THE Mushroom JOURNAL

OFFICIAL JOURNAL OF THE MUSHROOM GROWERS' ASSOCIATION
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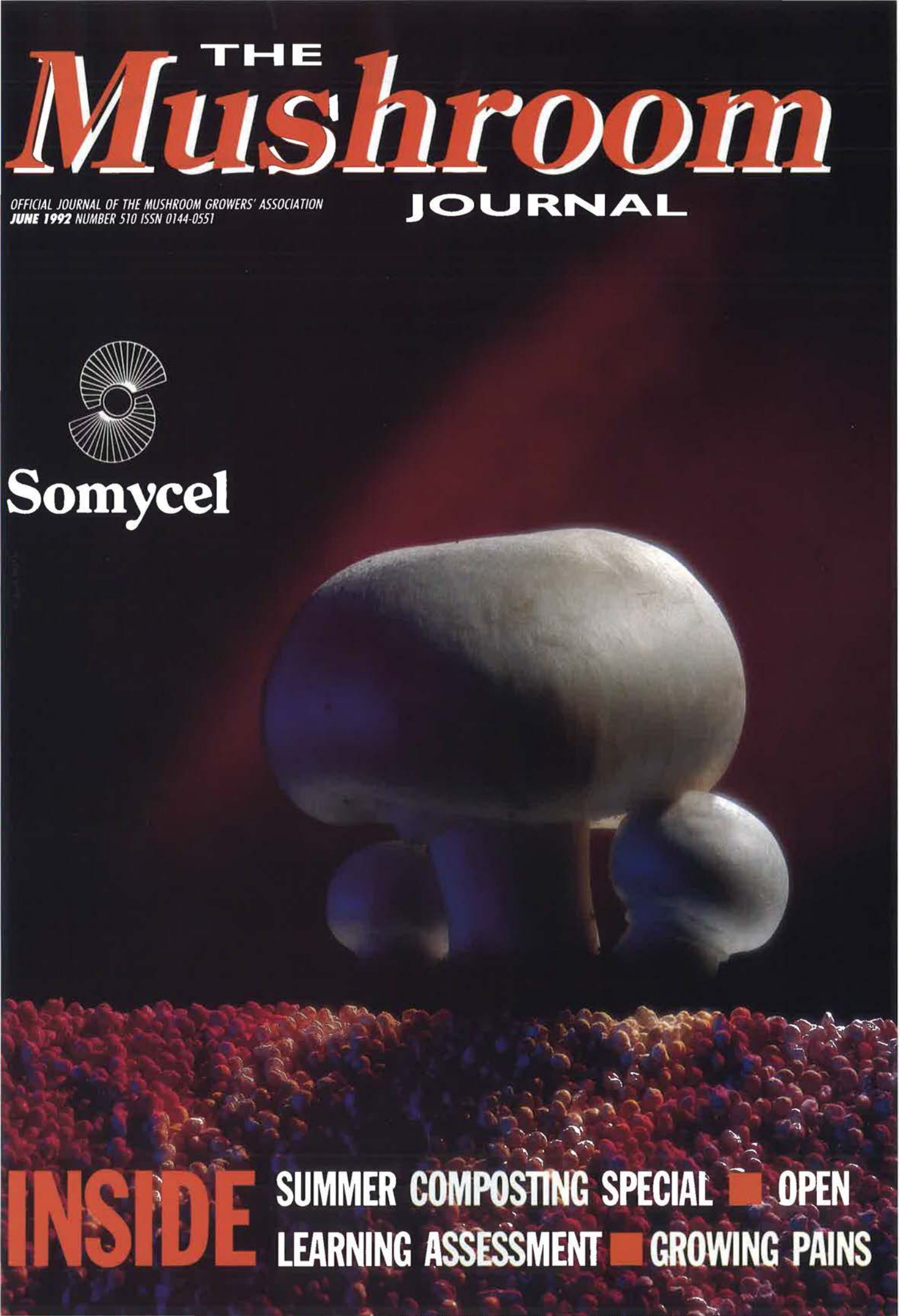
Somycel



INSIDE

SUMMER COMPOSTING SPECIAL ■ OPEN LEARNING ASSESSMENT ■ GROWING PAINS

Somycel STRAINS

		MILLETT	RYE	PELLET
AGARICUS				
— SMOOTH WHITE			*Somycel 521*	***Somycel 521P****
		Somycel 191		
	Bitorquis	***Horst K26****		
	Hybrid	*Horst U3*	*Horst U3 SS*	***Horst U3P****
	Hybrid	*Somycel 112*	*Somycel 512*	***Somycel 512P****
— WHITE			*Somycel 611*	
	Hybrid	*Horst U1*	*Horst U1 SS*	***Horst U1P****
	Hybrid	*Somycel 209*	*Somycel 609*	*Somycel 609P*
	Hybrid	*Somycel 205*	*Somycel 605*	***Somycel 605P****
	Hybrid	*Somycel 208*	*Somycel 608*	***Somycel 608P****
— CREAM		*Somycel 344*		
			Somycel 765	
— BROWN			*Somycel 856*	***Somycel 856P****
PLEUROTUS	*Ostreatus*	***Inra 3001****		
	Ostreatus	***Somycel 3004****		
	Pulmonarious	*Somycel 3014*		
	Pulmonarious	***Somycel 3015****		
	Colombinus	*Somycel 3030*		
	Ostreatus	***Somycel 3035****		
	Cornucopiae	*Somycel 3040*		
	Eryngii	***Somycel 3058****		
	Ostreatus	***Somycel 3100****		
	Sporeless Hybrid	***Somycel 3200****		
	Sporeless Hybrid	***Inra 3300****		
PHOLIOTA AEGERITA		***Somycel 4021****		
COPRINUS COMATUS		***Somycel 4030****		
LENTINUS EDODES (SHII-TA-KE)		*Somycel 4055*		
		Somycel 4065*		
LEPISTA NUDA		***Somycel 4101****		

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Articles for consideration are welcome; also letters for publication which should make a point strongly and as briefly as possible. They may be faxed or posted and should be addressed to the Editor.

The editor, editorial advisory board and the MGA do not necessarily support, nor are they responsible for, statements made by contributors to the Journal. The leading article is normally a statement of MGA policy.

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THE Mushroom JOURNAL

June 1992 **No 510**

EDITORIAL

Composting issues to be resolved

Two issues are paramount with composting, which is the fundamental activity to the whole of mushroom production. Unless the procedure and, therefore, the result is correct, nothing else in the production cycle can rectify the damage; quality of spawn, environmental controls of all kinds even when assisted by every advanced technique possible, all are negated. So the first major concern of any mushroom enterprise is to get the whole composting operation correct.

But having done this we are then faced with the second issue which, unless we take extreme care and watch our interests closely, could jeopardise the present structure of our industry. This is, of course, the business of reducing compost odours. To hear some of the discussions taking place at the moment one could be forgiven for thinking we had forgotten that the prime business of compost making is to produce mushrooms. So much debate goes on around the ever-increasing demands of the environmental lobby and the constantly-emerging edicts of the various departments concerned.

The compromise between our production requirements and the environmental considerations looks as though it will be difficult. In Holland, for example, they have concentrated on the indoor phase II stage of compost only to discover that both output and quality have suffered.

As with so many products these days we seem to be struggling between ever more critical demands of our major customers and ever more stringent limitations on achieving these which are placed upon us by regulatory bodies.

Perhaps, once again, we should look to research for the answer and expect that results from the HDC funded compost project will give it to us.

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WORLD OF MUSHROOMS

A European Fungi Conference will be held at Kew Gardens 7-11 September 1992. This XI Congress of European Mycologists will discuss the investigation, recording and conservation of European fungi.

During the congress, there will be a demonstration of mushroom cuisine.

Kew Press Office will be happy to assist in arranging facilities.

IPP are in the news again with the release of their new mid-range hybrid strain "Le Lion" X25. This new variety has been developed to provide more prolific production in the later flushes, and less in the first flush. It allows a more even flushing pattern to be achieved, therefore helping to improve both quality and yielding potential.

"Le Lion" CMS25 casing spawn is of course also available, and for further information about this variety we suggest you contact Stuart Whitehall of IPP.

Kitty Fearon – latest recruit to the MGA office – working as Accounts, Admin and PR assistant.

We have recently had news that the Vineland Station of the Horticultural Research Institute of Ontario, Canada, is to begin building a new mushroom research unit.

Plans include a research unit of six cropping rooms, each having over nine square metres (about 100 square feet) of cropping area, with a bed depth of up to 25.4 centimetres (10 inches). Each cropping room will be controlled by microprocessor.

Phases 1, 2 and spawn running will be carried out in specially designed small tunnels, and for filling and spawning operations the technology derives from a mix of tray and tunnel growing.

How green are your mushroom labels?

"If you're going to pick a labelling company, pick one that understands your business."

So says **Pricemaster** Plc's sales and marketing director, Steve Deakin. The company supplies labels and barcoding systems to Monaghan, Chesswood, Blue Prince, Pixie House ... "We are among the biggest suppliers of barcode system tray-end labels to the mushroom industry," Deakin says. "Our commitment is total. No labelling company invests more time and money in perfecting environmentally friendly methods," he adds.

We apologise for giving an incorrect address in February for J. and A. Symonds. It should have been "ELF Mushrooms", Woodlands, Church Lane, Aldeby, Beccles, Suffolk NR34 0DG.

Stabilised chlorine dioxide (Purogene) is now extensively used in the USA as a whitening agent and bactericide for the control of bacterial blotch (*Pseudomonas tolaasi*).

In trials, chlorine dioxide at 50 ppm, either alone or in combination with 0.075% calcium chloride, significantly reduced *P. tolaasi* infections, resulting in a large increase in marketable yield.

In the UK, the use of activated Purogene is permitted on the growing crop at 5 ppm, either on its own or with calcium chloride. Higher doses are currently awaiting approval under FEPA.

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droplet must be at least 50 micron, so a machine like the electric Dynafog Hurricane is more suitable than a conventional thermal fogger.

Available from **Fargro** of Littlehampton.

Fargro also offer biological control of sciarids. In trials on two south coast mushroom farms, Fightagrub nematodes were applied, after casing, using a coarse spray. Treated beds were compared to standard treatments of Diazinon and Dimilin. The level of control achieved by Fightagrub was equal to Dimilin and after the third flush significantly better than the Diazinon treatment. Fightagrub is applied at a rate of 10 million to 15m^2 of casing.

Details from: Toddington Lane, Littlehampton, West Sussex (0903) 721591.

DIRECTOR'S NOTES

Ken James

AGM decisions and consequences

A very good attendance of grower and trade members made for some useful debate on the issues brought to the AGM.

The Executive recommendation to reduce the promotional levy to 4.4p per litre was accepted, with only Chesswood voting against. They wanted a nil levy for 1992.

Unfortunately, both Chesswood and Blue Prince have decided to resign from the Association. As companies they are long and respected members, and we must be sad that they are not willing to help introduce the changes which the membership overwhelmingly approved. I hope that their decision will soon be reversed.

It is vital that the membership as a whole does not take panic steps, for the work of the MGA is just as important for the success of the remaining 85% of the mushroom market.

Council (previously Executive) action

Promotion **At its first meeting after the AGM, the Council followed the recommendations of the Working Party, as approved by the AGM, to set up a small working party to review not just the contribution system for promotion, but the whole subject. This will include: member attitudes, perceived and assessed real commercial benefits, funding needed, participants (review all organisations importing into the UK market), equity of funding by participants, with firm proposals made to Council by end of October. It is expected that this review will clarify the MGA's attitude and support for promotion for the future.**

MGA reserves will be used to give members a breathing space to assess this role properly. After the first quarter, collection of the spawn levy in 1992 will be suspended until the working party reports and proposals are agreed by the membership. Invoices will be sent, but will indicate that members may continue to pay voluntarily.

Ideas and thoughts from members are requested please.

Committee structure **The Council agreed a system of operations for working groups dealing with the many issues confronting the industry. It aims at maintaining essential continuity of input, inherent in the reference back from the AGM, whilst setting out clear work plans and reporting methods. Another move to give members better services.**

Role of Chairman **The Council accepted the view of the AGM that the Chairman's role and title be maintained.**

This first meeting, under the chairmanship of Geoff Ganney, was confident that the role and value of the Association can be appreciated and achieved if all members take an active part.

Success at European level

For over two years I have reported on discussions by the European Mushroom Group and the Commission, dealing with changes we need to give confidence against unfair third country imports. At its meeting early in May, the Group was pleased that most of the changes asked for have been incorporated into new regulations. These have a five-year term and should ensure that imports compete fairly in the European market. Full details are available from the office.

The European market and consumption

Following on from the new EC regulations, the group agreed to work on achieving higher consumption in all countries, to combat reports of poor prices and trading conditions throughout the Community.

Consumption in 1989 varied from under 1kg per annum in Spain and Italy, to over 3kg in Germany and Holland (still low compared to the five-plus kilos achieved in British Columbia!). Over the next months, ideas will be exchanged on the design of an effective fresh mushroom promotion. The possibilities of EC aid, similar to that received by the apple industry, will be explored. Any measures which take the pressure off the UK market will be welcomed by all growers. Promotion is a commercial concept, not something to fund when profits are high.

Quality standards

For two years there have been indications that the Commission would be seeking common quality standards for mushrooms. The recent agreement on import quotas and tariffs has inevitably led to the Commission wanting a base to work from.

The MGA started serious discussions to set UK standards at the end of 1991, but pressures on the Executive meant that work was stopped.

Four EC countries have adopted standards and, unless we move quickly, it is these standards which will be used as the basis for a common Community standard. We already know of some measures in other countries' standards which will be unacceptable in the UK market. Another area where the work of the Association will be vital to protect the interests of its members. The Council has agreed to set up a small working group to deal with this issue.

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A self-assessment of Open Learning

By Alasdair M. Day
Blue Prince Mushrooms

"There is much we ALL have to learn about Mushrooms!" says the Open Learning text. So, bearing this in mind, I would like to add my own response on how Open Learning has affected life on the farm since I embarked on my journey through Modules 1 to 7 about a year ago.

To start at the beginning, or rather Module 2, Composts and Composting. Part 1 of this module immediately sparked off some heated discussion with Keith Morrill, our production manager. For instance the title – "Why Compost?". Answer: "Right, now then..." and so the coffee break becomes an extended one.

As well as learning from the SAQs (Self Assessment Questions) and 'Activities', there is much to be learnt from the lively discussions provoked by similar questions.

This module also has a video accompanying it called "Compost Assessment", another topic greatly discussed, and a daily activity on most farms (weekly on ours, with our delivery of Burcross Compost). When a group of us took part in one 'Activity', filling in a score sheet showing our individual compost assessments, and the final scores were all different, another discussion broke loose. (As with all compost deliveries?)

The areas which remain firmly in my mind from Part 1 and subsequent discussions are stack ventilation, microbial activity, and stack temperatures; i.e. does compost really work at 65°C?

From Part 2, "How Compost Works", the table of raw materials and additives, the GCRI formulae for synthetic compost, and the calculation of how much chicken manure to add, and how to use other additives, were all food for thought as well as food for mushrooms.

Part 3, 'Phase One', turned up the bane of every compost manager's life – scheduling. Good old Christmas, Easter and "No, you can't have the horse manure today."

Part 4, 'Peak heating'. Obviously the Open Learning has to cater for peak heating on shelves, in trays and bulk pasteurisation tunnels; not that the theory is any different and the theory behind controlling phase 2 is dealt with well.

This is just a brief summary of what I have gained from Module 2, obviously its content is much greater.

PHOTOGRAPH KINDLY SUPPLIED BY PETER ATKEY OF HRI LITTLEHAMPTON.

Module 3 – Spawns, Spawning and Spawn Running.

Part 1 ties together the mushroom and its needs from the compost. Part 2 deals with the spawn and the mushroom, and Part 3 explains spawn running. Part 3 contains a very interesting picture of a mass of hyphae making up the mycelium and shows the short, spiky crystals of calcium oxalate. Have a look at the photograph, is this what grows into your casing?

One activity from Part 3 was quite revealing about our peak heated compost. We filled some containers with compost at intervals from the end of phase one right through to the end of phase two and added a little spawn to each one. It is amazing just what mushroom mycelium will grow in. (See picture over page.) Could this be a test for efficient peak-heating?

Module 4 – Mushroom Cropping was the module from which I learnt most, yet as growing manager expected to learn least. There is a copy of one particular table, giving the weight of water in the air at a range of temperatures and relative humidities, which now appears on several office walls and, what's more, is often referred to!

One exercise of current interest was to take a number of 2-litre lemonade bottles, fill them with spawn-run compost, and case them with different materials. It may be of interest to note that the materials used (Dutch-type casing, blended Irish peat, straight sphagnum and straight lime, etc) did produce different yields; the best yield being 43.3% (as a percentage of compost weight) and obviously the worst being 0%. I'll let you try this one yourself to work out which was which! ▷

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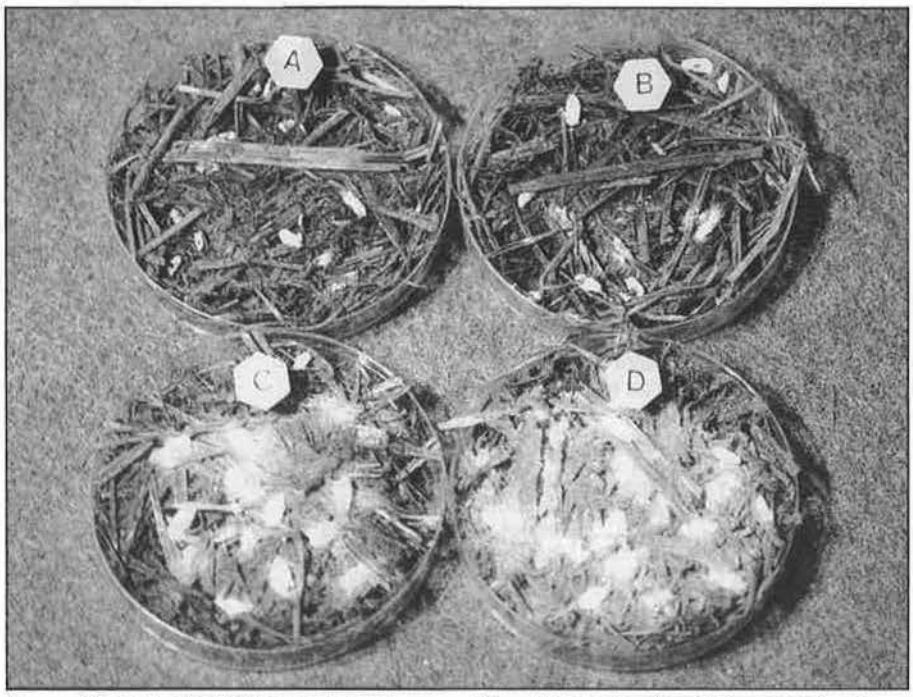
The experiments which were useful in our recent change from one form of poly ducting to another were those of measuring air speed across the bed, measuring the evaporation from the beds, measuring the direction of air movement in the growing room, and measuring the variation in temperature around the growing room. There is also a table which relates air speed ft/sec and humidity against scaling of the mushrooms. Quite surprising what air speed one can use over 85% rh; this prompted the dust to be wiped off the anemometer.

Again I would like to quote from the Open Learning text: "It is rather easy, after a few months of doing a job ONE way, to think you've got it all taped. However, it is useful to discover the value of experience, making use of others' mistakes, of their ideas and knowledge, as well as what you yourself learn from doing a job under varying conditions."

Now that I am well into the series of Open Learning modules, I hope to continue to gain the value of experience without making too many of my own mistakes, while putting the knowledge into practice.



A – 0 hours after filling peak-heat.
B – 18 hours after filling peak-heat.
C – 65 hours after filling peak-heat.
D – 110 hours after filling peak-heat.

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Geoff Ganney's GROWING PAINS

April Fools' Day

Telephone call from a major supermarket requesting us to pre-pack a mega fungus found in large hardwood forests, *Armillaria bulbosa*. A note in the *Daily Telegraph* had drawn attention to this phenomenon, which can spread over 40 acres, weighing about 100 tons – which is about the size of a blue whale. Well, what's new? Probably best to pre-pack it with a JCB!

2 April

Reduced deep litter chicken manure for our summer composting in order to help us complete phase II in time. Always have problems cooling down in the summer if we hold our nitrogen levels too high; then we had better look out for increased temperature surges during spawning growing. Well, that's our theory, which worked last year, but probably won't work this year.

3 April

Uneven casing moisture is a real pain this week, resulting in inability to even up water levels throughout the cropping sheds. This again leads to the need for extra waterings for levelling up mycelial growing, resulting in a delay in airing. So what's the problem? Just, in fact, that it makes us late in crop timing – something that in today's marketplace is totally unacceptable.

5 April

Recent arrival of some more eelworms made me contemplate our pasteurisation temperature of 56°C. Have often found in the past that, where this happens, some growers are tempted to go to 60°C or 62°C and also increase the time factor. Decided to stay as we are and watch for dead spots and wet compost. Overkill can lead to other problems!

6 April

Not really sure if the increase in casing depth to 2¼ inches on the supplemented crops at Woodhurst had any real effect. A trend towards heavier individual mushrooms appeared likely until we overpinned a first flush due to too dry a casing layer. Unfortunately, most mushroom trials rely on repetition in time and complete farm conversion to find a real trend. Probably what we shall have to do.

7 April

No sign of any sciarid flies, and can only conclude that the reduced crop cycle is preventing any build-up. Am very concerned about the rabbit damage in some Marigold crops! Have you ever seen rabbits scratching out trays of compost to form a new burrow?

9 April

Casing on young spawn runs is giving rise to delays in mycelial growth into the casing. It certainly is not making watering that easy, and the limits for grower error are greatly stretched. Problem only arises due to a shortage of facilities, but is one we at present have to cope with to get our throughput of crops.

10 April

Contemplating looking into hardwood for constructing trays – may well pay in the long-term. Remember many years ago when looking at crops growing in French caves that many trays were made of rough-sawn oak. In the end, it will no doubt come down to price, life of the timber and timber stress factor. Still going to line with polythene.

12 April

Attended a wonderful lunch party in celebration of Joan and Hugh Barton's golden wedding anniversary. Good to see Jim Sinden, Bill Allen, Winston Alderton and many others from the mushroom world. The talking was endless, as were the memories that unfolded.

13 April

New ADAS logo had me standing on my head to work out how a few arrows could make up a representation of land, growth and forward movement (that part was a maybe!); and how it helped the independent status was about as clear as our aerated 'goody pit'.

14 April

Editorial board meeting covered many topics, and the debate on your Journal's progress is always prolonged. But please let us hear from you with constructive criticisms, ideas, thoughts on how to get more desperately-needed advertising, letters, items of interest, or any other subject matter that is likely to be of interest. What did you feel about the first attempt at a 'Yearbook'?

15 April

Introducing any new type of mushroom pack seems to raise problems with acceptance from supervisors and pickers. I suppose that, with the vast range being catered for, any additional item is likely to be the straw that breaks the camel's back. It is, however, an unfortunate fact of mushroom life that, in today's market place, the range of packs is likely to grow rather than shrink.

17 April

Lighting in mushroom sheds always seems to be a topic where it is more guesswork as to the best layout, rather than there being an efficient methodology on the topic. No doubt, somewhere in the depths of some Dutch company's files, there is a satisfactory answer.

19 April

Damp mushrooms giving rise to quality control problems on the Woodhurst farm, and basically this is due to poor exhaust vent design. Balanced louvre exhaust may be fine, but not when high outside wind pressure stops them opening. Sounds like a sledge-hammer job!

20 April

Each of the three farms were down last week by about the same relative percentage! Same compost, same casing, same everything, except growing environment. What do we conclude? **A total week's poor compost**. But why? And how do you find a way to interpret the compost before you have to spawn the thing? Then some extra nutrition could be added for natural success. You mean there is not too much natural success in mushroom growing...

21 April

Identification of the correct type of bubble disease found on mushrooms has true significance in combating the problem, not solely from a chemical standpoint, but also in hygiene priorities. Due to some significant changes in morphological reflections, I would defy the probability of accurate visual diagnosis. Laboratory examination is essential – is it a 'dry' or 'wet' bubble?

22 April

Phew, what an AGM! Must carefully arrange next year's holiday programme! The association has come to life again – discussion, debate, anger, ideas, near turmoil, passion and concern and a positive attitude to improve. Not total agreement on the way forward, but then that's no bad thing if time can be taken to discuss and agree a mission statement (objectives) for the association to progress along. Much more could be said, but not here. But here I can recognise the tremendous effort put in by outgoing Chairman Jim Dumbreck (not forgetting his wife Margaret's continual support), in what I would describe as not the most calm times. Greatly enjoyed working with Jim, and we certainly have made a lasting friendship. It was a pleasure to be able to have the privilege of presenting my dear friend for 26 years, Fred Hayes, with a decanter for his 20 years' service to the association as ISMS representative. **Fred, you are a true Mushroomologist.**

23 April

Recovery is slow! Not sure if I was elected Chairman, President, or just a prat! Time will tell and honour is to be cherished, and just as real, **whatever the name**.

First act in the new role as Chairman was to install two new correspondence trays. One **'In'** and the second **'Deeper In'**.

24 April

Still thinking about mixture uniformity of casing mycelial supplement when Mike Walton's letter arrives. Kindly, he says I can use it.

"A letter prompted by your "Growing Pain" for 7th February.

As you know, I recently visited your farm to examine the addition of the Growmaster to the pre-mixed casing soil. The casing was all that you describe in your notes for 7th February, but it does result in a very high moisture, very well-structured casing once applied to the beds.

Without doubt, casing soil of that structure from the preparation shed contributes greatly to the difficulties in effective mixing of casing additive. I also believe that it is the difficulties of mixing rather than particle size that give rise to the clumping on first breaks. Poor mixing invariably causes areas that are over-dosed and, while waiting for the under-dosed areas to be sufficiently colonised, the areas showing over-growth will inevitably clump. In other words, the compromise causes the problem.

*As to the solution, pre-mixing the Growmaster would be ideal but absolutely **not** recommended, since storing the casing containing Growmaster would offer an excessive hygiene risk.*

A reduction in the casing soil moisture would improve mixing qualities but, without doubt, this would be a retrograde step.

Shredding the Growmaster would also be counter-productive. Whilst offering more inoculum points, I feel you would continue to have over-dosed and under-dosed areas just the same. Considerable research effort was applied to the particle size and a certain minimum size offers much protection to the mycelium, especially when casing is very wet and close to being anaerobic. Especially in your particular casing soil, there is some advantage in the additive having a granulate structure.

Accepting the structure of your casing soil, I believe improving the uniformity of the flush revolves around the quality of the distribution and mixing.

The point of application seen seemed to be the best possible and, at the time of the visit, two people applying the product simultaneously was improving the distribution. Further improvement could perhaps be made by considering some form of mechanical distribution."

Many thanks for your thoughts, Mike.

26 April

Still unsure that the spawn is being mixed throughout the compost as uniformly as we would like. Mycelial growth seems more downwards than growing in all directions at the same time. Not too good when casing on eight days' growth. Coupled with some low temperatures during the first few days of spawn growing, it is not an ideal situation. Decided to revamp the whole spawning system.

27 April

Agreed to increase white peat percentage in the casing mix in order to alleviate some of the heavy, sticky, sludgy casing we have run into. It is quite anaerobic – don't really know why it has suddenly occurred. The blend is the same (but obviously is not!), water and machine time is unchanged. It has to be that the peat structure is different. Ray Samp spent the day encouraging me that our casing mix consistency was a load of crap! Well, to put a fine point on the subject, he was probably right. Then again he may not be! So we need to analyse, debate, seek out any variance, encourage uniformity and generally improve the housekeeping.

28 April

Visitation from the NRA to Marigold for the second time in a month has certainly concentrated the thinking on farm hygiene practice. Reductions in organic matter, stalks, split mushrooms or any debris being swilled directly into drainage channels has been dramatic. Chemical had been eliminated some years ago. Requirements to meet NRA standards will, however, require great improvements. There is some concern as to how to **design a clean waste water system** for a mushroom farm. I mention this as the significance to many mushroom farms is not yet understood but, I can assure you, will quickly have to be understood.

29 April

Greatly intrigued to see a workshop on 'Speciality Mushrooms' being organised at Penn State University. It is based on aspects of research and merchandising of such varieties of mushrooms. While perhaps not yet enough support in the UK, it would no doubt find favour on a European basis. The recent article in the *Grower* magazine illustrating pink mushrooms, yellow mushrooms and grey mushrooms, greatly illustrated the variety of products becoming available.

30 April

Reflecting on the presentation to Fred Hayes at the AGM for the days of the Aston seminars. No question that having a day to a specialised subject, with plenty of debate centred around top-class speakers, proved the most stimulating of mushroom events. Perhaps it is time to re-invent.

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Watering

By Peter Flegg

Watering mushroom beds can easily come to be regarded as one of those routine, and very boring jobs on the farm. Because it is a very frequent farm operation, it may not always receive the thought and constant re-appraisal it demands.

Supply and demand

Although the reasons for watering mushroom beds and bags may seem obvious, it may be worth a few moments thought on where the water for the crop comes from and where it goes to. Without doubt, some of the water for the crops must come from the compost and judging by the effects of watering on crop water content, some must also be drawn from the casing. What proportion from each is difficult to tell and no doubt varies.

Obviously water is removed in the mushrooms harvested and in the chogs. Another major loss of water from the beds is through evaporation from the casing surface from the mushrooms themselves and, if you are not on bags, any exposed compost under the beds. It has been calculated that a mushroom, while developing from pinhead to cup, can lose through evaporation an amount of water equivalent to half its weight when picked.

Actual amounts of water applied to the casing are not often quoted. What is satisfactory on one farm could well not be at all appropriate on another and the quantities are probably not even measured on many farms. So, watering has become a job requiring a considerable amount of skill and experience in being able to judge how much water the casing will hold without the compost and mycelium below it becoming damaged and, at the same time, leaving enough free air space in the casing to allow air and carbon dioxide to pass through.

Points to watch

Several factors contribute to a successful watering regime:

A uniform casing depth

There is not much point in being able to put on an even application of water if the casing on which it falls varies in depth from, say, 1 to 2 inches (25-50mm). An even depth of a uniform casing mix is most important.

The thoughtful application of water

While it is useful for a waterer to be able to apply water evenly over the casing surface, it often happens that the casing layer is not uniformly moist. There will inevitably be areas which have dried out more than others. The amount of water applied must be varied appropriately. Diseased patches must be avoided.

Care is also needed to avoid an excessive overlap in the fall of water from the hose. Several passes from side to side without care can soon result in alternate bands of casing which have received a double dose of water. Fortunately, there is some lateral movement of water in the casing so there is scope for some minor evening up. However, this sideways movement of water will not cope with grossly uneven water applications.

Awareness of evaporative losses

Changes in the rate of evaporation in the mushroom cropping house can sometimes catch out the most experienced growers. A common fault is to develop a watering routine and then not to notice a change in the weather. Or perhaps, more likely, not to relate it to what is happening inside the growing rooms.

Even expensive environmental control equipment may not entirely eliminate the effect of the weather on the cropping house conditions. Farms with just a basic system should certainly have to keep an eye on the effects of the weather. Get used to noting the evaporative conditions in your houses. Watch how readily floors, walls or bed side boards dry out after watering. If it is feasible, make a point of wetting a selected area of the floor every time you water and maybe also in between waterings, as well as notice how quickly that patch dries out and adjust your watering regime accordingly. Carrying on watering 'normally' when the casing is just not drying out can soon lead to poor pinning, slow cap development and disease. Remember, keep your weather eye open!

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The Sinden Lecture Part 2

The high-yielding, simple indoor composting system

By Gerard Derks

In our high-yielding, simple indoor system the routine of pasteurisation is the same as already adopted everywhere in the tunnel system. Normally pasteurisation takes six days, and the whole process of fermentation and pasteurisation is carried out in a maximum of eleven days.

There is only one big difference: the weight of compost that remains after pasteurisation is significantly higher than in the traditional system of preparing the compost. If we start in the traditional system with one ton of air-dry straw and we then add water, chicken manure and gypsum in the usual proportions, we will end up at the end of the fermentation with roughly three tons (100 kilos, more or less). Then pasteurising this material in the tunnel we lose about 26%, which then brings the weight of the material to 2220 kilos.

With the system described above, starting with one ton of straw again and adding more or less the same ingredients, we have at the **end of the pasteurisation** always at least three tons of compost ready for spawning. The moisture content of this compost at the moment of spawning is of 69-71%.

Unfortunately, at this moment I am not in the position to give you the explanation of this phenomenon, but I would like to tell you something else about composting. I have been growing mushrooms for 40 years now – yes, I am growing old – I have turned my compost with a fork and I have adopted the most mechanical means available nowadays to do this job.

In 40 years of composting, I have understood that our compost is not stupid, that we can talk to our compost if we use the proper language, and that our compost will reply and react to our language if we behave as an understandable grower.

Paul Middlebrook congratulates Gerard Derks on receiving the Sinden Award.

Forty years in mushrooms have enriched my knowledge and experience in this field but, at the same time, I have understood one very important fact – the bigger the island of knowledge and experience, the longer the coastline of doubts. And this most important fact is frequently forgotten by newcomers and technicians in our profession. They are often inclined to think that they can resolve compost problems with chemical formulae and physical laws.

If you do not understand your compost, your compost cannot understand you, and cannot react to your instructions.

By examining our compost with extreme interest, week after week, month after month and year after year, and, so to say, by talking to our compost, we have obtained the results mentioned above. We ourselves feel that often we are not able to explain why certain facts and certain changes are happening.

As I said before, in our experiments we have been aiming from the beginning to increase the quality and productivity of our compost. Also here the results have not let down our expectations.

Apart from his composting enterprise, Mr Francescutti owns a mushroom production plant of 28 houses, and obviously all the compost for this plant arrives – in bulk – from the Agrifung compost plant.

Some 80 growers in the area, and other regions in Italy, also buy their compost from Agrifung. During the past year I have followed the production of this new compost, and an accurate observation of the results gives me the following figures.

Compost in bulk, in blocks or in bags, partly tunnel-incubated and partly only spawned, shows a return of 35% (350 kilos per ton) for at least half of all compost delivered. Thirty per cent of the compost delivered does not reach this average, but about 20% of the delivered compost produces over 35%, and I have personally verified cases where the production was as high as 40-42%. The figures given refer to untrimmed mushrooms.

The difference in yield per ton of pasteurised compost lies mainly in the growing facilities of the local production enterprises. In Italy we have people that grow in well-equipped houses, as well as people that grow in old buildings, caves, etc. So it is obvious that the results cannot be at a maximum level in all circumstances.

We have also discovered, generally speaking, that the quality of the compost prepared according to this system is much more consistant than compost prepared in the traditional way.

In the traditional system, it happened now and then, to our surprise and to our alarm, that a given lot of compost was not up to the usual standards. In two years of experience with this new compost we have noticed that the quality is always very consistant and almost without any fluctuations at all.

This, in our eyes, is another big advantage for the compost prepared the way I have already described.

Also here, unfortunately, I cannot give you an explanation of the reasons, but the facts have spoken very clearly for over two years now, considering thousands of tons of compost every week.

If we have to make a balance of the pros and cons of the system, we can state that we have the following advantages:

1. With the system described, we can realise a significant increase in production per ton of pasteurised compost. Compared to the traditional system of fermentation in the open (at least nine days, without counting the time for mixing the raw materials) followed by pasteurisation in tunnels, we can prove any time and anywhere that we have an increase in yield of 10-15%.

2. Due to the fact that in our system we can work with a much higher (and for this system necessary) moisture content in the compost, and due to the fact that the loss of material by combustion is much lower than in the traditional process of fermentation, we are saving about 30% on raw materials.

3. For some reason or other, the quality of the compost prepared in accordance with this system is more consistant and extremely secure as far as end results are concerned.

4. As already stated at the beginning of this lecture, the system can be transformed in a very simple way into a most effective indoor system, with a relatively very low investment.

5. As described before, the area necessary for mixing and fermentation is very small compared to traditional systems and, as a consequence, does not demand an unreasonable amount of investment.

6. The system is very fast and does not require much labour. Buildings are used at their maximum and the full mechanisation eliminates expensive labour. Experience tells us that we save at least 60% of labour during the fermentation process.

7. The machinery involved consists of a straw-cutter, two screw conveyors, some belt conveyors, storage for the mixture of chicken manure and gypsum, a distributor for same, three simple tunnels with ventilation, an air-filtration plant and some additional equipment.

As an indication of the cost of the whole complex as just described, we reckon that a figure of about $750,000, including the buildings, would be sufficient. It must be understood that this figure varies from country to country, according to local circumstances. In any case, the cost of investment is significantly lower than for a traditional compost yard.

At this point I would like to underline once more the enormous efforts that have been put in to obtain these results. Credit must be given to Mr Bruno Francescutti and the staff of Agrifung for always being alert to finding new and, above all, **practical** solutions.

Twenty years ago they invented the tunnel system, and today it is almost impossible to think of a mushroom plant that is not using tunnels, pasteurised and/or incubated compost. With their invention of this "instant compost", as described in this paper, they have proved once again that they have the possibilities and capabilities to find a new and practical solution.

Mr Chairman, ladies and gentlemen, for 40 years I have considered the art of mushroom growing a very fascinating business. Either you have this art in your veins or you have not!

If you want to be a real mushroom grower, and if you want to be a good compost maker, you must be able to talk to your mushrooms and to talk to your compost: and believe me – after 40 years of experience – your mushrooms and your compost will understand your language and will react to your language as long as you are expressing yourself in the proper way. And from that moment onwards, chemical formulae, physical laws, computers and other sophisticated equipment can do the rest.

Mr Chairman, ladies and gentlemen, thank you very much for your attention.

This month we spotlight composting with special attention to summer conditions.

Comments on summer composting

by Dr James W Sinden and John A Peaker

Many growers in the temperate zone are afflicted by having reduced yields in late summer and early autumn. Mostly the cause is attributed to faulty composting during the summer season when high temperature and humidity reduce the air flow through the ricks. Certainly the environment does play a part, but the problem is more complicated than that.

Growers who live under the favourable autumn, winter, spring climatic conditions for composting should realise that there are successful growers whose composts are subjected to hot, moist conditions for most if not all of the year. They do not have to modify their composting process much, if at all. They show that mushrooms can be grown in an atmosphere much hotter than anything the British growers face. What do they do differently?

Like all successful growers they have understood that the product is the goal, a soft, darkened substance capable of sustaining vigorous growth and high yield of mushrooms without allowing intrusion by the familiar weed molds. The process by which this requirement is attained need not be adjusted nor changed throughout the year.

In the halcyon days of the future, when all preparation of the mushroom nutrient is done under controlled environmental conditions, the need for modifying the process to meet seasonal changes will disappear for the temperate zone growers also. Until then, they are faced with ricks in a yard and adjustment of the process to meet those changes.

So what to do? We would advise that those growers fix their attention on the product rather than on the process. For nine or ten months the process needs little change, and it is only in summer when suddenly a drastic adjustment becomes necessary. In other words, a hot environment is worse than any cold or moderate condition, even the coldest part of the winter.

Usual fault

Undercomposting is the usual fault. Look to the spawning line, whether phase II has been done in bulk tunnels or in trays or beds. What are the signs of undercomposting to look for? Simple feel and appearance can tell much. Darkening may give a false impression. If the compost has a mixture of ingredients including straw and horse manure, some ingredients darken rapidly and tend to coat the rest to give a finished appearance. Take a sample and wash it out with running water. The straw is likely to be still bright yellow and the waxy surface still shiny.

The feel of the compost for brittleness is important. If scratchy, hard bits remain, the lignin, stiffening part of the straw, has not been altered enough during composting, even though the cellulose chains have broken down allowing easy twisting apart a handful of the compost.

In a simple incubating oven set at 35-40°C (100-110°F) a sample of the compost should not become overgrown with molds or actinomycetes, indicating that food for the thermophiles is still present. If growth does occur, these organisms, while dormant at low temperatures, are going to take over again after spawning, perhaps when the spawn has grown enough to raise the temperature into the 30°C (86°F) range. They can quickly raise the temperature above mushroom range, killing or slowing its development.

The common inkcap also grows best at 30-35°C and, while not a thermophile, is often a good indicator that the composting has not been completed. Growers tend to believe that its growth is promoted by the presence of ammonia. While it is more tolerant of ammonia than the mushroom its abundant growth depends on the higher temperature and the presence of undigested carbon compounds.

The problem of summer composting is complicated by the tendency to increase the drier outer layer of the ricks as compared to the inner hot area. In an attempt to keep this dry layer wet enough to compost, the inner part becomes too wet, thus actually causing soggy centres through which the air movement slows down and the anaerobic core enlarges. This condition becomes evident when the centre sags leaving a trough down the middle of the rick.

Meanwhile the colder, outer layer in the range of phase II temperatures increases in width. It actually undergoes phase II composting, losing available sugars and other carbohydrates to the point of using up those needed for the later real phase II. The straw breaks down enough to look ready for spawning. In fact it is ready and yet is mixed back into the rest, and becomes badly overcomposted, as well as wasting nutrient that should be reserved for the mushroom.

Present drum turners rarely have the capacity to vary the flow of water across the rick. Thus, the attempt to get the outer layers wet enough causes the overwetting of the interior.

One remedy used is to reduce the cross section of the stack by narrowing it. Many drum turners cannot be adjusted very much for narrowing during the hot season. The limited width change causes the height of the rick to reduce, and that again affects the air movement through the rick.

Another factor affecting summer composting is the necessity to use new straw very soon after harvest. The new straw may come as bedding with the horse manure or be what the composter adds

at the farm or used as a complete substitute for horse manure. The lignin and the outer waxy cuticle of the straw do weather within months after harvest, often from attacks by micro-organisms acting at ordinary atmospheric temperatures.

So much for the causes of problems with summer composting. Remedies are not always easily applied.

Narrower, higher piles help. So does compacting the outsides of the rick. Compaction of sides is not easy but doubtfully can they become too tight to impede the flow of air? Differential watering from exterior to centre is a great help. Better to have the centres too dry than too wet. What is too dry? Below 65-70%. What is too wet? Above 75-80%. Usually these limits can be determined ordinarily by a simple hand squeeze. A hard squeeze resulting in only a few drops of liquid is in the low range. A similar squeeze that releases moisture easily up to a stream is in the high range. The outer layer should be in that range after turning.

One problem of the so-called cross-mix turners is the tendency in hot weather to have all parts of the rick evenly wet. If the turner can be rigged to allow the outer layer of the new rick to be wetter than the centre, that aim should be accomplished.

As to composting time, all three phases pre-wet, phase I and phase II should all be lengthened in summer, especially if new straw is involved. This may sound puzzling coming from we who have always been advocates of short-composting, which we still are. But composting during hot weather aggravated by new straw can be slowed up. How much? There is no exact time to fix. Our interest focuses on the product and not the process.

The Quincy farm in Florida, USA, has adopted a successful method of overcoming the problems of hot weather composting in their sub-tropical climate. They protect their ricks as soon as they are formed and, after each turn, with a specially-made cover of plastic that extends over the top and nearly to the concrete on each side. This is made over the top of a woven plastic that is airtight. The sides are of a fine netted plastic that would allow as good aeration as tightly compressed side compost.

Such a cover retains moisture without impeding aeration, and increases the amount of hot part without causing an increase in the anaerobic core. The farm using the cover has a high yield without suffering any summer lows.

In any case, the final finish to composting depends on a successful phase II, no matter what has gone on in phase I. Phase II can remedy many of the problems encountered in outdoor ricks. Probably phase II in bulk processing is better controlled than in beds or trays. The optimum temperatures of 48-53°C (118-128°F) are easier to maintain in a bulk tunnel than in a layered situation because the temperature, volume and pressure of needed air within, whether new or recirculated, can be very adjustable in the compost and blown through directly. In layers where the circulation must depend on the biological production of heat to propel the air, especially in the early stages, the ambient air must be cool enough to increase the circulation, and even then may not be adequate at first. During the first day or two the compost may heat too high in the centre while the surfaces are too cold.

Under either situation the product may be equally capable of producing the same yield, but layered compost requires more careful handling by a knowledgeable controller. In bulk rooms computerised programs are successfully applied.

Again the product, not the process, is the governing factor. If the phase I composting has been completed to the point where an overabundance of easily digestible carbohydrates is still available to feed the thermophylic flora, then phase II must be prolonged until these are exhausted, otherwise overheating during spawn run and the development of weed molds will result.

Beating those summer composting blues

By Simon Middlebrook

Introduction

When people from outside the industry visit a mushroom farm, they are invariably surprised at the complexity of modern intensive mushroom production – the cool chain requirements to maintain product quality; the aesthetic demands of crop presentation to the customer; the level of technology now commonplace to provide the optimum environment for crop development; the investment involved in bulk phase II; materials handling systems and so on.

Take these same people to the heart of a mushroom farm – the composting yard – and they are equally surprised at what appears to be, in comparison, a very antiquated area. Compost preparation is probably the most basic yet, conversely, the most complex of the technical aspects of mushroom production. Farms that produce well can suddenly experience reductions in crop performance as a reflection of alterations in the composting process. Whilst modern facilities allow the grower to have considerably greater influence and control over the volume and quality of crop produced, compost quality has the largest impact on final yield. As a process, it therefore deserves the level of attention to detail that is the hallmark of successful mushroom growing.

Composting is made up of three clearly recognised stages – pre-treatment phase I and phase II. As a largely outdoor process (75% of the compqsting time is "outside"), the weather exerts considerable influence on day-to-day composting. Maintaining compost quality through the summer period – or beating the "summer composting blues" – usually in crops during August to October – encompasses more than a wary eye on the weather.

The quality of composting and, therefore, its productivity, is influenced by a

practical understanding of the process and management of:

a) those areas where influence can be exerted:
- raw materials – both type and quality.
- composting schedule.
- materials handling.

b) aspects that cannot be controlled but have a significant impact on:
- seasonal changes in raw materials.
- environmental conditions.

c) the tools available to monitor the process and its inherent change:
- organoleptic perception ("feel").
- analytical interpretation.
- management skills.

Raw materials

Historically, the main raw materials used for composting have been wheat straw based horse manure and water, with additional supplements such as deep litter poultry manure, gypsum and, for instance, cotton seed meal and other proprietary activators. Over recent years, wheat straw supplemented with deep litter poultry manure has become an increasingly popular alternative.

Of these materials, straw provides the basic composting ingredient. Straw used for bedding horses has to be clean, *i.e.* mould free, to avoid respiratory difficulties. As such, fresh horse bedding has provided a good base for composting. If left for any length of time, however, the effects of degradation from the mix of urine and droppings can result in the use of a moulding, burnt out material.

In the early 1980s horse bedding provided the bulk of the compost at Middlebrook, Selby. This was collected from up to 100 stables – a combination of racing stables, studs, riding schools etc. Collection time was variable, particularly in the summer months, with larger stables providing a regular supply in under seven days, but smaller suppliers had gradually been allowed to exceed that to two weeks between collections, and in some cases even extend up to a month. This meant that considerable volumes of poor quality material were therefore entering the start of the composting chain, making control difficult and a reliably consistent product unlikely.

A review and resultant rationalisation of stables to match collection capabilities effectively resulted in a reduction to 50 stables within a maximum collection period of 7-10 days, giving a more reliably consistent product with which to work. These circumstances highlighted how a satisfactory material could be provided from clean wheat straw. This is not difficult in winter, but in summer, with significant reductions in use of bedding, collections become more difficult if adequate volume is to be picked up. This results in a potentially very variable product, comprising a mix of untouched straw and areas where significant moulding has begun.

A reduction in stables resulted in increased use of straw based compost – wheat straw and poultry manure, to blend part way through pre-wet with the horse bedding, representing on average 50% of the composting mix. The potential for straw based mixes, allowing more control over composting consistency, became more and more obvious as availability of horse bedding of a suitable quality became more difficult.

As a result of a programme of fine tuning, Selby moved through 1986-88 on to a full straw based compost. The move to this mix, where it can be viably undertaken, undoubtedly removes a major seasonal variable as a result of the elimination of horse bedding. In order, however, for the consistency that can be achieved on straw based composts to be realised, straw quality previously guaranteed by the stable owner ensuring a good clean product for his horses becomes very much the composter's concern.

Prior to 1985, wheat straw came onto the farm conventionally baled (small bales). Conventional baling results in a shorter straw by the nature of the physical damage exerted by the baling rams. The increased use of straw resulted in examining round bales as an additional means of supply, particularly after experiences with the 1984 harvested straw which had grown through a particularly wet spring and, as a result, was well leafed and had proven difficult to adequately break up in pre-wet the following year. Round bales, therefore, provided an ideal means of both handling straw and achieving a material of a good length. Volumes of round bales, therefore, increased significantly as bulk spawn running was introduced, where concern was focused on the length of material available due to the additional handling involved through the bulk system.

The summer of 1986, however, was notably wet through harvest and baling conditions were, therefore, difficult. By spring 1987, straw quality was showing significant deterioration with considerably moulded straw indicating higher baling moisture the previous year, making compost preparation again difficult through the summer period as straw quality declined.

The impact of poor quality straw as a raw material, whether as older horse bedding or poorly baled straw, highlights the requirement to prepare for the summer months not only by inspection of materials immediately prior to use but also making time each year to look at expected straw quality prior to harvest, *e.g.* drier or wetter spring, volume of leaf, disease levels and, during harvest, baling conditions, straw conditions, moisture and, additionally, storage thereafter.

Clean straw, baled in the right conditions by suppliers who must be sympathetic to your needs, allows considerable confidence in the quality of next year's summer composts.

Environmental factors

Pre-treatment and phase I are significantly affected by changes in environment conditions and, as the most important stages in composting, require constant attention in order to maintain production potential.

Winter composting in the UK provides a good climate of moderately cool temperatures with, in recent years, few difficulties with extremes. Temperature differential between composting materials and ambient encourages the process. Rainfall, whilst providing an embarrassing excess of goody water at times, necessitates some careful watering to prevent overwetting.

Summer conditions, however, demand more perseverance to maintain the end product desired. Ambient temperatures of 28-30°C have become much more commonplace in recent years. These high temperatures can be supplemented with either very still conditions or very drying winds.

Anaerobic conditions can readily develop. Achieving and maintaining moisture levels becomes increasingly frustrating. As a final twist, the resulting undercomposted material can create difficult clearing problems in phase II.

This last stage of composting, relying as it still does in most cases on ambient air for temperature control, is affected as higher volumes of fresh air are needed to control conditions due to the reduced chilling effect of the warmer ambients. A greater volume of ammonia is more readily driven off to atmosphere as opposed to being converted and greater moisture loss can be a problem.

To minimise the overall impact of summer conditions – *i.e.* to ensure that the productivity of the end product is not impaired, necessitates ensuring that adequate time is allowed in pre-treatment to

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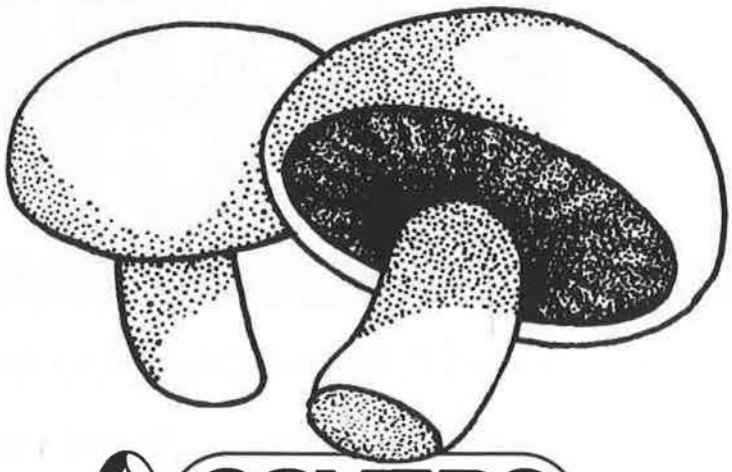

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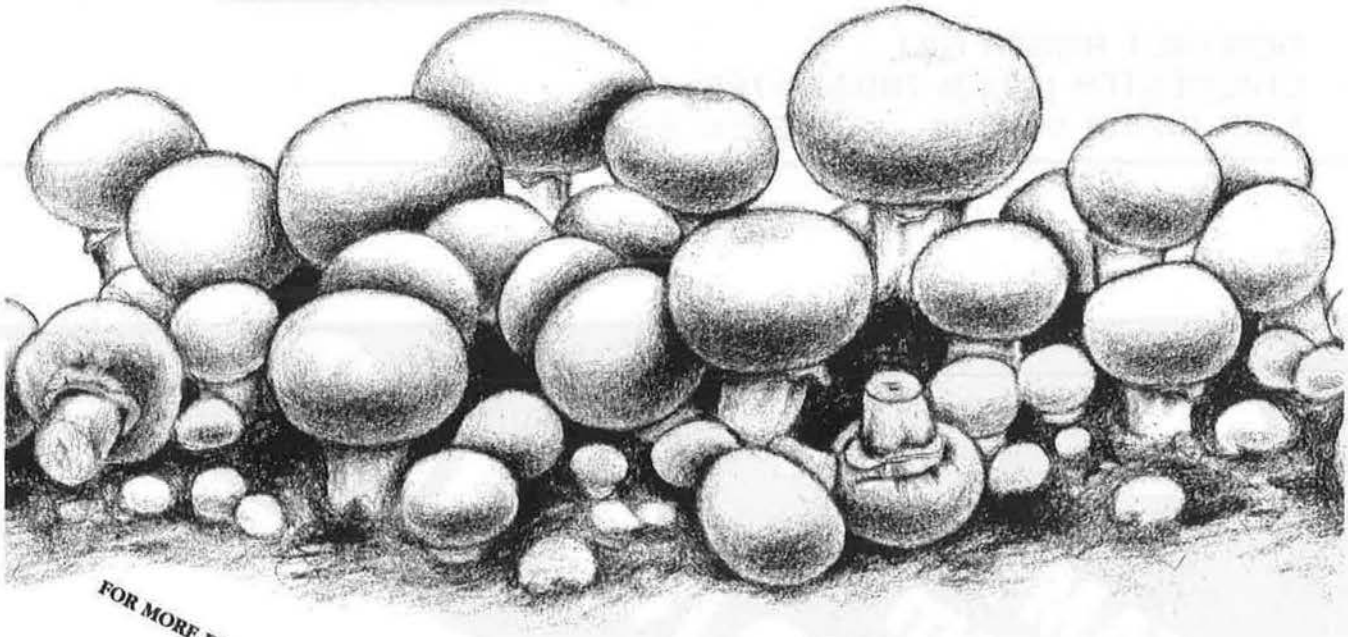

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cater for the fact that the process, even given satisfactory materials, is slower. Watering, which in winter may take place particularly in the first 6-8 days, becomes extended throughout pre-treatment with a careful "little and often" approach to prevent anaerobic development – which will result in a slowing of composting and generation of higher levels of odour. Considerable surface drying of the early stages of pre-treatment can falsely suggest the need for much higher volumes of water which can have a negative effect.

A satisfactory phase I is, therefore, achieved by maintaining a good pre-treatment and thereby having an adequately broken down and active material. In the past we have narrowed stacks further in summer than in winter to assist in drawing of air through the material. The addition of a further day onto phase I is often considered if compost activity is sluggish. Moisture loss remains the main difficulty and becomes particularly exaggerated with inadequately broken down material. This continues to be the problem into phase II where moisture losses will continue. This can be combated to an extent by addition of quite high volumes of water onto the compost during filling.

Whilst, therefore, phase I and phase II allow for some adjustments, managing the more difficult composting conditions during the summer months revolves around, as in winter, maintaining a good pre-treatment.

Materials handling

Conventional composting involves the handling of the materials either by front end loader or, increasingly, by mixing machines. The timing of moves is dependent upon schedules but at all times the aim is the same – to break open material and blend; to aerate; to add water; to mechanically damage. Consistency is the target as a uniform material not only composts more quickly but, most importantly, also gives the best result.

The manner, therefore, in which materials are handled and mixed is a vital and elemental part of the composting operation. It must be borne in mind that compost quality is very reliant on people and, in particular, those people who carry out the day-to-day mixing of materials in the pre-treatment areas.

Difficulties of summer composts can be affected as much by changes in those managing and those operating the composting area through the peak holiday periods of the year which are, simultaneously, the most demanding in terms of the attention to detail and consistency needed to prevent a downturn in compost quality.

Composting schedule

The compost yard is the area of the farm that allows and needs most manipulation. Outdoor composting requires constant evaluation and a flexible approach to the schedule to ensure that the required end product is created. As environmental pressures become greater, the schedule must reflect the need to maintain optimum conditions and modifications can be both for materials changes, *e.g.* shorter straw, and for seasonal changes. It is, therefore, a valuable tool for adjustment to conditions that may be present in summer.

Controlling change

Managing composting to achieve a good quality end product involves managment of change in materials, season and people. To achieve this, the process is best worked around a number of key factors:

1. material breakdown (degree of decomposition).
2. moisture content.
3. phase II clearing time.

This requires months for assessing the differing stages. "Physical change" is an effective means of monitoring the progress of the process – the senses of sight, touch and smell being particularly effective. For these to be consistent they must be backed up by analytical checks, *e.g.* moisture content, ammonium levels, pH etc and a balance of the two used to interpret change. This process of control has to start with the raw materials, not only straw or horse bedding as discussed but also deep litter poultry manure.

Changes in compost condition are particularly difficult through the warmer month of the year when achieving a combination of adequate breakdown and sufficiently high moisture contents not only results in a greener and drier compost, which together provide the poorest compost condition, but is also further reflected in difficulties in achieving adequate volumes of compost filled into the cropping system.

Shelf systems seem to be most prone to reductions in volumes of compost filled if the physical breakdown has not been sufficient. Tray systems with more flexibility in the degree of compression available from the press are more able to cope with wider variations in compost condition. This is compounded with bulk spawn run compost which requires to be well broken down and of a sufficiently high moisture content to achieve fills of 90-95kg/m^2. This has to be set against the need for a longish material at the outset of composting to cope with the degree of machine handling involved.

The 1991 harvested straw is a good example of change having to be made as material condition alters towards the summer period. A dry straw at harvest with adequate, but not excessive, leaf is proving brittle and beginning to shorten quite considerably by completion of bulk phase III. This has resulted in compost being filled into shelves below the level of the side boards. The introduction of a mechanical harvesting system necessitates the height of the cropping surface being maintained at shelf-top level by second and third flush. As a result, alteration to the compression settings of the head filling machine have been necessary to address the changes.

Moisture is the primary activator of the process and effective systems revolve around the successful and uniform application of water at the outset of pre-treatment. Activation of breakdown will readily allow absorption of moisture and whenever this is achieved fewer difficulties are experienced through the rest of phase I and phase II. Moisture and condition, therefore, operate hand in glove and control of the two is the most difficult to achieve in summer. Significant attention should, therefore, be given to this important area during this period.

Phase II provides a ready indicator of whether the earlier stages are being adequately effective. High levels of activity during conditioning generally reflect a greener compost combined with some rapid clearing. Ammonia levels can, however, easily become too high if poultry manure applications are not watched carefully and compost loses condition, *e.g.* poor temperatures in phase I.

Different pointers can be used to highlight change. The skill of producing a quality compost is using what can be seen and monitored to control change and thereby maintain as much consistency as is practical.

Conclusions

I have highlighted a number of aspects of composting that I feel to be important in ensuring that a material that is able to sustain high production levels can be produced through the most difficult period of the year – SUMMER. There are other points that are equally important and different farms have individual experiences. Underlying all compost operations, however, is the principle of monitoring change and making adjustments equally in summer and winter by a regular and careful approach, with a constant awareness that compost quality is fundamental to successful cropping in both winter and summer.

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Absorbing the water and enzymes

By Dr W A (Fred) Hayes

It is surprising how little we know about straw, the main ingredient of a compost and the provider of the major nutritional elements for mushroom growth and development. Also it is arguably the principal source of the many variables which affect the composting process.

Experienced composters have long recognised that identifying and reacting to the changing physical characteristics of straw, is one of the many arts which have to be mastered to achieve the consistency of finished compost which present day standards demand. From the beginning to the end of composting, water and its relationship with the degrading straw is of paramount importance, involving both uptake and release of water.

So-called 'free' or 'surface' water, if allowed to persist throughout composting, will restrict the porosity which is necessary for gas transfer and the required microbial activity. One of the main aims of composting is to transfer added 'free' water into 'bound' water, which is incorporated into the straw during its decomposition. The success or failure of achieving uniform uptake of water, particularly during the preparatory and early phase I stages, often determines the quality of a compost. Evidence of this may be seen by the quantity of uncomposted, yellow, and shiny straw elements, visible at the time of spawning.

Water uptake by straw is undoubtedly related to the outer coating of wax which acts as a barrier to water and to the molecular structures which bind the fibrous elements of straw, lignin, cellulose and hemi-cellulose. These must be disrupted and exposed for the processes involved in degradation and composting to proceed. The addition of water, the mechanical action of moving and mixing straw with the ingredients, the generation of heat, the evolution of ammonia and possibly anaerobic conditions, all contribute to this necessary breakdown of the barriers to water uptake and gives emphasis to the importance of the preparatory stages.

Over the years a number of possible methods to accelerate the uptake of water by straw have been explored. These include simply mechanically grinding straw, shredding, tearing or even exploding the fibrous elements. Pretreatment with alkali, wetting agents and ammonia are chemical treatments which have also been successful but have limited application due to costs and the difficulties of treating relatively large quantities of straw.

Adding enzymes to supplement the enzyme production of the composting micro-organisms, as an aid to the composting process has been considered a possibility for many years, but the benefits of such treatments have not been realised. More recently, an enzyme based product, 'Compostzyme', specifically formulated for use in mushroom composting has been successfully used in commercial compost operations in France, and commercially based trials done in England over the last two years have given positive results with conventional straw/horse/chicken manure based composts.

In the successful trials, very small amounts of enzyme are added during the preparation stage, which results in greater water uptake by the straw, and this requires a significant adjustment to the overall watering regime to avoid the mixture becoming dry. Overall structure and texture is improved, giving a higher proportion of bound water in the finished compost. As far as can be determined in field trials, mushroom yield and quality standards are improved.

In Australia, a product (Pritan) has been formulated to meet the requirements of an accelerated process, in which compost is prepared ready for spawning in five days. This product contains enzymes and a biological inoculum and it is reported that commercial trials have also been successful.

Despite positive indications that these new products are potential useful aids in preparing composts, both conventionally and by new methods, there are serious gaps in our knowledge and experience of how best to exploit their benefits under the widely varying conditions of composting, week by week.

As we start the difficult summer months, composters and growers alike will be reminded of those variables associated with straw quality and its ability to absorb and fully integrate water during its degradation. It is possible that enzymes, products of this biotechnological age, will play their part in future years.

Activate the microbes – are they getting enough?

By S L Oldham Adco Ltd, Stretton House, Derby Road, Burton-on-Trent

A good quality compost is essential to modern mushroom production, and the key to efficiency, but how is it achieved?

Compost quality depends upon it being a selective base for mushrooms. It must also provide quantity and balance of nutrients to meet the requirements of modern strains and the desired standards, regardless of season, raw material availability and other variable factors that affect its production.

Much of the desired quality can be achieved by careful management, controlled environments and careful selection of raw materials. An aid to consistency through the year are compost activators. Such products have been on the market for many years, but how do

they benefit the composter and grower?

Compost selectivity

Selectivity is fundamental to mushroom cultivation. A selective compost favours the growth of spawn at the expense of competing micro-organisms. It depends upon the proliferation of certain microbial populations and the suppression of others. Different populations dominate at different times. Bacteria tend to dominate during pre-wet and phase I, while the actinomycetes predominate during the later stages. Fungi are also involved in the interaction between these various groups.

The beneficial micro-organisms form the biomass (brown/black layer covering degraded straw); these microbes are described as thermophilic (i.e. temperature "loving"). When the supply of soluble and readily available nutrients has been used up and incorporated into the bodies of the micro-organisms, the biomass (dead micro-organisms) forms the basis of the nutrient supply for the mushroom. The biomass should therefore be maximised; but also selective, ensuring the growth of spawn at the expense of competing organisms.

Selectivity can be ensured by providing:

i) suitable temperature;

ii) adequate moisture;

iii) sufficient oxygen;

iv) available food (i.e. to the microbial population).

Modern composting techniques are geared to ensure that the requirements for temperature, water and oxygen are met. These are achieved by attentive management of pre-wet, mixing, phase I and phase II. Adjustments to the water content, timing and stack widths are all measures designed to encourage microbial activity by giving the required physical conditions for their growth. Unfortunately, there are many inherent variables. These include weather conditions during pre-wet and phase I. Raw materials vary widely according to source and time of year. Thus, without careful attention, quality of compost could deviate according to season or raw material availability. Compost activators have been developed to overcome this variability and to assist in providing a balance of nutrients for the microbes all year round.

Microbes and mushroom nutrition

Microbes feed principally on the straw made up of lignin, cellulose and hemicelluloses (insoluble carbohydrates) (C), making these carbon sources accessible to the mushroom. There is also a requirement for nitrogen (N). Nitrogen is required by both the microbes and the mushroom. During composting the microbes "fix" nitrogen from ammonia into protein, making nitrogen available for the mushroom.

Nitrogen supply is traditionally boosted by horse and chicken manures, but alternatives can be included. The advantage of compost activators is that they are formulated to produce a standard, known C:N ratio, which is invaluable in compensating for deviations due to variable raw material sources.

Micro-organisms are also a source of minerals and trace elements and synthesise essential vitamins and other growth factors, boosting those already present from the main materials.

The action of compost activators

Some compost activators are based upon a soluble carbohydrate, sucrose, provided on an absorbent base which also contains nitrogen. An alternative source of sucrose is liquid molasses, but this has inherent disadvantages from a handling and application point of view.

Bacterial activity is encouraged by the addition of sugar and readily available nitrogen. Bacteria dominate early in the microbial succession, therefore their activity can be stimulated by providing activator at an early stage.

Without a ready supply of food, the micro-organisms will not thrive to colonise the straw, and biomass production will be limited. It has been reported that sucrose enabled larger populations of thermophilic bacteria to develop, and suggested that increased yields were associated with the increased biomass.

It has been shown that the layer of dark brown material which accumulates on straw surfaces during composting consists of bacterial and fungal cells with a matrix of amorphous material. This material appears to contain bacterial polysaccharide, a carbon source more suitable for the mushroom than simple glucose. It has also been suggested that the cultivated mushroom may be a "microbial scavenger", deriving a fair proportion of its nutrition from dead micro-organisms (the biomass). Thus, as a supplier of sucrose, compost activators enable a greater production of biomass, and thus the potential for a greater mushroom yield.

In providing an extra, available energy source for the microbes, it is also ensuring that carbon is "saved" for the mushroom to use.

If the supply of soluble carbohydrates is insufficient, bacteria attack the proteins and amino acids to obtain energy. This results in a loss of valuable nitrogen, in the form of ammonia, since the proportion of nitrogen in these compounds is in excess of the bacteria's requirements.

Once the supply of soluble carbohydrates is exhausted, another group of micro-organisms, the actinomycetes, begin to predominate. These microbes can use the insoluble carbohydrates as an energy source and so compete for the food supply of the mushroom. Thus, for a good quality compost, the dominance of this group of micro-organisms should be delayed. The more available the soluble carbohydrates, the more selective towards beneficial micro-organisms the compost will be.

Soluble carbohydrate supplementation during composting has also been shown to enable the bacteria to convert ammonia to bacterial protein, thus ensuring a higher compost nitrogen after peak heating. This is in addition to the extra nitrogen provided by activators.

Controlled trials and practice have shown that, with composts including proprietary compost activators, the evolution of ammonia ceases at a more definite point and at an earlier time during peak heat than with composts made without an activator. By using a sugar-based activator, the peak heat can be reduced by as much as 48 hours. If the evolution of ammonia is allowed to continue, competitor moulds (*Chaetomium*) can take hold.

The benefits

The advantages of compost activators are therefore numerous. The ensured availability of energy guarantees proliferation of microbial activity and therefore an increased biomass. Increase in biomass produces more nutrients necessary to the mushrooms with increased yield of mushrooms. Availability of energy for the microbes and conversion of nitrogen sources for the mushroom, rather than usage by the microbes, results in reduction of loss of dry matter, thus more compost is available for production. Therefore, the inclusion of an activator will maximise the output from a specific set of raw materials.

Earlier clearance of ammonia during peak heat could also mean savings in energy for the running of phase II.

When pressures are placed upon the composting system due to raw material availability and variability, the activator becomes an invaluable tool. For example, seasonal changes in horse manure due to equine management can be alleviated by increasing activator usage, ensuring no loss in nitrogen in the final compost.

In conclusion, compost activators, by boosting specific microbial populations, assist in producing a quality compost, the basis of efficient, profitable mushroom production.

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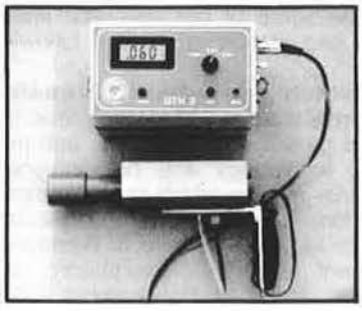

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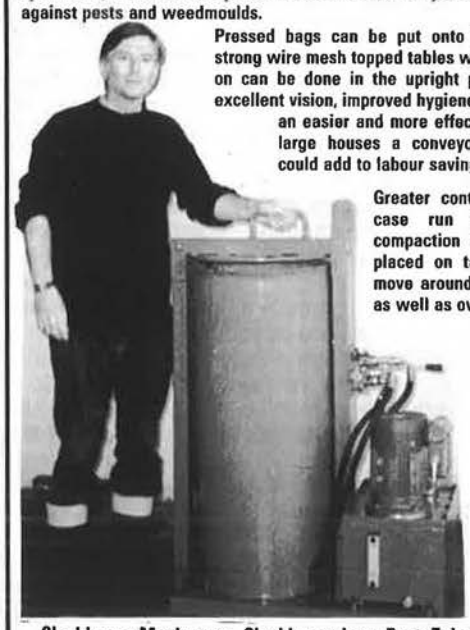

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The Microbiology & Crop Protection Department in Horticulture Research International

J. M. Lynch and T. J. Elliott
Horticulture Research International, Littlehampton, West Sussex

With the restructuring of HRI and merger of the Lee Valley mushroom programme of ADAS into HRI, the entire mushroom R&D programme now falls within the Microbiology and Crop Protection Department of HRI and is based at Littlehampton.

The Department has a broad remit. In addition to our work on mushrooms we have R&D programmes in a wide range of disciplines: in virology, entomology, insect pathology, plant pathology and in many aspects of bacteriology and mycology. A major effort aims to exploit viruses, bacteria, fungi, nematodes, and insect predators and parasites as biocontrol agents for pests and diseases in a wide range of crops. We study the epidemiology of plant viruses and the population biology of micro-organisms, insects and spiders using both classical and molecular biological approaches. These studies will enable us to evaluate the environmental impact of the use of genetically engineered organisms.

Researchers do not operate in isolation and there is considerable interaction between different programmes. In the measurement of microbial biomass, technologies developed at Littlehampton to determine the amount of mycelium in spawned compost have wide application to studies of the population dynamics of microbial communities. Plant pathology and entomology are linked by the recent recognition of insects as vectors of plant pathogens and of the antagonistic organisms which may control the pathogens. These are just two examples, we could provide many more.

The Department has an excellent range of facilities for the liquid and solid culture of micro-organisms, protein separation, immunology, electron microscopy, molecular biology, fermentation and containment of genetically-modified organisms.

Mushroom strains are a major component of our collection of micro-organisms stored in liquid nitrogen. Our major aims are to develop and improve mushroom production and to manipulate microbial inoculants and insect predators, parasites and pathogens to enhance the growth of crop plants and restrict the pests and diseases to which they are vulnerable.

The Department has strong links with growers and industry, and close co-operation with many universities including Imperial and King's Colleges, London; Aberdeen, Birmingham, Cardiff, Hull, Kent, Liverpool, Manchester, Nottingham, Oxford, Reading, Sheffield, Southampton and Sussex; and with the NERC Institute of Virology and Environmental Microbiology, Oxford. We also have close contacts with many laboratories in Europe, North America, Australia, New Zealand, Japan, India and the Philippines and we have formal co-operative agreements with USDA, Russian Institute of Microbiology, the Dutch Institutes of Soil Fertility and Crop Protection, the Japanese Institutes of Agriculture and Agro-Environmental Science and the Universities of Bonn, Georgia, Idaho, Moscow State, Poona and Washington State.

Besides core funding from MAFF and DES, our customers include the Horticultural Development Council, Department of the Environment, Agricultural Genetics Company, Ciba-Geigy and Shell.

The senior permanent staff of the Department are: **Peter Atkey** (electron microscopy), **Professor Alan Brunt**[1] (plant virology), **Kerry Burton** (mushroom post harvest biology and biochemistry), **Mike Challen** (mushroom genetics and molecular biology), **Dr Richard Chambers** (glasshouse entomology, biological control), **Dr Norman Crook** (insect virology), **Dr Tim Elliott** (mushroom genetics, breeding and molecular biology), **Dr Terry Fermor** (mushroom composts and disease, genetic release), **Dr Helen Grogan** (mushroom crop science including compost, weed moulds and other *Agaricus* species), **Neil Hayter** (integrated control in glasshouse crops), **Paul Jarrett** (*Bacillus thuringlensis* genetics and strain improvement), **Professor Jim Lynch**[2] (Head of Department) (rhizosphere, biological control, genetic release), **Dr Ralph Noble** (mushroom crop science including compost, weed moulds and other *Agaricus* species), **Paul Richardson** (use of insect parasitic nematodes for pest control), **Jeff Smith** (compost science and alternative edible fungi), **Dr Keith Sunderland** (biological control, spatial dynamics, agroecosystem ecology), **Dr John Whipps** (plant disease biocontrol, rhizosphere and genetic release), **Phil White** (mushroom pest control), **Dr Doreen Winstanley** (insect virology), **Professor David Wood**[3] (mushroom physiology, biochemistry and molecular biology).

These staff are supported by a variety of permanent and contract staff as well as visiting workers and research students, making a community of about 65 personnel.

The mushroom commodity sector group is led by Tim Elliott who works in close association with Richard Gaze, the ADAS National Mushroom Specialist based at Littlehampton. In a subsequent issue of the Journal we will cover in outline the current research activities of the mushroom group. It is intended that in future there will be regular input to the Journal on mushroom R&D within HRI, collated by Peter Flegg, and he will describe some of our specialist knowledge and expertise in the following fields:

Mushroom genetics, breeding and molecular biology: Basidiomycete genetics, mutagenesis and protoplast technology and basidiomycete molecular biology which includes transformation, gene cloning and electrophoretic karyotyping. Use of Restriction Fragment Length Polymorphisms and Random Amplified Polymorphic DNAs for strain identification and genetic mapping.

Culture collection: Storage systems for micro-organisms.

Novel mushrooms: Developing the cultivation of wild mushroom species, especially *Agaricus* spp.

Mushroom nutrition and biochemistry: Physiology, biochemistry and

[1] Visiting Professor, Imperial College of Science, Technology & Medicine, London
[2] Visiting Professor, King College London and Washington State University
[3] Visiting Professor, King College London

molecular biology of the growth and fruiting of edible fungi and other basidiomycete fungi.

Mushroom compost science: Compost microbiology; determination of role of compost microbial biomass in cultivated mushroom nutrition; identification and characterisation of microbial biomass lytic enzymes; identification of chemical components associated with compost specificity.

Mushroom pest & disease control: For pests this includes investigating the biology and damage associated with a range of mushroom pests, but especially sciarid, phorid and cecid flies; the use of various bioassy techniques; processing compost and other samples to assess pest population densities; laboratory culture of pest species. For diseases this includes the epidemiology and control of fungal, bacterial and viral pathogens.

Nematology: Taxonomy, ecology and behaviour of insect-parasitic nematodes (IPNs) and plant-parasitic nematodes affecting mushrooms.

Mushroom production science: Mushroom compost production, specifically controlled environment compost, factors influencing crop productivity, composting efficiency, and pollution problems associated with compost production; environmental factors in mushroom production and their effect on yield, quality and flushing pattern of *Agaricus bisporus* and other *Agaricus* species.

Mushroom quality: Factors influencing mushroom quality: post-harvest gene regulation and enzyme changes cause mushroom quality to deteriorate. Modified atmosphere packaging cooling and other post-harvest techniques for conserving mushroom quality through the fresh distribution chain are investigated, together with methods of objective quality measurement.

Our mushroom R&D programme therefore covers virtually all aspects of mushroom science from basic studies of biochemistry, physiology and genetics, through compost chemistry and microbiology, entomology and pathology to post-harvest biology. We value the industry's continuing interest in and support of our mushroom activities. After many years of lobbying, the British industry now has an effective R&D team working together at one site.

Research & Development Committee Chairman's Report

By J. Rothwell

This is my first annual report since taking over as Chairman of the Research & Development Committee in July 1991, and I would like to start by thanking my predecessor, Harold Linfield, for his outstanding service to mushroom growers as Chairman of the Research & Development Committee. During the year, we also lost another stalwart member who has served the Committee well, namely Bob Dumbreck. I was sorry to see Bob retire from the Committee, as I always found his contributions to the meetings invaluable, as his knowledge of our industry is considerable.

I must welcome new members Adrian Hearne and Geoff Ganney. Of course, I would also like to thank all those who served on the Committee in the last year for their continuing hard work.

Since I took over as Chairman, the Committee has discussed many topics. The most significant of these has been our contribution to the MAFF Code of Good Agricultural Practice for the Protection of Air. We were able to get a section inserted of specific application to mushroom growers and it will be a significant help to those growers facing problems from their local authorities over smells from composting operations.

Members of the Committee were involved, with spawn composters, on work with MAFF and the Department of the Environment, to produce guidelines for Industry and Environmental Health Officers, dealing with compost odours. We believe they could still be too onerous and the MGA is in further discussion with MAFF on this issue.

The Committee has also discussed several items related to pesticide use. In particular, we have reviewed the NFU pesticides policy, considered the revision of maximum residue levels, off-label approvals, and the review of the use of methyl bromide. It was also decided to make a survey of pesticide use. Although the results of this have not yet been collated we anticipate that these results will be very important. Many chemicals are coming up for re-approval and it is vital that we do not waste time and money applying for off-label approval for chemicals that are no longer used.

As I am sure many of you are aware, the Research & Development Committee has, in the last year, assumed responsibility for the selection of the Sinden Award and the student award to the young grower or scientist of the year.

It has been a busy year. But what of the future?

Since the inception of the HDC, the role of the R & D Committee has changed. We are no longer involved directly with R & D, but through joint membership on the HDC Panel, R & D Committee members are still keeping a close eye on the relevance of work commissioned through HDC. However, there are still matters of a technical nature that need discussion and action that do not fall within the scope of the HDC. It is my belief that this Committee is the right forum for these discussions.

Matters which should continue to be dealt with by this Committee include such things as new legislation covering health and safety, pesticides and the environment. All these subjects will have an enormous effect on the way we run our businesses in the future so we must always be ready to make contributions to legislation or guidelines whenever we are given the opportunity.

A good example is of the work of the MGA Committee to ensure that planning for the move of R & D from Littlehampton to Wellesbourne is pressed forward. Paul Middlebrook has been involved in the detail and now the Government has made funds available, the first sod – real action! – will be cut at Wellesbourne in the autumn. I hope that the changing role proposed for the MGA will not reduce our effectiveness in this respect. We believe that this Committee has an important job to do and I and the Committee feel strongly that it must not be wound up as this would leave the smaller growers, particularly, without anybody to monitor the new legislation and innovations that come along. There are no grounds for scrapping this Committee on cost, as it meets on the same day as the HDC all the members are together anyway. I am sure that the cost of preparing the minutes and the agenda will not tax the resources of the MGA too much.

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The speakers

Chairman's opening address

GEOFF GANNEY

Technical director of James A Gooding Ltd for 20 years and recently appointed chairman of MGA. A member for 27 years, he already serves on the Horticultural Development Council, Mushroom Research and Development Committee, and the MGA Editorial Board.

'Can You Handle The Product?'

TIM HAYNES

In the mushroom industry for 15 years, he began his working experience at J A Gooding Ltd, where he progressed from general mushroom worker to grower in charge between 1977 and 1985, moving to Catfield as senior grower. In 1989, he entered into partnership in bag-growing. Since 1990, he has introduced growing on blocks.

'A Mushroom Adviser's Year'

DICK RUCKLIDGE

After a mushroom growing career spanning 23 years, with W Darlington and Sons Ltd (later Blue Prince Mushrooms), Dick started SpawnMate Ltd in 1982. In 1986 he sold the business, and has since operated chiefly as an adviser to medium-size growers. Most recently, he has been involved, as joint owner with his son Richard and with Charles and Kate Spencer, in an exciting new venture, Home Harvest Ltd.

'3 Steps to Heaven – Growing by Numbers'

MILES MIDDLEBROOK

Miles Middlebrook is one of the few third-generation mushroom growers in Britain and, after graduating from Writtle Agricultural College, he joined the family business of Stanley Middlebrook Mushrooms, eventually building up a team of growers to handle the 50,000 sq ft per week, on both Dutch shelves and a rack system. After the acquisition of the business by Booker plc, he continued in the expansion to 78,000 sq ft filled per week. In 1989, he left Middlebrook to build his own farm from a green-field site, filling 2,000 sq ft per week, his greatest challenge to date!

'Is There a Doctor in the House?'

DR JOHN FLETCHER

Dr John Fletcher has had a long and distinguished career in mushroom science since obtaining his PhD at Birmingham University, starting in a small glasshouse in Cheshunt, Herts, in 1961, and working in a variety of 'laboratories', ranging from an air raid shelter in Leeds and a World War II underground command centre, to polythene tunnels at ADAS, Wye!

One of Dr Fletcher's major achievements was the discovery of Sporgon, which has been used worldwide as a product for *Verticillium* control.

In 1969, he went to the University of Guelph for a post-doctoral year, and was presented with the Sinden Award in 1984 and received the BCPC Medal in 1991. He became President of the British Society for Plant Pathology in 1989.

'I Have Had That Problem'

PETER MUNNS

In 1965 Peter Munns became involved in mushroom growing at Wrington Vale Nurseries (which became Country Kitchen Foods), until 1968 when he became managing director of the Shepherd's Grove and Valley Farms, a post he held until 1973.

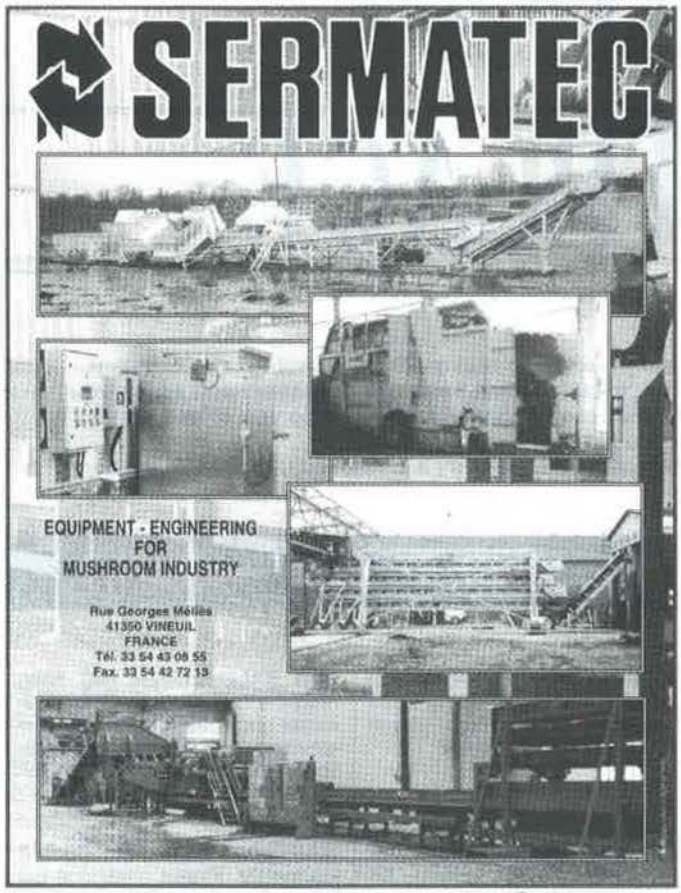
For the next three years, Peter worked as consultant in such diverse locations as Israel and Yorkshire.

Returning to growing, he purchased Kingcup Mushrooms in 1976, since when he has streamlined and mechanised the tray farm substantially, with multiple and direct sales absorbing 90-95% of the farm's greatly increased production.

'Speed with Quality'

BOB PINKERTON

Bob Pinkerton, recognised as one of the greatest innovators of the mushroom industry, began growing with his brother in 1936. After war-time service, in 1946 he returned to basic mushroom growing, and in the early 1950s built his Hockley farm, adding – again built from a green field – the Hawkwell farm in 1963. Bob has employed unique growing techniques, having the only tray farm with mechanical ruffling. He is reputed to be the first British grower to supply pre-packed mushrooms for supermarket outlets.



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Adrian J. Hearne B.Sc.

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ALSO

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THE Mushroom JOURNAL

MARKETPLACE

For just 30p per word you can advertise all your wants and sales in this classified feature. That spare piece of equipment cluttering up your space; those packing cases, pallets, plastic trays... anything you do not want. OR anything you need: that spare part which would enable you to renovate that machine standing idle; any item conceivable which becomes necessary and which you cannot easily obtain locally; OR do you offer a service? Need assistance in some matter...
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PEAT/CHALK/CASING MATERIALS

CROXTON + GARRY offer mushroom chalk from plants at Melton near Hull and Steeple Morden near Royston (Herts). Both BRITOMYA C and SNOWCAL 10 are available in 25 kg bags for use levels of 10 – 25 kg per bale of peat. Enquiries: CROXTON + GARRY LIMITED, Curtis Road, Dorking, Surrey RH4 1XA. Tel: 0306 886688. Telex: 859567/8 C and G. Fax: 0306 887780.

MUSHROOM CHALK SUPPLIED IN BULK OR POLYBAGS (50kg bags). Best quality Lincolnshire Casing Chalk. Enquiries Caistor Limes Ltd, Caistor, Lincolnshire. Tel. (0472) 851281.

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To advertise here just phone **Nicki on 0780 66888** or **Fax 0780 66558** and your message will be seen by everyone in the mushroom industry.

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TAMPLIN LINE EQUIPMENT. Contact Ken Proud for details on Casing Mixers, Conveyors, Spawn Distributors, Compost Loaders etc., plus spares for existing lines. Tel: 0243 512599. Fax: 0243 511189.

FOR SALE: Lochon bag filling machine complete with 2 feed elevator and spawner, also out-flow elevator — all in very good condition, can be seen operating. Tel. 0592 51168.

WANTED. Portable Cooling Equipment. Please telephone Bill Musson, 0253 764203.

SITUATIONS VACANT

GROWER WANTED. Grower required for a medium sized farm in the East Midlands. Must have proven success in the industry, with experience in all aspects of modern mushroom growing. Please write with full c.v. to Kavell's Mushroom Company Ltd, Orston, Nottingham NG13 9NX.

SUNDRIES

INEXPENSIVE DISPOSABLE PICKING GLOVES. Free samples and prices from Mushpro Ltd, 266 Belsize Road, London NW6 4BT. Tel. 071 328 5715.

PROPERTY

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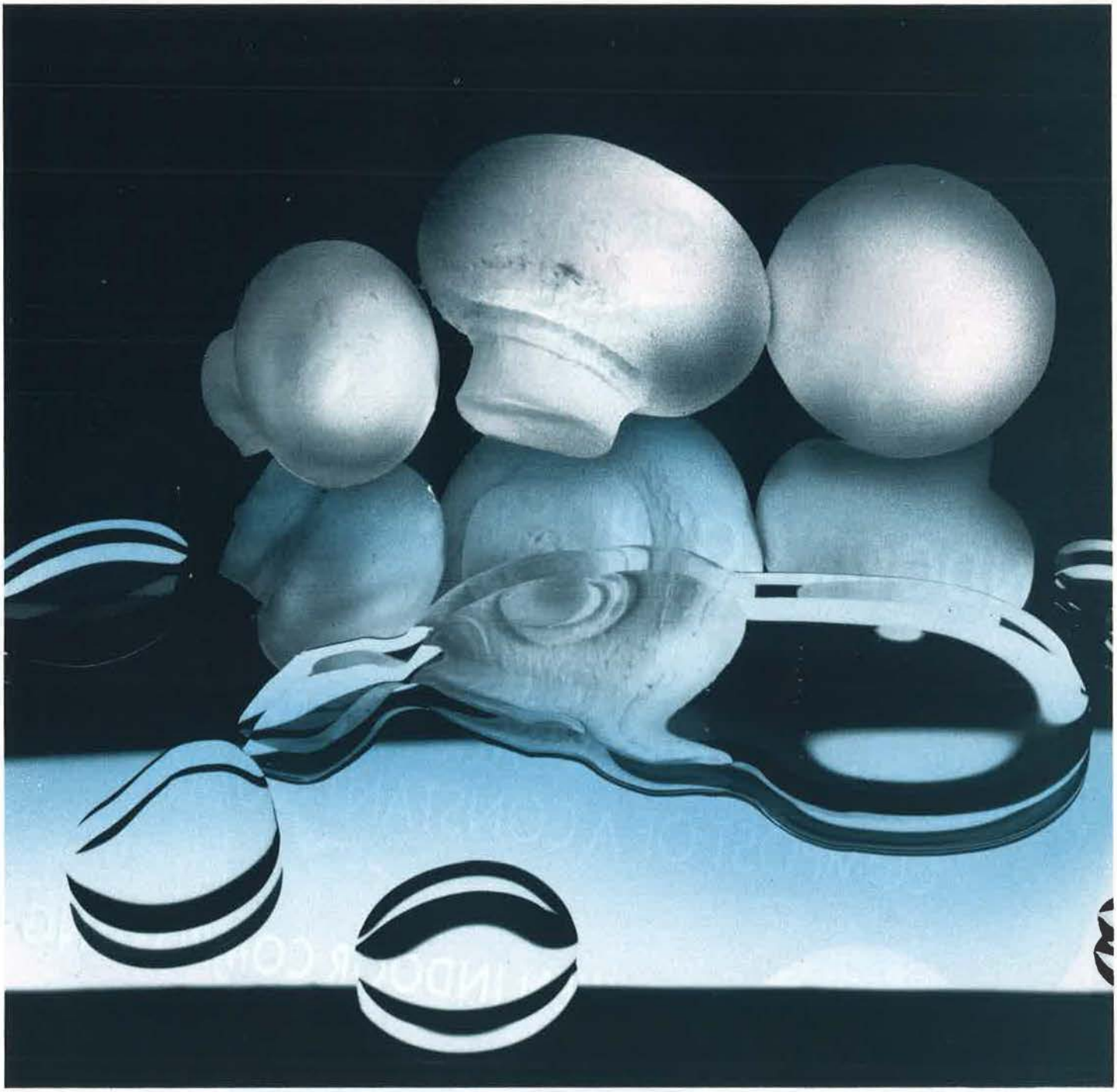

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