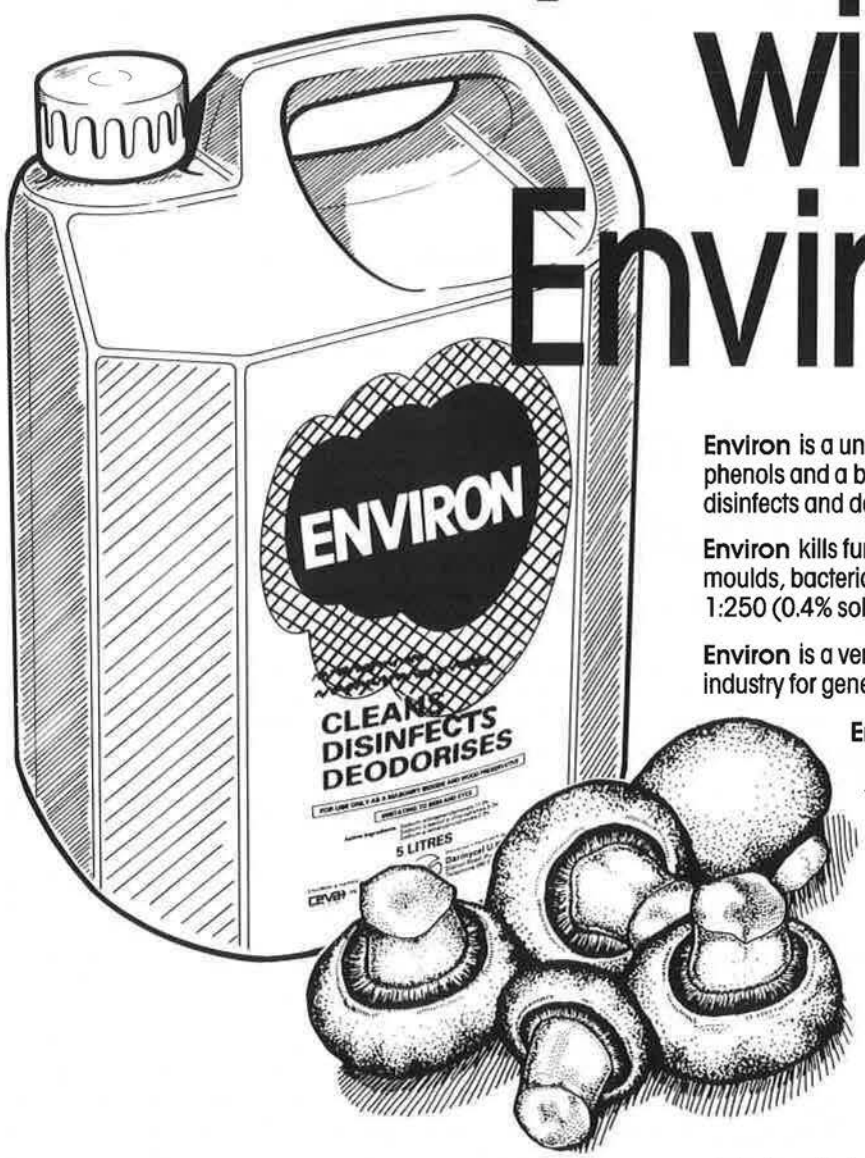

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ENVIRON IS A TRADEMARK

Trough growing and single zone composting at Minskip

By **Helen M Linfoot** BSc, SRN, Minskip Mushrooms, Boroughbridge, England

We began growing mushrooms at Minskip in 1960 using old fish trays. By 1965 we had started to combine Phase 1 and Phase 2 within the same building, ie single zone composting. It should be mentioned that Lambert's papers on composting (1934, 1941, 1950, 1952) were instrumental in the development of the idea. At the same time, Captain Sanford was also working with a closed environment composting technique in Sussex. The single zone composting technique we now use at Minskip was described in *Mushroom Journal* No. 195.

Our compost was traditionally prewetted, filled into trays, the trays being stacked with the compost touching, without corner legs, so as to form a tight, complete block within the peak heat chamber. Phase 1, with a high temperature sweat-out process (70°C), caused shrinkage and subsequently the development of air channels crossing the tray stack at all levels. This allowed a "with air" Phase 2 conditioning at traditional temperatures.

By 1970 larger trays (20 ft) were in use. Composting in this deeper, bigger tray had to evolve to maintain the production of a good compost.

Late in 1978 the first experimental trough was built. It seemed logical to produce the compost within this mini-tunnel and subsequently to spawn run, case-run and crop *in situ*. So, a total one zone system was born.

By 1980 the results of this unit were so successful a commercial trough farm was built. During the last 8 years we have learned how to compost correctly at the chosen depth and to control all aspects of spawn run, case-run, pinning and cropping in order to achieve a commercially economic result. Along the way, as with all systems, modifications have been made and problems 'ironed out'. At first the compost depth was up to 36" with a weight of 80-100 lb/sq. ft. These depths of compost were difficult to control through all phases of production. We now work at a depth of 24" (45-50 lb/sq. ft) at spawning.

This system is very different from conventional systems because the added depth gives more heat within the compost block. This heat must be controlled and the ventilation process used has direct effects upon cropping. During composting fans move air upwards through the block but for all other phases of production air is sucked downwards. Moisture moves with the heat, therefore blowing upwards makes the top moist. We use time-switches to bring on the fans, the time-switches being adjusted following daily temperature probing. Sensors are satisfactory if the temperatures are uniform and low, but problems may arise when balancing the fans with the normal growing air flows.

Mushroom production

Spawning

This is one part of our system that needs mechanisation. If the trough is spawned *in situ* using a manual spiking method it is laborious and haphazard, the advantage being it is truly "clean". We have a machine that runs on the trough walls which spawns efficiently to a depth of 8", but now we trough-spawn by bringing the block of compost out and putting it through a New Holland forage feeder. Through-spawning has improved the uniformity of the first flushes and increased yields. The spawn running environment is easily and efficiently controlled, the top of the compost is kept moist by damping the walls and floors or using live steam.

Case-running

Once the compost is fully run, we apply 1" of a chunky, wet, peat mix, but much less water is applied during the case-run period compared with what is done using other systems. Good mycelial development at the compost-casing interface is essential before any water application. When ventilating downwards it is conceivable that using a casing which is too wet, 'moveable' water may travel downwards and cause damage at the interface.

Pinning

This is a huge subject but, in brief, once a good thick, white spawn run is achieved the compost is cooled, either by reducing the air temperature with fresh air or, if necessary, also using the compost fans. The bed temperatures are reduced to 18-20°C. Once the temperature is down, the compost fans are used to their minimum. Air extracted by the compost fans can be exhausted to the outside or partly recirculated to provide moisture and carbon dioxide. Future work will establish the benefits of a ventilated casing layer.

Cropping

During cropping there is essentially little difference between growing in troughs and using other systems, other than that the ventilation through the casing and compost is positive rather than passive. This ventilation maintains a more open-textured casing, which because it can 'breath' keeps cleaner. At no time does panning occur. The crop is taken over 7 flushes, the later flushes being of good quantity and quality. Fruit bodies are heavier and denser

than from other systems. Much lighter watering is required than with other systems, light waterings only are needed until mushrooms are "large pea size" then, as the mushrooms develop, medium watering can be given. Because of the downward pull of air during compost ventilation there is less water loss from the system.

Yields have been averaging 10 lb/sq. ft with some as high as 12 lb/sq. ft in 7 flushes.

Costs of production

At a yield of 9 lb/sq. ft price average 65 p/lb

Variable costs	p/lb	p/lb
Raw materials	4.8	
Spawn	1.2	
Casing	1.1	
Packing materials	3.3	
Energy(oil/electricity)	4.0	
Labour		14.4
Filling	1.0	
Picking/packing	3.6	
Others inc spawning	2.5	
Casing/emptying		7.1
Fixed costs	14.3	14.3
	35.8	35.8

These costs were calculated some time ago, but even now are only around 40 p/lb. This includes all labour, including our own and gives a satisfactory margin. However, in common with all other systems if the yield pattern and quality is not *consistently* maintained the margin will erode, even disappear. During the evolution of the system at Minskip this can and has happened at times. It is only in the last 2 years that we can, with confidence, produce high yields of consistent quality. We are sure all growers will agree that for such a new and different system, 9 years is really a very short time to learn all its idiosyncrasies.

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Fresh mushroom pub deliveries

An update on the local presentations, following on from the 'Mushroom Bites' promotion, reported in the April issue.

Eastern England

Damian Hearne of Capel Mushrooms, Capel St Mary, Ipswich, Suffolk presenting Sally Oliver of the Cricketers, Clavering, near Saffron Walden, Essex with a basket of fresh mushrooms inside the pub.

Northern England

John Bleazard of Mereside Mushroom Co. Ltd. Staining. Blackpool presenting Alison Clarke of the Miners Arms, Nenthead, Alston. Cumbria with a basket of fresh mushrooms inside the pub.

South of England

Adrian Sampson of Sampson Mushrooms Ltd. Oving. Chichester presenting Kay and Derek Sharpling of the Langham pub, Hastings, Sussex with a basket of fresh mushrooms outside the pub.

South West of England

John Callow of Axbridge Mushrooms, Axbridge, Somerset presenting Philip Henshaw of the Farmers' Arms, Frome, Somerset with a basket of fresh mushrooms, outside the pub.

Wales

Peter Munns of Kingcup Mushrooms Ltd. Hinstock, Market Drayton, Shropshire presenting Juliet Williams of the Anchor Inn, Ruthin, Clwyd with a basket of fresh mushrooms outside the pub.

Scotland

Catherine Mitusch of Green Myre Mushroom Farms Ltd, Cupar, Fife presenting Harry Bain of the Town House, Markinch, Fife with a basket of fresh mushrooms outside the pub.

10lb Fresh Produce Box excites growers and supermarkets

GT Enterprises has developed a 10lb rigid expanded polystyrene fresh produce box that overcomes many of the problems associated with vacuum formed plastic trays and is ideal for both transportation of fresh produce and supermarket shelf display.

The strength of expanded polystyrene boxes enables them to be stacked much higher in vehicles and in supermarket storage, increasing vehicle and store base utilisation. Polystyrene absorbs shock and offers better protection against bruising than vacuum formed plastic.

'The 10lb box,' says Vic Davis of GT Enterprises, 'can reduce transportation costs by half over 5lb plastic trays. With mushrooms per pallet compared with 420lbs per pallet for twelve 5lb plastic trays per layer at the maximum of seven high because of their lack of rigidity and poor stacking capability.

'The other advantages of expanded polystyrene boxes for fresh produce, lie in that they are unaffected by condensation and moisture and have good insulation properties - a major benefit when chilling produce. Prices are on a par with traditional packaging.'

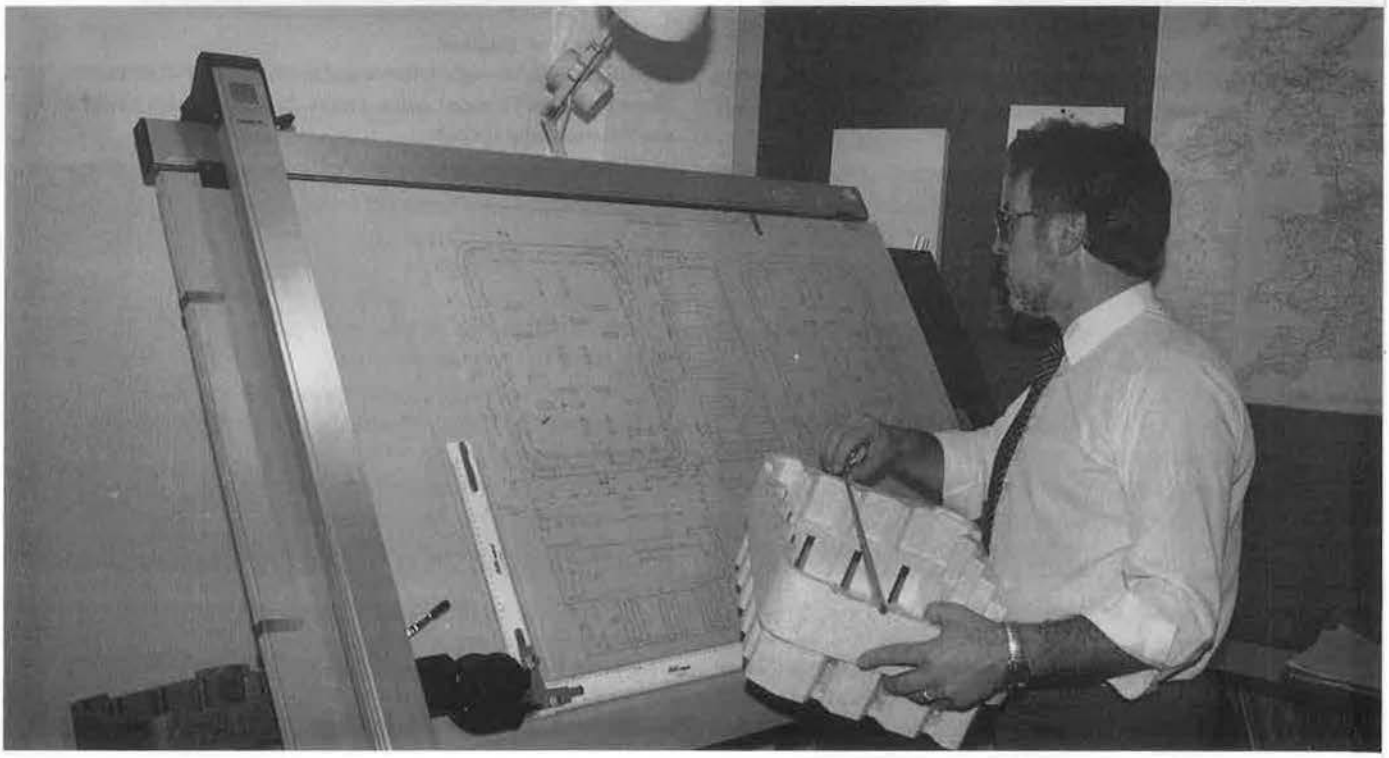
Recent research, commissioned by a number of mushroom box manufacturers, from the Agricultural Development and Advisory Service (ADAS) has shown that during rapid cooling and storage, weight loss of mushrooms was least from expanded polystyrene boxes than from cardboard boxes, plastic trays and plastic punnets.

Due to the ridigity of the expanded polystyrene boxes and their design, which includes air holes in the base and crosscut corners, cold air circulates more quickly during cooling and refrigerated transportation even when stacked on a pallet. The insulation properties of expanded polystyrene keep the produce cooler for much longer after leaving storage or going on non-chilled display.

A major user of GT expanded polystyrene boxes is Chesswood Produce, the UK's second largest mushroom grower. Roy Haycock, Chesswood's marketing director, said, 'We are a big user of GT's 5lb boxes. The product arrives in a fresher condition and therefore has a longer shelf life in the supermarket and looks better for a longer period when on display.

'What really excites Chesswood is the 10lb box. It will reduce our costs and therefore that of the supermarkets. Using the boxes for shelf display enables more mushrooms to be displayed in the same space. Using the usual shelf space allocated to mushrooms, six 5lb boxes, supermarkets can now display four 10lb boxes. A 33 per cent increase in mushrooms displayed. This will also reduce the amount of packaging on display and reduce the need for handling the produce.'

GT Enterprises (Littlehampton) Ltd was recently acquired by Styropack Ltd, a subsidiary of Shell Chemicals, and is the leading manufacturer of expanded polystyrene boxes for horticultural produce, vegetables and fresh fish. GT's method of manufacture does not use CFCs and the boxes are ozone-friendly throughout their life.



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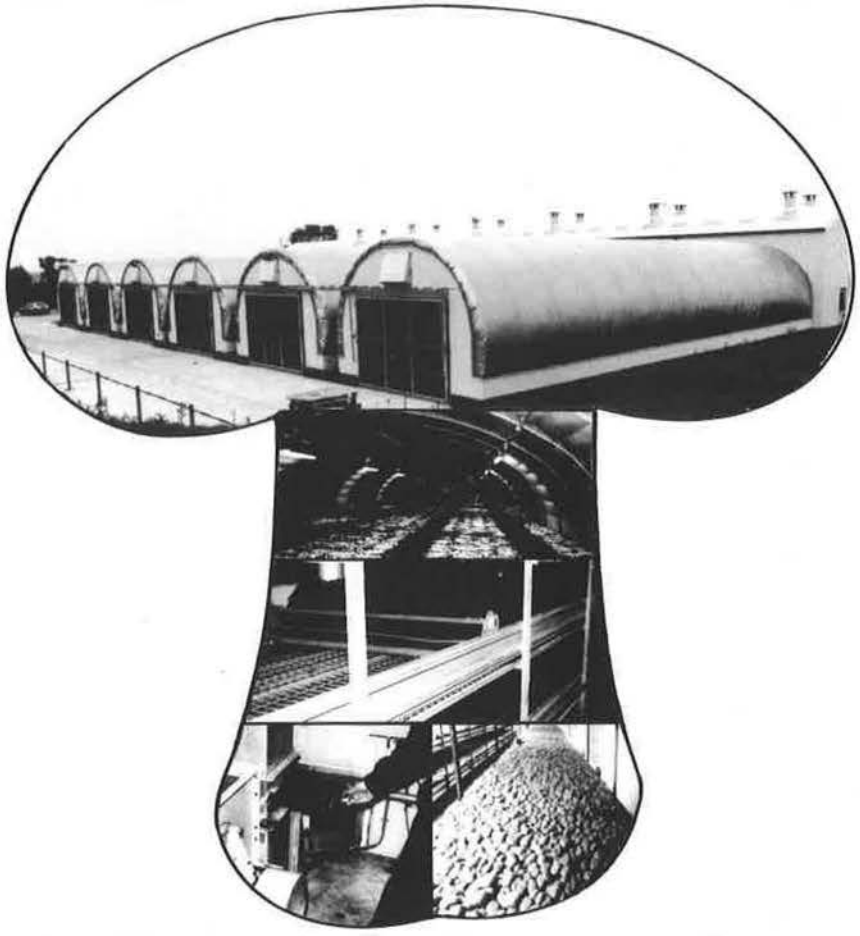

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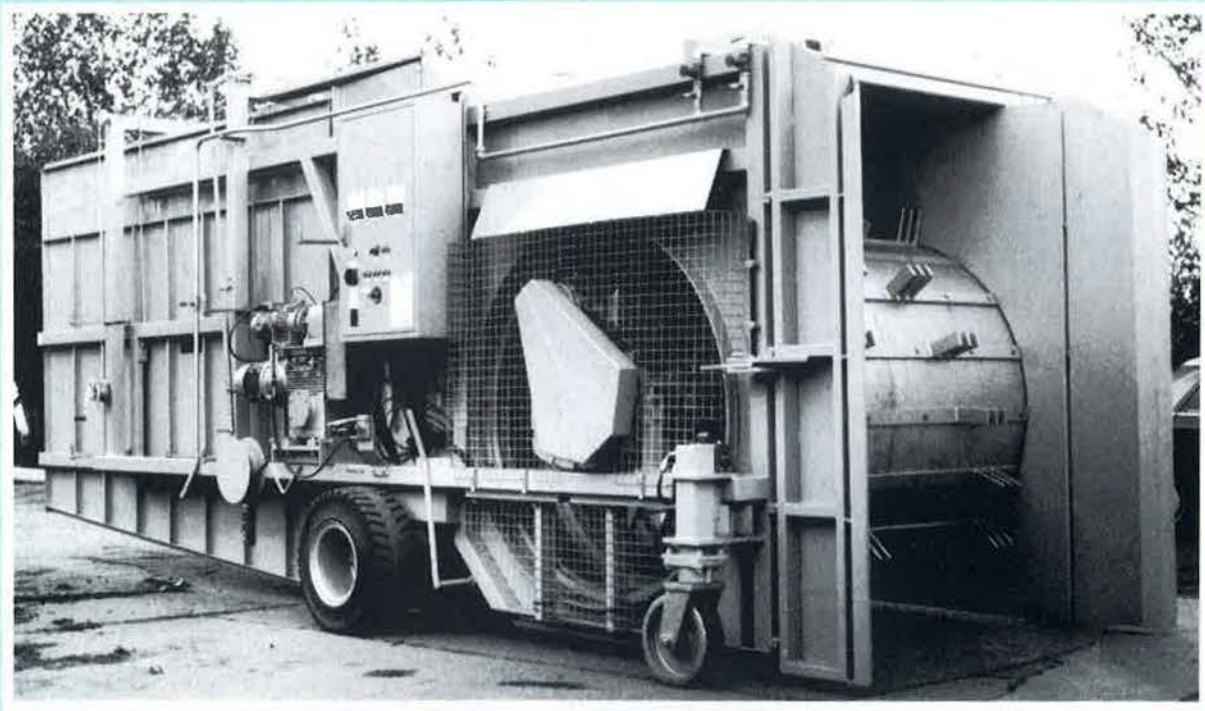

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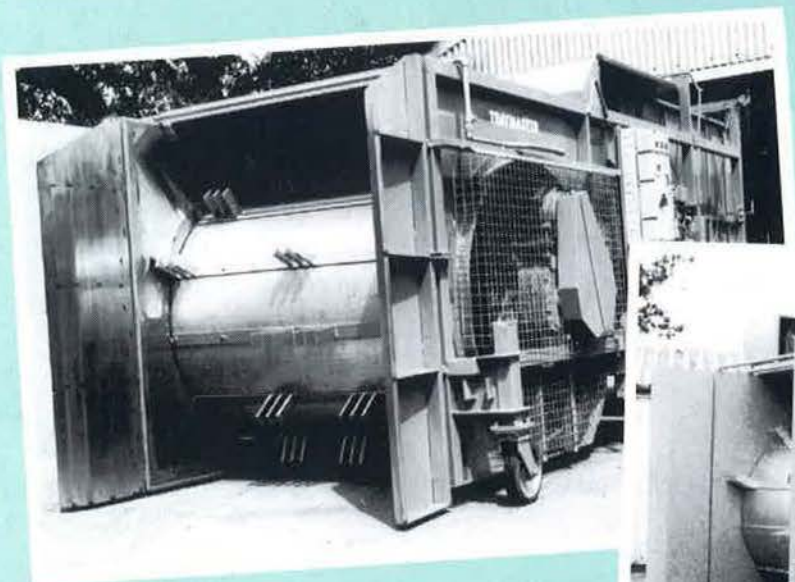

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