Assured Produce

Crop Specific Protocol

MUSHROOMS

(CROP ID: 22)

January 2009

Control Document No: 00035/09

Acknowledgements

Assured Produce gratefully acknowledges the contribution of all consultees in the preparation of the original protocol, and thanks are also due to Dr John L Burden for this revision of the protocol.

Preface

This crop specific protocol has been written to complement and avoid duplicating the generic principles of the scheme and appendices.

It is advisable to read the Assured Produce Generic Crop Protocol Standards and the Assured Produce Generic Protocol Guidance Notes (referred to in this document as the Generic Standards and Generic Guidance Notes) first before reading this crop specific protocol.

This protocol is designed to stimulate thought in the mind of the reader.

This crop specific protocol contains crop specific parameters and guidance, where applicable, for the requirements stated in the Generic Standards.

All statements in this protocol containing the words **"must"** (in bold type) will be verified during the Assured Produce assessment and their compliance will form a part of the certification/approval decision. The score required for these **"must"** control points can be found on the final page of this document and in the checklists produced by Assured Produce licensed certification bodies.

Disclaimer and trade mark acknowledgement

Although every effort has been made to ensure accuracy, Assured Produce does not accept any responsibility for errors and omissions.

Trade names are only used in this protocol where use of that specific product is essential. All such products are annotated ® and all trademark rights are hereby acknowledged.

Notes:

There may be other withdrawals or revocations. Products containing substances which have been revoked are shown on the PSD website (http://www.pesticides.gov.uk). Growers should check with their advisers, manufacturers, the Assured Produce website 'Newsflashes', the PSD website (www.pesticides.gov.uk)

Growers should comply with the ‘Use up by’ dates for all pesticide products. Growers should also be aware of and comply with changes on new product labels.
There may be changes for the following reasons:

- At re-registration stage after Annex 1 listing there may be: reductions of dose rates; changes in timings and/or number of applications for some products.

In the following Appendices products and use by dates are only listed for SOLAs, and in some cases new product MAPP numbers may not be available yet.

For pesticides on-label, only active substances are shown.

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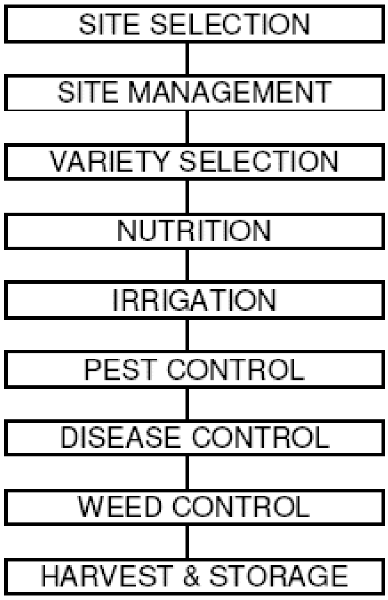
1 General introduction

Following a systematic approach will help growers to identify and manage the risks involved in crop production. This protocol is based on a typical crop production process. Using a flowchart approach, food safety, Health & Safety, environmental and quality hazards are identified. Appropriate controls may then be established to minimise risk. Food safety and Health & Safety issues always take precedence over quality and environmental controls.

The flow chart is structured as shown below; the sectional layout of both this protocol and the crop specific protocols follow the same structure.



The content of each crop specific protocol is reviewed annually by informed farmers and growers, food technologists, scientists, the relevant fresh produce association, processors and agronomic consultants. Updated editions are issued prior to the cropping season.

The review process considers both new developments and all relevant technology which has emerged throughout the course of the previous year and which have been found to be both workable by the grower and beneficial to the environment. As one aim of the Scheme is to transfer such information and technologies to growers, attention is drawn to those features of specific relevance to ICM by using *italic* script. In order that growers may be confident that they are working to a current document, each protocol is dated and numbered.

2 Planning and records

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

3 Site selection

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

4 Site management

4.1 Soil mapping

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

4.2 Soil management

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

4.3 Soil fumigation

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

4.4 Substrates

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

4.5 Drilling and transplanting

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

4.6 Systems of production

There are a variety of Mushroom production systems. All have a common biology, but differ widely in the 'system' of production employed.

4.6.1 Composting

Phase I

The production of raw or Phase I compost is common to all systems with some exceptions, though increasingly within the industry parts of this process are now being performed in aerated bunkers not in windrows, all intended to improve uniformity of the process and reduce odour pollution.

In essence Phase I compost production consists of wetting and blending the raw ingredients, straw and a manure. Historically wheat straw though Barley and Oats can also be used, (in recent years a proportion of other threshed plant crops are now being used including; Oil seed rape, Pea and Bean haulms and Myscanthus grass). Horse manure, poultry litter and occasional other straw-based manures can be used along with other high nitrogen supplements of both organic and inorganic origin.

Not all the ingredients are used by all compost manufacturers. Nowadays for homogeneity synthetic composts made of straw and poultry litter are used by many large producers, most straws are pre-wetted for a period before the nitrogenous materials are added to the mixture. Poultry manures **should be** stored under cover and not in large quantities to reduce site odour.

The straw and manures are initially blended together to produce a homogeneous mixture and piled into rough stacks to allow the composting organisms to "start working". The material is then either formed into windows or filled into aerated bunkers depending on the system employed. The process can take as little as 15-17 days if bunker technology is employed or slightly longer if traditional `windrows' are used. Bunkers are being used increasingly by compost manufacturers, as they facilitate forced air movement through the compost mass, so favouring ideal conditions within the entire compost mass enabling the micro-organisms to function effectively throughout at the same time reducing unpleasant odours.

Gypsum and nitrogenous additives have historically been incorporated at various stages in the procedure, but in order to improve homogeneity of the compost, most additives are now added near the beginning of the process.

(New) Gypsums other than raw mined material are now available to the industry, if they are to be used by composters, extreme care must be taken to ensure that they do not contain heavy metals or any other contaminants.

During the process, biological fermentation takes place and the compost is frequently turned to blend the ingredients and to ensure that the various zones within the compost mass experience the full range of heat and oxygen profiles that occur.

At the completion of Phase I, which takes between two and three weeks, the subsequent path the compost may follow varies, depending upon the system employed.

Phase II

Fermentation continues during the Phase II composting process, but crucially during this phase the compost passes through a pasteurisation phase that kills potentially harmful pests and diseases. The temperatures attained during this period along with the free ammonia in the compost are important components of this process. The pasteurisation process is followed by the important “conditioning period”, where the compost temperature is lowered and other microbes work on the ammonia still present and the remaining food sources in the compost. The micro-organisms, then "fix" available organic and inorganic ingredients into the biomass fraction of the compost. This is a vital process in compost production and infers selectivity on the compost that then becomes selective for the growth of mushroom mycelium over that of other potential competitor organisms.

Phase II composting may take place either in specially designed and constructed phase II tunnels, (if the compost is prepared in bulk), in specific peat heating rooms (if the compost is in trays) or even in certain systems in situ in the growing houses. Batch sizes can vary greatly from 10 - 20 tonnes to up to 200 tonnes in large bulk systems.

The bulk tunnels now employed vary in construction, but have in common a method of forcing air through the compost, (either via a plenum chamber beneath a slatted floor covered with a net, or by pipes within the floor of the container that force air, via small spigots directly into the compost mass. The air forced into the compost helps to control the temperature within the compost mass and provides the oxygen for the active micro-organisms involved in the process. In contrast compost filled into trays or shelves is aerated and the temperature controlled by air passing over and around the containers in either specialised Phase II buildings or in cropping houses, these systems rely on passive movement of air through the compost.

Only when the compost is conditioned and the ammonia levels reduced to near zero is the material ready to have the mushroom spawn added to it.

Phase III or spawn-running

Spawn running is the accepted term to describe the process of colonising the compost with mushroom mycelium that grows from the spawn added to the phase II compost: when fully colonised the material is then called phase III material.

Historically this phase has been carried out within the growing houses, but increasingly over the last decade phase III compost has become more readily available from the compost manufacturers in the UK and from Europe. At the start of the process spawn is mixed into Phase II compost, either as it travels from the bulk Phase II tunnel to the growing container, (be that shelf, tray, bag or block), or by mixing it into compost in situ in shelves, or by emptying and refilling trays.

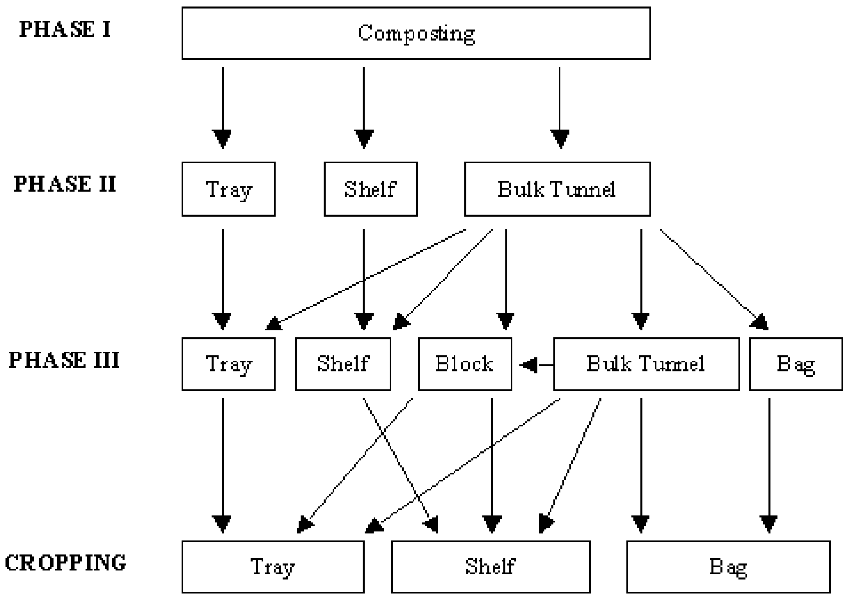
In all instances the common purpose of this phase, regardless of growing system, is to optimise growing conditions, compost temperatures of around 25°C enable the mushroom mycelium to colonise the compost effectively. Bags and blocks may be individually protected by the polythene of the containers used, but in all other instances the parameters of CO_2 and humidity are kept high within the spawn running rooms to encourage mushroom mycelium growth throughout the compost. Nowadays in the UK, bags production has declined dramatically and is now a minor production system.

By the beginning, or in a few cases the end of spawn running, a wide range of mushroom growing systems emerge from the common beginning of Phase I composting. The interrelationship of the differing production systems is laid out in the following diagram.

Systems of production are distinguished primarily by the growing facility used for cropping and a brief description of the main systems follows. However, the diagram shows the progress of different systems illustrating that a superficially similar system may have followed a different route.

Systems are sometimes further distinguished by whether they are in situ single zone systems, or 3 to 4 zone systems whereby containers, usually trays, are moved from one building and environment to another, (e.g. peak-heat, spawn running, holding and cropping rooms). Further subdivisions could be made with the advent of bulk Phase II and III. However, the purpose of this description is to outline the variation, whilst stressing the common themes.

In recent years holding rooms are being used more extensively in tray operations, indeed some compost suppliers are now offering trays fully cased, case run and vented, (phase 5). When the grower receives them, mushrooms are already on the bed and the crop is ready to be picked in a couple of days. This has the advantage of shortening the growing cycle on the farm, thereby utilising the expensive growing facilities more effectively and concentrating the growers effort into producing quality mushrooms instead of all the peripheral problems associated with composting, casing, case running and venting the crop.



4.6.2 Shelf system

In this system of growing, cropping takes place on shelving, now usually constructed of aluminium, and can be 3,4,5 or 6 shelves high. Rooms may contain 2, 3 or more tiers of shelves.

The shelves may be filled with Phase I compost, but are most commonly filled with Phase II or Phase III compost.

Whichever type of compost is used, it is now most commonly winched in and out on nets. Apart from the filling and emptying equipment, the system is characterised by the use of light machinery that uses the shelving as tracking. It brings gantry engineering to the crop facilitating spawning, casing, levelling, ruffling and cutting Mushrooms for processing.

(NEW) In the last year more Phase III compost has become available from the continent, transport arrangements have meant that the materials are tipped straight onto the floor rather than being loaded directly into the shelves which involves more standing time for the vehicles. Areas where materials are tipped have to be cleaned effectively, care must be taken that there is no carry over of disinfectants into the compost.

4.6.3 Tray system

Compost is contained in trays (usually of timber construction) of various dimensions, with either fixed legs or removable spacing blocks.

It is still quite common for Phases II and III to be carried out in the trays, though few new facilities are being built on these lines.

Where Phase II is conducted in the trays they are often stacked in specially constructed houses up to 10 or 12 high. After the phase II process and when the compost has been spawned, these trays are then moved to a different set of houses specially designed to facilitate an effective spawn run.

When the compost is fully colonised they are then cased and either again returned to specialist facilities to complete the case run or transferred to the growing houses to complete this stage. In the growing houses the trays are arranged in stacks, usually 4 high, in a number of patterns, to achieve a compromise between access for picking and maximum house utilisation.

The trays are normally handled using fork-lift trucks and the filling / emptying, spawning and casing operations are conducted on specially constructed handling lines.

The system is very flexible, but requires expensive filling, spawning and casing machinery and a great deal of labour in moving them for any new treatment or environment. However, in order to shorten the cropping cycle still further some farms now retain the trays in specialist growing rooms right up to the time of cropping, (Phase V compost), only then moving them to the cropping houses. This maximises the volume that can be handled in the growing facility by radically shortening the time the trays are in the growing facility from 5 - 6 weeks with phase III compost to 3 weeks with Phase V compost.

Segregating the growing phases is a good ICM tool that restricts disease transmission from the old crops back to the early stages of the next crop. Trays also present an easier option for robotic harvesting should it ever come to fruition.

4.6.4 The Bag system

The bag system is characterised by low investment in plant and machinery and a high labour input for filling, casing etc. Bags were initially grown in a distinctive system on one level, usually the floor: their configuration depending on the floor area available, but restricted to rows no wider than four bags to aid efficient harvesting.

In recent years to improve farm output bags are placed on shelves within the house, but increasingly nowadays bags are being superseded by blocks, simply for the ease of handling and because the system can be more easily mechanised. In the past bags were an ideal system for basic mushroom production but as costs have escalated and labour has become more difficult to acquire, growing systems, relying on technology rather than labour, have tended to predominate in recent years and bag growing is now very much a minor system of growing.

4.6.5 Block system

Whilst the block system closely resembles the bag system, it differs in that Phase II or III compost is compressed into blocks and "containerised" in an over-wrap of polythene whereas bags are loosely filled polythene sacks. Because of their rigidity, blocks can be - and usually are - fitted into shelves or trays and thence, with some minor differences, become shelf or tray systems .

When used within shelf or tray systems, blocks are capable of becoming more mechanised and, as with all other currently employed systems and variations, are intrinsically compatible with ICM principles. As a result, the use of blocks has grown enormously in the last decade.

4.7 Compost production

The relationship between Mushroom compost and the cropping organism is a complex one. Mushroom compost provides the Mushroom both with its nutrient and its sole growing environment. It also provides the Mushroom producer with the main vehicle for commercial manipulation of the growing system.

The objective of this protocol is not, therefore, to provide a prescriptive account of either composting practices or nutrient analyses, although a brief description of composting was given in Section 4.6.1.

Every compost yard's procedures will vary in detail, but the fundamental practices are the same and aimed at homogenising the material and allowing composting or fermentation of the bulky material to proceed as effectively as possible.

However, composting is potentially polluting and this aspect must be addressed. Pollution can be caused by run off from the compost yard and odour from the composting process, (particularly where those process have not been performed effectively).

(NEW) The Environment Agency's Technical Guidance on Composting and the DEFRA Codes of Good Agricultural Practice for the Protection of Air and Water provide both practical guidance and background to the legislation and policing authorities.

Growers should note that Spent Mushroom Compost is now classed as a waste material and exemptions may have to be applied for. These may be open to interpretation but, the required documentation for compost producers, spreading spent compost and carrying spent compost should be applied for. The industry is at present attempting to negotiate a more reasonable position for the material than is currently outlined in the legislation. Details and advice can be gained from the Environment Agency 0845 603 3113, or from their web site; enquiries@environment-agency.gov.uk

4.7.1 Water

Run-off from compost yards may be heavily contaminated with organic matter. To meet anti-pollution requirements all water run-off from compost yards and areas where compost is handled **must be** contained for recycling, allowing only clean roof water into the normal drains.

Virtually all yards now have drainage to catchment tanks that are constantly aerated to avoid anaerobic conditions. Unacceptable odours emanating from compost yards can often be traced back to poor handling of the run off water. Spare capacity is usually required, either in the form of additional tanks or by over sizing the main tanks, to accommodate excessive rainwater, that may at times, fall on the catchment area.

Run-off water from the compost yard **should be** screened before it reaches the tanks, thereby reducing sediment that can quickly turn anaerobic. The tanks should be adequately aerated with suitable pumping systems and the trapped leachate is delivered back to the compost stacks discretely (ensuring that large water droplets are formed thus avoiding spray drift), virtually all potential pollution problems from this source may be avoided.

Some farms may be adjacent to watercourses into which run-off from concrete surfaces, other than compost yards, will be discharged. Such concrete surfaces may be contaminated with organic debris, pesticides and disinfectants associated with crop production. To prevent contaminated run-off from such concrete surfaces, from getting into soil or water courses, run off samples from water discharged into water courses should be analysed for pesticides and organic matter, and if unacceptable levels are found, the run off should be contained and treated accordingly.

4.7.2 Air

Aerial pollution is less precise, less confinable and thus more subjectively assessed and more emotive. On the whole, therefore, it is potentially a greater problem than water-borne pollution.

A great deal can be accomplished towards minimising if not completely removing the problem. There has been much debate recently concerning the practicality of enclosing Mushroom compost yards and thus containing aerial pollution. Whilst this is in some ways an attractive solution it remains, and is likely to remain, a grossly uneconomic one especially small operations.

It is generally recognised that the vast majority of offensive odours emanating from composting are produced during periods of anaerobiosis. Anaerobic conditions can be caused singly or in combination by, for example, materials being over-wet and consequently excluding air; or materials being left overlong in one position or in heaps that are too large so that the micro-flora are able to exhaust the oxygen supply.

Over-large heaps simply exacerbates any potentially anaerobic situation. Thus, whilst the principles of nonpolluting compost are simple enough, achievement of them is often made difficult due to the logistical difficulties of moving hundreds if not thousands of tonnes of raw material around in a confined space.

The logistical and organisational skills required in moving bulky materials round, in what are almost inevitably constrictive yards (acres of concrete are very expensive) during the early stages of producing a homogenous compost are prodigious.

However, skilful analysis of potential problem areas and careful re-planning of physical procedures, has demonstrated that these problems can be virtually overcome whilst at the same time maintaining production of high quality compost.

In recent years aerated floors and bunker technologies have increasingly been employed in compost yards. By first effectively wetting the straw, before the nitrogenous materials are added and then filling them quickly into aerated bunkers the period that these materials are exposed to ambient conditions has been substantially reduced.

By forcing air into the mass of material, thereby keeping it aerobic, the length of time that traditionally the material was exposed to ambient conditions is significantly reduced and the organisms responsible for malodorous effects are thereby also significantly reduced.

There is increasing pressure to enclose compost yards, once enclosed or in bunkers and tunnels, there is an opportunity to treat exhaust gasses by either scrubbing, passing them through biofilters or discharging them through chimneys, however, these are often expensive options.

4.7.3 Summary

Steps **must be** taken to avoid anaerobic conditions, whenever possible, in the preparation of compost.

The run-off liquor should be collected for recycling, passed through a screen to remove solid material and constantly aerated to prevent it turning anaerobic.

Where possible dry poultry manure should be used and stored under cover.

Research funded by the mushroom industry and DEFRA has been undertaken to adapt the composting processes. This research has indicated that manipulation of pre-wet practices, positive aeration of the phase I process and dirty water storage can, in some circumstances significantly reduce the production of offensive odours.

Owing to the fact that Mushroom compost raw ingredients include an appreciable quantity of animal manures, tests have been undertaken to establish the situation in relation to *E. coli* . The results indicate that finished Mushroom composts do not contain significant numbers of *E. coli* . The reasons no doubt are the high temperature regimes (70 - 80ºC) during phase I, in conjunction with the high levels of ammonia, and particularly the controlled pasteurisation regime (60ºC) for a number of hours that occurs during phase II composting.

However mushrooms should be tested post harvest, to reaffirm this situation.

Compost producers should also be vigilant and aware of possible ramifications of avian flu entering the UK and of any restrictions that may be imposed on handling poultry manure. Alternative nitrogen sources should be examined and preparation made for their use, in case it should ever become necessary to substitute chicken manure.

(NEW) Growers must also acquaint themselves with the recently introduced regulations concerning the removal of spent mushroom compost as it is now classified as a waste material under new EA regulations.

4.8 Casing materials

Casing is currently a mixture of peat and lime. Both peat and lime sources are numerous and varied, ranging, respectively, from raw sphagnum peat to dark, deep dug humified material and from ground limestone to sugar beet lime, produced during extraction of sugar.

It is recognised by the industry that a renewable alternative to peat for casing would be desirable however, the function of the casing layer is so crucial to the productivity and quality of mushrooms produced and the precision of production timing that it has proved difficult to find acceptable substitute materials. The casing layer is a critical material in mushroom production which triggers the vegetative mycelium that produces the mushroom sporophore (i.e. the Mushroom crop). Casing therefore has an enormous influence on the number, timing, weight and quality of the Mushroom crop. Some progress has been made in the area of peat alternatives however in that partial-substitution of peat with alternatives (eg coir, MRF or treated spent mushroom compost (SMC), production from these alternative casing soils is not as reliable or productive as a high quality peat casing soil.

Both DEFRA and industry-funded research and development, is still concentrating on maximising the various combinations of raw materials but also, and more relevantly to this protocol, upon gaining a deeper understanding of the functioning of the casing in relation to sporophore initiation and development.

One aspect of Mushroom production which should perhaps not be overlooked in this context, is the fact that the industry recycles approximately 0.5 million tonnes of spent mushroom compost per year which is itself a peat substitute for land improvement and various growing mediums. This material is increasingly being used as a substitute for poorer quality peat, which has traditionally been used to improve poor soils prior to and following planting schemes in both domestic and industrial projects. However, because of the potential pest and disease hazards and textural problems associated with the material it is at the moment ruled out as a direct substitute for peat in mushroom casing in the UK, though in other countries with different economies, it is used successfully as a partial replacement.

Protection of casing materials

Casing materials **should be** stored in adequate facilities.

As with many pests, the earliness in the cycle that they gain entry and the level of initial infestation, will dictate the scale and seriousness of the subsequent outbreak. It is vital, therefore, to protect casing from contamination of any sort. Much of what can be said in relation to protection is equally true for both pests and diseases.

Where casing or casing materials are stored on farm, every effort should be made to disinfect the storage areas before the casing is received and to physically isolate the stored casing from chance infection by staff activity or wind blown dust.

Hygiene procedures between casing batches is particularly important. Bins and bunkers need to be thoroughly cleaned between one batch of casing and another.

Baled peat may constitute a high risk in that it is often stored for considerable periods and the external debris that accumulates on the bale wrapping is often considered as a potential contaminant.

All surfaces, concrete, bunker walls, and handling equipment and machinery, pose threats of potential contamination. To achieve adequate protection, careful analysis is required of all the possible sources of contamination that casing mixing and application will present.

4.9 Hygiene

Any consideration of Mushroom pests and, particularly, diseases should be prefaced by a discussion of the general principles of hygiene.

The enclosed, usually compact, continuously mono-cropping environment of Mushroom farms, offers a unique opportunity for pest and disease control by good hygiene practice.

Good hygiene practice is an absolute must in any modern mushroom growing facility - failure to adhere to it will allow pests and diseases to thrive with perhaps catastrophic impacts on the production and the economics of the grower's business. The general principles of hygiene are simple enough and can be summarised as follows

- exclusion
- containment
- elimination

In practice, hygiene can never be perfect, due to the physical difficulties and often cost implications of the required procedures. Imperfections in our knowledge of the epidemiology of any given pest or disease hamper perfect hygiene practices as does, at times, the inability to eliminate the problem by either chemical or physical means.

But having accepted the limitations of hygiene, it must be understood that hygiene forms the major foundation upon which to build an integrated crop management programme employing as constituents all other control mechanisms, including pesticides and biological control agents.

4.9.1 Exclusion

This concept recognises the fact that for the most part, pest and disease organisms will emanate from another adjacent crop and exclusion, in theory at least, is possible and, if accomplished, completely curative. Initial, primary infections are often very small and their source untraceable with any certainty. Gross contamination of the farm or raw materials is usually obvious and, therefore, combatable.

Exclusion takes many forms, ranging from absolute filtration of well-sealed Phase II tunnels and rooms, Phase III and Case Run facilities. Dust and fly filters on cropping houses are also important barriers. In general, the creation of positive pressure with filtered air, within sensitive production areas and coupled to disciplined labour control that does not allow contamination by personnel, equipment and machinery from infected areas to clean ones are imperative.

4.9.2 Containment

When pest infestations or disease outbreaks occur, as they inevitably do even on the best-managed farms, damage can be limited by containment of the pest or disease to the crop in which it has occurred.

The means whereby this can be achieved, and the likelihood of success, will vary from one pest or disease problem to another and may be facilitated or otherwise by the layout of the farm.

As with the other general principles of hygiene control, specific priorities and particular methods will be referred to under sections dealing with the individual problems. However, it is always worth remembering that once an outbreak has occurred, this usually represents the largest and most potent source of infection for neighbouring and subsequent crops. It is far easier to exclude a disease in the first place, than to treat it once it is established.

In a few instances, chemical control may be used for immediate elimination, but more normally the objective has to be to contain or confine the problem to the site of occurrence. This may take the form of removing or covering diseased Mushrooms on the mushroom bed, or the use of appropriate disinfectants on floors and equipment, but in most instances the most important tactic is careful staff management, as staff can move diseases effectively between crops. Contaminant pests, such as Phorid, Sciarid, Cecid or mites, are also very effective vectors both within growing houses and between houses and farms, if both care and operational planning are not good.

Staff training is often required in order that pickers, in particular, can identify and avoid contact with problems.

4.9.3 Elimination

At the end of each crop, or earlier if exclusion and containment of pests or diseases have been unsuccessful, the problem, real or potential, must be eliminated from the farm to avoid levels rising higher than any hygiene programme can accommodate.

At its simplest, this refers to killing off the finished crop and with it any pests or diseases that may be present, emptying the crop carefully and cleanly to avoid contaminating the farm environs and thoroughly cleansing the house and any emptying or filling machinery. The mechanisms for killing off crops will vary dependent on the growing system and include sterilisation by heat ("cooking-out") and disinfectant drenches and fogs. All good hygiene programmes contain the assumption that each component is flawed and subsequent ones must therefore be designed on that assumption.

For example, assuming that "cooked-out" compost is still potentially infected when it is emptied or simply fogging or spraying a crop will at best only kill the organisms on the surface, so organisms within the compost mass will not be treated.

Superimposed upon these generalisations, concerning any hygiene programme, must be a clear understanding of the epidemiology of likely pest and diseases in order to facilitate accurate analysis of the most likely routes and times of infection.

5 Variety selection

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

6 Nutrition

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

7 Irrigation

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

8 Crop protection

8.1 The basic approach to crop protection

The guiding principle is that pesticide inputs should be minimised through prevention rather than cure. An integrated approach should be adopted to achieve this involving the following management steps:

Good management and cultural preventative techniques

Mushroom production has specific problems as a result of being an intensive, protected mono-crop exhibiting no varietal resistance to any pest or disease.

There are, however, various actions that can minimise the major pest problems, for example:

a. Good farm hygiene to avoid compost or mushroom debris lingering about the farm.
b. Recognition of vulnerable stages within the production process and thereby highlighting entry points into the cropping cycle, such as Phase II cool-down, spawning and spawn- running , casing and case running rooms and of course harvesting.
c. Regular fly trapping to anticipate pest build-up.
d. Sound observation of the developing, standing and harvested mushrooms.
e. Prompt treatment of any disease observed.

Where possible crops **should be** cooked-out on completion to eliminate the risk of introducing diseases from old crops into new ones. Where cooking-out is not feasible then crops should be sprayed thoroughly with a suitable disinfectant. All spent compost should be removed from the farm immediately after emptying and any crop debris cleared up immediately.

Corrective action

If the above fails to prevent or control the situation, the following approach should be adopted:

a) Where corrective action is required, biological and physical methods of pest control should be considered first.

- Contain the diseased mushroom to prevent other vectors contacting with it and spreading it to other locations (trap beneath a container, damp tissue, or salt, but apply any containment vehicle gently so as not to spread spores from the diseased tissue).

- Ensure that hygiene procedures are being performed effectively.

- Introduce biological controls known to be effective against the target organism.

- Wash areas effectively, but be acutely aware that splashing diseased material can spread spores as well.

b) If chemical control is needed, the following points should be considered, whilst ensuring effective control is achieved:

- Use of the least toxic and persistent product.
- Use of products that do not affect biological control agents and naturally occurring beneficial organisms.
- Use of the minimum effective dose rate.
- Use appropriate application methods with effectively maintained equipment, and spot treat wherever possible.

8.2 Plant protection product choice

See Generic Standards and/or Generic Guidance Notes.

Approved uses not included on the product label

In some circumstances product labels do not include all of the approved uses and growers and advisers wishing to check the approval notice of a particular product should note that this information is available from www.pesticides.gov.uk/psd_databases.asp

A search on the database for a product name should yield a results page. A click on the product name should

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link to a summary of the approval information. At the bottom of the summary are links to available notices which will give the statutory conditions of use.

In the case of products with older approval an electronic approval may not be available. In these cases growers should contact the PSD Information Services Branch for details of the approved conditions of use. Contact details are: p.s.d.information@psd.defra.gsi.gov.uk tel. 01904 455775.

8.3 Advice on the use of pesticides

See Generic Standards and/or Generic Guidance Notes

8.4 Application of pesticides

See Generic Standards and/or Generic Guidance Notes

8.5 Records of application

See Generic Standards and/or Generic Guidance Notes

8.6 Protective clothing/equipment

See Generic Standards and/or Generic Guidance Notes

8.7 Pesticide storage

See Generic Standards and/or Generic Guidance Notes

8.8 Empty pesticide containers

See Generic Standards and/or Generic Guidance Notes

8.9 Pesticide residues in fresh produce

Mushrooms **must be** checked annually for residue levels using an accredited laboratory.

See Generic Protocol Guidance Notes 8.9 for further background and generic advice.

Assured Produce is aware that a key area in the production of fresh produce which requires continued attention by growers and their advisors is that of keeping pesticide residues to a minimum. This issue is not just one of meeting the MRL trading standard but ensuring that any individual or multi residues are kept as low as possible below this level.

- **Optimising late applications of fungicides and insecticides to the edible part of the crop.**
- **Optimising the use of post harvest treatments.**
- **Ensuring minimum harvest intervals are followed**
- **Ensuring that application equipment is applying products correctly**

See Appendix 5 for the pesticide targets and guidelines on this crop.

8.10 Pest and Disease control

8.10.1 Pest control

8.10.1.1 Sciarid flies (*Lycoriella auripila)*

Sciarids, mostly of the species *Lycoriella auripila*, are potentially very damaging. Mushroom pests causing direct damage to mushroom tissue and crop loss from damage to the mycelial network that produces subsequent mushrooms. They also have a high nuisance value if present on marketed produce, and are very effective vectors of several diseases.

Several generations of flies can affect one crop if they gain entry early enough and once a farm has a presence of flies a multiplicity of measures will have to be employed throughout the cycle, in order to combat the infestation:

Physical protection when cooling Phase II compost

This should largely be taken care of by the absolute filters that should be fitted to all Phase II rooms; whether they be bulk tunnels, tray peak-heats or in situ Phase II in cropping houses; to avoid the devastation that can result from virus infections.

In addition, however, all other points of entry, in particular door seals, ductwork and air-handling units should be made fly proof. It is generally assumed that rooms with over pressure will exclude unwanted organisms, but Sciarids are known to be capable of entry against considerable forces of exhausting air, if there is no other barrier to stop them. Flies are attracted from considerable distances to exhausted air streams from mushroom facilities, so treatment, whether passive or active at these locations can be very beneficial as a control measure.

Minimal exposure of Phase II compost at spawning

It has been clearly demonstrated that this is a major potential weak area in the growing process and attempts to exclude Sciarid flies at this stage is difficult but essential if control is to be effective.

Introducing filtered air and maintaining positive pressure in the spawning hall is essential if ingress of flies to the compost at this vulnerable stage in the process is to be achieved.

The faster that this process can be conducted , the more the potential risk of infestation by flies can be reduced.

Growers must be constantly aware of the vulnerability to infection at this stage and occurrences of unnecessary exposure MUST be identified and avoided.

Protection of spawn-running rooms

Sciarid flies are most attracted to freshly prepared, uncolonised compost in the early stages of the mushroom growing process.

Spawn-running and case-running may be carried out in varying circumstances ranging from purpose-built chambers to the final cropping houses. In all circumstances, control strategies depend upon filtering incoming air, sealing doors and all ductwork and extract frames and filters.

Protecting the compost during this phase can be difficult if the compost has to be moved across the farm to spawn running facilities. However, securing these areas from flies is essential if effective control is to be achieved. High levels of filtration are vital if the elimination of flies from the early stages of the process is to be achieved and successive generations of flies are to be excluded.

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In those instances where spawn-running and case-running are carried out in purpose-built rooms, levels of exclusion similar to those for Phase II rooms is feasible. This may often exploit the cooling requirement of spawn-running by the re-circulation of cooled internal air, thus obviating the need for taking air into the rooms for long periods. But ductwork, door seals and extract vents still need to be secure.

Protection of compost in case running rooms

The same comments expressed for spawn running apply equally to this process.

Use of pesticides at spawn-running, in casing and during cropping

Pesticides are often a hugely valuable buttress to the strategy of exclusion described above, but they are not always essential. The need to use pesticides can more easily be identified if regular trapping and monitoring of fly populations is undertaken.

Standard sticky traps or illuminated traps can be informative and effective in both monitoring and reducing the level of fly infestation. There use can also help to highlight any weaknesses in the exclusion/hygiene programme employed.

Light traps are considered useful, by some growers, in removing adult flies from cropping house environments, and like sticky traps they are a useful monitor of fly activity.

Chemical control: Chemical and biological pesticides are available.

Application Method	Active ingredient		Product
Casing drench treatments	diflubenzuron, *Steinernema feltiae*	Full Approval	Dimilin Flo, Dimilin 25 WP various (biological agents)
Treating empty houses or spraying outside of buildings	bendiocarb	Can only be applied to empty buildings not to the crop	Ficam W

(NEW) Decis, Decis Protech and Bandu cannot now be used on mushroom crops

Py Spray Garden Insect Killer cannot now be used as an insecticide on mushrooms

If in doubt check the PSD Information Services Branch for details of the approval. Contact details are: p.s.d.information@psd.defra.gsi.gov.uk tel. 01904 455775.

(The insect parasitic nematode *Steinernema feltiae* is available in several commercial formulations as a casing treatment).

Resistance to Diflubenzuron is still a potential problem.

8.10.1.2 Phorid flies (*Megaselia* spp)

Megaselia halterata

These flies are generally a less important pest than Sciarid's causing pro rata considerably less direct crop loss. They can be a great nuisance value to Mushroom pickers and are certainly instrumental in the spread of Mushroom diseases and if not controlled can reach huge populations and cause considerable direct losses.

As with Sciarid fly control a multiplicity of control tactics involving both physical protection and the use of pesticides are required to produce a satisfactory control strategy in both spawn and case-running rooms.

The general principles of control are similar to those for Sciarids, but the different life cycles of the two flies places specific emphases on the overall fly control strategy. As these flies seek out colonised compost, ingress into the house via any crack or opening should be prevented, taping gaps around doors is often used as a barrier.

Where as Sciarids are most attracted to freshly produced uncolonised compost and casing, Phorids are drawn to the growing mycelium. In contrast to Sciarids, to which compost is most vulnerable from cooling down and during spawning, crops are most vulnerable to infestation by Phorids during active spawn growth. In the past Phorids were largely summer problems, however, modern farms provide conditions conducive to an all year round presence.

Chemical control:

Application Method	Active ingredient		Product
Treating empty houses or spraying outside buildings	bendiocarb	Can only be applied to empty buildings not to the crop	Ficam W

(NEW) Decis, Decis Protech and Bandu cannot now be used on mushroom crops

Py Spray Garden Insect Killer cannot now be used as an insecticide on mushrooms

If in doubt check the PSD Information Services Branch for details of the approval . Contact details are: p.s.d.information@psd.defra.gsi.gov.uk tel. 01904 455775.

Megaselia nigra

This is an unimportant pest, but one that does infrequently still occur, causing severe damage to the stipes and caps of Mushrooms. If light is excluded from houses the problem is solved. If structural alterations are made to buildings, for example, to allow the ingress of cooled air, care should be taken not to inadvertently allow light spillage.

8.10.1.3 Cecid flies (*Heteropeza sp. & Mycophila sp.)*

There are two genera of Cecid fly known to infest mushroom farms, *Heteropeza* (white) and *Mycophila* (orange) Cecids.

The adult flies are rarely seen as they are so small, but the paedogenic larvae, (larvae to larvae generations without going through a sexual phase), can on occasions be seen in large numbers. However, with the greatly improved hygiene practices now employed on Mushroom farms and casing plants and the increased use of deep dug peat in which the flies will not have laid eggs, the pest is not so prevalent as it has been in the past. But, their potential for spoilage is considerable and once a farm is contaminated they can be very persistent and difficult to eradicate.

The overriding control strategy is hygiene:

Protection of casing materials

As with many pests, the earliness in the cycle that they gain entry and the level of initial infestation, will dictate the scale and seriousness of the subsequent outbreak. It is vital, therefore, to protect casing from contamination of any sort and much of what can be said in relation to protection against Cecid larvae is equally true of other pests and diseases and has been mentioned in 4.8.

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The use of deep dug peats will tend to eliminate this pest from raw materials as the material in situ is too deep for the flies to lay eggs in.

Effective post crop sterilisation

Both as a primary source of crop contamination and as the source whereby casing may become infected, it is important to ensure thorough post crop sterilisation . Chemical treatments are ineffective against this pest, an effective cook out is the best treatment.

The greatest risk of recycling and build-up of Cecid problems is in the grain and joints of timber trays, and cracks and crevices in the floors and walls of buildings: historically these have been the cause of most intractable Cecid problems. Monitoring has shown that temperatures sufficient to kill Cecids are difficult to achieve in such inaccessible places between leg posts, thick sideboards and crevices within concrete. It isn't possible to be prescriptive in relation to the time required to achieve a kill in these circumstances, but in the cases of Cecid outbreaks on tray farms that do not respond to normal control measures, extension of both time and temperature of cook-out should be considered. Tray dipping preserves the timber and indirectly helps alleviate this problem.

Inter-house isolation

If Cecid outbreaks occur they can be very easily spread from affected houses to younger cleaner ones by staff movements. The larvae adhere with great facility to clothing that has brushed against trays or shelves, as well as on the hands and feet of farm personnel.

Strong effective hygiene precautions are necessary.

Chemical control: This is not currently possible on the crop. But strong disinfectants can be used to eradicate them within structural crevices during the end of crop hygiene routines if cook outs are not an option.

8.10.1.4 Tarsonemid mites (Tarsonemus myceliophagus)

Tarsonemid mites cause a characteristic reddish-brown staining at the base of the stipe as a result of their feeding habit. If mite numbers are high, the base of the stipe may be pointed and poorly anchored. Additionally, staining may also occur on the caps of the Mushrooms.

The now unusual presence of these mites, probably indicates a chance infection via raw material, neither is usually a constant source of infestation but once numbers are high they can, like Cecids and nematodes, become problematical contaminant pests.

In common with some nematodes, consideration should also be given to the likelihood of a partial failure of Phase II that might initially permit the presence of this pest.

The hygiene required to control Tarsonemid mites is essentially similar to that described for Cecids.

In this instance as with most other pests and diseases, cooked-out compost **should be** removed from the farm immediately after emptying and disposed of in the most appropriate manner so eliminating the potential of re-introducing disease onto to the farm (see section 8.1).

Chemical control: This is not currently possible on the crop. But disinfectants can be used to eradicate them within structural crevices during the end of crop hygiene routines if cook outs are not an option.

8.10.1.5 Red pepper mites *(Siteroptes mesembrinae syn Pygmephorus mesembrinae)*

Unlike Tarsonemid mites, red pepper mites are readily visible. There is no direct control available. They are considered indicative of the presence of *Trichoderma* mould within the compost upon which they feed.

Hygiene measures similar to those for tarsonemid mites are wise if less urgent. Elimination of the moulds they feed on, namely *Trichoderma* and other weed mould species within the compost must be the primary objective in controlling this, at times, costly nuisance. (See Section 8.10.2.6)

Chemical control: This is not currently possible on the crop, but effective disinfection at the end of the crop will dispose of them.

8.10.1.6 Nematodes

Thanks to improved composting facilities, Fungal feeding nematodes are very much a pest of the past, it is the saphrophytic species that can on occasions cause problems in today's crops.

Glistening `bristles' of migrating nematodes can sometimes be seen on the casing surface, each `bristle' consisting of many hundreds of nematodes. These are usually saprophagous nematodes. Although they can be a result of a failure of the phase II process, the cause for their presence nowadays is more likely to be contamination of materials and hygiene measures within the system.

a. Despite modern advances in compost technology, nematode infestations can still arise from inadequately pasteurised compost or contamination of Phase II compost by raw Phase I or a breakdown in hygiene procedures. Tracing the source of outbreaks, whether it is casing contamination or inadequate Phase II practices, often requires meticulous analysis of farm procedures and careful sampling.

   Heavy infestations have been implicated, in certain circumstances, in significant crop loss.

   The use of ruffling or levelling machinery will very effectively spread saprophytic nematodes through a mushroom bed and the use of them should be curtailed if major outbreaks occur.
b. Occasionally mycophagous nematodes occur. These infestations can cause serious loss and require stringent hygiene measures if they are to be eliminated.

The greatest danger in the rare instances in which mycophagus nematodes occur, is that their presence will either not be diagnosed or will be misdiagnosed. Unlike the common, often harmless, presence of saprophagous nematodes, mycophagous nematodes are always potentially very damaging to the crop.

Their original source, unless it is continuous, is probably less important than the fact that once established on a farm they can be very readily spread from older crops, in which numbers have built up, to younger cleaner ones.

Casing and cropping containers are particularly vulnerable to contamination.

Chemical control: This is not currently possible. But effective pasteurisation and good hygiene procedures during spawning, spawn running, casing and case running are important in curtailing these pests.

8.10.2 Disease control

8.10.2.1 Hygiene measures for *Verticillium fungicola* (dry bubble), *Mycogone perniciosa* (wet bubble) and *Dactylium dendriodes* (Cobweb)

a. Constant examination of the crop

   Regardless of the original source of disease organisms, which can arise from a number of sources, be it soil, dust, contaminated casing materials, or poor hygiene procedures on the farm, it is generally accepted that the major cause for serious disease outbreaks lies in undetected or un-contained disease

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on the farm. If diseases are not treated effectively they can quickly become a major threat to productivity and the economics of the farm.

It is essential, therefore, to maintain constant methodical vigilance of all crops. Staff involved in such tasks requires training in order to identify early disease symptoms and the more subtle manifestations of disease. It is essential to have accurate diagnosis of which "bubble" or cobweb species is present as chemical control measures and treatment will differ.

b. Immediate isolation of observed diseased Mushrooms before harvesting or watering is essential in the effective control of these diseases.

   Once disease has occurred on the beds, both watering and picking are the most effective methods of spread, particularly within a crop but in the case of pickers, also to other crops.

   It is therefore essential that both identification and isolation of disease be regularly and routinely carried out prior to watering and harvesting. Isolation techniques are varied and differ slightly from one disease to another (e.g. a finite piece of bubble compared to a patch of cobweb) but all have a single objective, to contain the disease organism either by clean removal or by covering, for example with salt. The method chosen will vary depending upon the prevailing circumstances.

c. As an aid to hygiene, it is desirable to work in younger crops before moving on to older ones. Especially if there is a disease outbreak, work from clean to infected crops.

   All harvesting equipment should be thoroughly cleaned with disinfectant before removal to another house. Ideally, such equipment should be confined to one house.

d. **Avoid dust.**

   Dust, within a cropping house and on the farm in general, is a potent carrier of spores and mycelial fragments of the disease organisms and should be avoided as a **high priority**.

   Dust filters on cropping houses have been shown to be effective in reducing disease levels. Phase II and Phase III rooms and spawning areas are now universally protected to such a high level that ingress of dust is automatically excluded.

e. Protect materials used in production - compost during spawn running - casing materials and casing during case running.

   As with most diseases and some pests, early contamination applies almost uncontrollable pressure upon other control measures and the fungal diseases are no exception. Stringent hygiene applied to the storage and handling of casing is always well rewarded and is probably the major fundamental defence against the three main fungal pathogens.

f. Employ effective cook-out and crop disposal.

   In similar vein, elimination of any disease in completed crops greatly aids the clean beginnings of subsequent ones.

g. Use of fungicides to synergise hygiene effects.

   The judicious and sparing use of the only available fungicide can greatly enhance the hygiene measures outlined. Fungicide should not be used prophylactically, but only when an occurrence of disease is anticipated, has occurred, or in those unfortunate situations where disease is endemic. To avoid the unnecessary use of fungicides the resistance of the pathogen should first be established.

h. Washing down is **important,** though splashing mushroom beds is to be avoided at all cost. All Mushroom waste should be removed and disposed of in the most appropriate manner: this eliminates the risk of re-introducing disease on to the farm.

i. Fly control is especially necessary to aid disease control.

8.10.2.2 *Verticillium fungicola* (Dry bubble)

Dry bubble has shown itself to be a most devastating disease. Stringent hygiene practices should be employed to treat disease **before** cultural events occur. Watering the crop is especially risky as the spores are sticky and are dispersed effectively in water droplets. Spores also very easily become incorporated into the dust fraction on a farm and are spread very effectively by contact with harvesters or any fly that may alight on the infected mushroom surface. *Verticillium* spores are also known to remain viable for long periods, so care should be exercised when the fabric of buildings are being altered as they will invariably contain spores.

Particular attention should be paid to preventing fresh casing from becoming contaminated with farm dust, especially if there is a severe outbreak of *Verticillium* on the farm. Fly control is especially necessary when *Verticillium* is a problem as flies are attracted to the aroma of infected tissue and cooking out crops early if they are severely infected will also assist in reducing the potential spread of the disease.

Chemical control:

Prochloraz is the only fungicide currently available within the UK for the effective control of *Verticillium.* Some isolates of *Verticillium* are more tolerant to prochloraz than others, but HDC funded research has shown that prochloraz will still give significant control of such isolates. In cases where the chemical does not appear to be effective it is worthwhile having isolates tested for tolerance as resistance has been reported. It is also worthwhile checking that the chemical is being applied at the correct rate.

8.10.2.3 *Mycogone* (Wet bubble)

Wet Bubble is a disease that can be introduced by casing contamination or dust blow around the farm or from soil in the vicinity. Early infection manifests itself by large swollen lumps of tissue, bursting through the casing layer often before a mushroom is harvested. In later flushes smaller pins often show blanket infection that can be easily confused at first glance to a Verticillium infection.

It produces two spore types, one which is small and water-dispersed like *Verticillium* , and a second which is a large resting spore capable of persisting for a long time in the environment. Stringent hygiene should be employed to treat this disease.

Chemical control:

Prochloraz is the only fungicide available that can be used. On-farm trialling or a tolerance test may be necessary to ascertain which fungicide is the most efficacious.

8.10.2.4 *Dactylium (Cladobotryum)*(Cobweb)

This disease is now more common, possibly due to changes in fungicide availability and cropping house environments. The principles of control are similar to those for *Verticillium* and *Mycogone* and centre around efficient hygiene. The spores of *Dactylium*, unlike those of *Verticillium* and *Mycogone* , are dry and are readily airborne if disturbed. It is essential therefore to closely monitor crops at risk and practise early containment of this disease.

Patches of cobweb should be identified and treated immediately, not left until tomorrow. Handle gently when treating and never water on untreated disease. Salting areas of disease must be preceded by gently covering the patch with damp tissue to prevent clouds of spores being disturbed and released into the air when salt is applied. This method of disease treatment is the most effective treatment.

The major crop loss caused by *Dactylium* is often due to spoilage from a cap spotting symptom as the spores are easily released and are quickly spread throughout the crop by the air handling system. Therefore air movement within the growing house should be minimised to prevent spread around the room.

Disease monitoring staff should be familiar with this manifestation of the disease and be able to distinguish fungal spotting from bacterial blotch symptoms.

It is sometimes helpful to have laboratory diagnosis of this symptom as several organisms can cause cap spotting, including *Verticillium,Trichoderma* sp and *Aphanocladium.*

At least two species of *Dactylium (Cladobotryum dendroides* and *C. mycophilum)* can cause Cobweb disease. Resistance to carbendazim has been detected in a large proportion of *C. mycophilum* isolates but as no Carbendazim formulations are now available for use on mushroom crops, physical measures are the only options now available.

Chemical control:

There is no specific Chemical control for *Dactylium* ,Prochloraz is now the only chemical that can be used although it will only give limited control and resistance has been reported.

8.10.2.5 Aphanocladium Cap Spotting *(Aphanocladium album)*

This disease manifests itself on the mushroom by cap spotting symptoms, though its derivation may well be from the compost. The spotting is usually brown in colour roughly circular though often with an irregular margin.

It often manifests itself when humidity's are high, indeed this form of cap spotting can often easily be distinguished from other pathological organism by simply placing the mushroom in a polythene bag with a damp tissue and keeping it warm for a day or so. After a period by holding the mushroom to the light, a tuft of dense mycelium can often be seen clearly with the naked eye emanating from the spot.

As the mycelium of the pathogen is also white, it can be hard to decipher in spawn run compost.

Chemical Control:

Sporgon can be used on the crop, but there is no chemical control possible for the source that usually lurks within the compost.

8.10.2.6 False Truffle *(Diehliomyces microsporus)*

This is now a relatively rare disease; modern composting facilities have almost eliminated it from commercial farms. It is a competitor mould of *Agaricus* in the compost . Avoidance of very high spawn running temperatures alleviates the problem. But an effective phase II and good hygiene procedures after Phase II are the best control measures.

No pesticides are approved.

8.10.2.7 Green mould *(Trichoderma harzianum)*

Trichoderma spp. cause a number of problems. The most serious one is compost green mould caused by *Trichoderma harzianum* Th2 now referred to as Trichoderma aggresssivum f.europeaeum. This organism can cause severe crop losses. Other severe strains have been reported elsewhere in the world, but they have not yet been reported in the UK or Europe to date.

A well balanced compost formulation, followed by a good phase II procedure coupled to a high level of hygiene at spawning, filling, spawn and case run, is needed to control *Trichoderma* problems on the farm. In particular, because of it's affinity to high carbohydrate levels , hygiene relating to spawn, spawn storage and spawn application is especially important , as is a well balanced carbon nitrogen ratio and a well conditioned compost.

Several other species can occur on tray timbers, chogs (mushroom stalks) and on casing and can cause serious Mushroom cap spotting problems especially when growing larger flat mushrooms that remain on the bed longer to mature. The symptoms are similar to cap spotting caused by *Dactylium* so it is important to correctly identify the organism responsible for the spotting symptom. Colonies of *Trichoderma* green mould on casing should be treated with salt prior to watering to prevent spores being splashed onto mushrooms.

If *Trichoderma sp* is established in the compost it is the development of colonies of red pepper mite that feed on the spores that are of concern as they are mobile can readily spread the spores to new crops. Infected areas must be treated to prevent spread though this is often only practicable on the surface. With severe infections, careful removal of the section, block or bag can be considered, though extreme care when handling the material must be exercised at all times to restrict further spread.

Chemical control:

Bavistin can no longer be used on spawn or be applied to the crop to reduce the prevalence of *Trichoderma* moulds and associated cap spotting symptoms. The presence on the surface of *Trichoderma* moulds and cap spotting symptoms was often incidentally controlled by other pesticides being used for one of the other major fungal pathogens. Now that only Sporgon is available, careful physical removal of the fungal growth or covering with salt is the only other control.

8.10.2.8 Bacterial Blotch *(Pseudomonas tolaasii)*

Blotch symptoms caused by *Pseudomonas tolaasii* is the most common organism and can result in large crop loss due to staining of mushrooms and spoilage.

Although the organism is believed to be always present on the mushroom, good environmental control will eliminate the development of the symptom. The ability to achieve rapid evaporation following watering and to control humidity and temperature levels accurately, has brought about considerable advances in bacterial blotch control. However, at certain times of the year when ambient humidity's are high, treatment of water with sodium hypochlorite may still be necessary to reduce bacterial populations and disease symptoms.

Chemical Control:

Sodium hypochlorite is an approved commodity substance used to treat the water that is applied to the Mushrooms. The recommended application rate is 150 ppm of available chlorine.

8.10.3 Virus disease

The great improvements in filtration and advances in crop hygiene procedures introduced within the industry has in the last few decades virtually eliminated the "traditional" La France symptom from the crop in the UK. However, a new Virus complex, termed Mushroom Virus X (MVX) was identified in Britain in 1996 and has since devastated the viability of a number of farms. MVX is much more insidious than La France virus ever was and hygiene and process control measures to control MVX need to be considerably more stringent.

These are summarised as follows:

a. It is imperative to exclude Mushroom spores and Mushroom mycelium fragments from the latter stages of Phase II by absolute filtration and from Phase III by equally effective filtration and recycling cooled air.
b. Mushroom spores and Mushroom mycelial fragments are very effective carriers of the condition and all stages where compost is handled or exposed are vulnerable e.g. filling bulk phase II or III onto shelves, casing, ruffling, venting etc.
c. Preventing early contamination of the crop is very important.
d. Preventing spores and mycelial fragments circulating from old to new crops is important in controlling the

condition. Filtration of exhaust ducts from cropping houses and control of all debris emanating from mushroom crops is important.

e. The spores that are released into the farm environment when growing open mushrooms are a major hazard. When harvesting closed cup mushrooms ensure that no mushrooms are allowed to open as distribution of spores around the farm must be controlled.
f. Isolation of cropping areas from Phase II and III production areas is important if physically and economically possible.
g. Effective post harvest cook-out to kill mushroom mycelium and spores is required to control outbreaks.
h. Effective sterilisation of growing containers and compost handling machinery, to eliminate cross contamination between growing houses and farms is essential.

Routine examination to monitor virus levels is advised should symptoms develop. Advice should be urgently sought if the levels do not respond to heightened hygiene methods. The Central Science Laboratory at York now performs the virus analysis service: Tel: 01904 462 781 web site http://www.csl.gov.uk

8.10.4 Disinfectants

These products, that are used to kill both pests, diseases and treat mushroom debris and form an integral part of the hygiene programmes repeatedly mentioned in this protocol.

The suppliers to the Mushroom industry have selected a range acceptable both to the crop and the operators on the farms.

These materials are not subject to the approval mechanisms of the Control of Pesticides Regulations but come under a new set of regulations, The Detergent Regulations 2005. This new legislation aims to enforce regulation 684/2004 which came into force on the 8th October 2005.

Formaldehyde was frequently used as a disinfectant and fumigant on mushroom farms as a commodity substance. **(NEW)** Its approval expired on the 31/12/2008 so can be used no longer.

9 Harvesting and storage

The Mushroom crop is harvested by hand into the container in which it is to be sold to the consumer.

Growers should, if they have not already done so, enlist the advice of their local Environmental Health Officers on the complex requirements of the Food Safety Act and associated Regulations.

Most Mushrooms are destined for cool chain marketing. They are grown at approximately 18°C. In order to retain field quality they **should be** brought down to 5°C as soon as practicable. The most desirable storage temperatures are within the range 2-4°C. High humidity storage facilities will assist in retaining quality up to the point of sale.

10 Pollution control and waste management

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

11 Energy efficiency

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

12 Health and safety

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

13 Conservation

See Generic Standards and/or Generic Guidance Notes.

Not all comments in these documents are relevant to Mushrooms.

Appendix 1 Insecticides approved for the control of mushroom flies (Sciarids and Phorids)

Active Ingredient	Product Features	Approval Type	Harvest Interval (1)	LERAP Category	Hazard Rating	MRL (mg/kg)
pyrethrins + resmethrin	Casing drench or fogging treatments	Off Label essential use(Pynosect 30 ®) 1	recom-mended to be at least 7 days given the MRL	none stated	Harmful	0.1 for resmethrin (LOD)
Bendiocarb	Can only be used on Empty Buildings		Cannot be applied to any stage of the crop		Harmful	

Notes:

(New) The "Off-label use" for Decis, Decis Protech and Bandu expired on 31st Dec 2008

(New) The "Off-label use" for Dimilin Flo expired on 31st Dec 2008

Check the PSD Information Services Branch for details of the approved conditions of use. Contact details are: p.s.d.information@psd.defra.gsi.gov.uk tel. 01904 455775.

(1) Essential Use Derogation. Off label essential use M01653

SOLAs provide for the use of a named product in respect of crops, situations or pests other than those included on the product label. Such use is undertaken at the user's choosing and the risk is entirely theirs and /or their advisers. The off-label use may only take place if all the conditions given in the "Notice of Approval" document, the product label and/or leaflet and any additional guidance on off-label approvals have first been read and understood. The conditions of approval given in the "Notice of Approval" are statutory and supersede any on the label which would otherwise apply. All SOLAs are conditional on the extant approval of the specific product. Not all formulations of each active ingredient may be currently approved for use on Mushrooms. Check before use. Label recommendations are revised regularly, read a current label before use.

Appendix 2 Biological control organisms for sciarid fly control

Organism
Steinernema feltiae

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Appendix 3 Products approved for controlling fungal diseases in Mushrooms

ActiveIngredient	Product Features	Approval Type	Harvest Interval	LERAP Category	Hazard Rating	MRL (mg/kg)
prochloraz	casing treatment	Full	4 days [(1)]	none stated	Irritant	2.0

Notes:

Bavistin DF can no longer be used on the Mushroom Crop.

[(1)] The harvest interval for prochloraz is 4 days. This means that mushrooms cannot be marketed if they are harvested within 4 days of an interflush application. Some interflush treatments may no longer be feasible.

Appendix 4 Products approved for tray dipping

There are no products approved for this operation.

The HSE has changed the field of use from a surface biocide and wood preservative to only as a surface biocide.

Dichlorophen and phenolics do NOT have PSD or HSE approval for use on wooden trays.

Appendix 5 Commodity Substances approved for use on Mushroom Crops

Product	Maximum Individual Dose	Date of Expiry; (unless later decisions are made or further prescribed extensions are granted)
Sodium Hypochlorite		31 st December 2008

Sodium Hydroxide has been included in Annex 1 in the Directive 2008/127 EC published on December 20th 2008. It is therefore legal to continue to use the substance at the moment.

It may however be subject to further scrutiny under the revision to the Plant Protection Directive 91/414/EEC so this matter should be checked with PSD in the future.

Contact details are: p.s.d.information@psd.defra.gsi.gov.uk tel. 01904 455775.

(NEW) Formaldehyde can no longer be used as a Fog or disinfectant on mushroom farms.

Appendix 6 Guidelines on minimising pesticide residues

Assured produce is aware that a key area in the production of fresh produce which requires continued attention by growers and their advisers is that of keeping pesticide residues to a minimum. This issue is not just one of meeting the MRL trading standard but ensuring that any individual or multi residues are kept as low as possible below this level.

Active ingredient	Target: pest, crop, disease	Current position	Suggested guidelines	MRL (mg/kg)
chlormequat	A plant growth regulator for cereals (4)	Residues rarely found (1) (2) (5)	Current practice is satisfactory	10
diflubenzuron	Sciarid fly larvae	No residues reported (3)	Current practice is satisfactory	0.1
omethoate (dimethoate)	Insecticide and acaricide used on cereals (4)	Residues rarely found, (1) (2)	Current practice is satisfactory.	0.02
prochloraz	*Verticillium Mycogone Cladobotryum*	Residues rarely found (1) (2) (3)	Current practice is satisfactory	2.0

Notes:

(1) Pesticide Residues Commission (PRC) data for 2001

(2) Residue levels between the limit of detection (LOD) and the MRL

(3) Data for 2001-2004 from two commercial mushroom growers

(4) Pesticides used on cereals may be present in the cereal straw and bran used in mushroom-growing substrates.

(5) PRC confirm that chlormequat residues were only found on *Pleurotus* and *Shitake* mushrooms and not in *Agaricus bisporus*

Appendix 7 Control Points: Mushrooms

CS.22 **MUSHROOMS**

CS.22.1 In order to meet anti-pollution requirements, all water run-off from compost yards must be contained for recycling, allowing only clean roof water into the normal drains. Protocol reference: Section 4.7.1
Soiled water storage must be screened to remove particulate matter and aerated to prevent anaerobic conditions developing. (Revised)

CS.22.2 Run-off samples, discharged into water courses from concrete surfaces, should be analysed for pesticides, disinfectants and organic matter - Protocol reference: Section 4.7.1

CS.22.3 All spent compost should be disposed of in the most appropriate manner and one which eliminates risk of introducing disease onto the farm - Protocol reference: Section 8.10.1.4
Mushroom Compost as from 15th May 2007 comes under waste regulations.

CS.22.4 All waste mushroom material should be disposed of in the most appropriate manner and one which eliminates risk of introducing disease onto the farm - Protocol reference: Section 8.10.2.1

CS.22.5 Steps should be taken to avoid anaerobic conditions in compost stacks and heaps - Protocol reference: Section 4.7.3

CS.22.6 The finished product must be analysed occasionally for contamination with E-coli and for chemical residues - Protocol reference: Section 4.7.3 & 8.9

CS.22.7 Mushrooms should be cooled after harvesting - Protocol reference: Section 9.0

CS.22.8 Where possible, crops should be cooked-out on completion to eliminate the risk of introducing diseases from old into new crops. If crop is not cooked-out, crops should be sprayed with suitable disinfectant- Protocol reference: Section 8.1

CS 22. 9 Mushrooms must be analysed occasionally for any pesticide residues
Protocol reference: Section 8.10 **(NEW)** Decis and Pynosect 30 can no longer be used on mushroom crops.