



Department of
**Agriculture,
Food and the Marine**

An Roinn
**Talmhaíochta,
Bia agus Mara**

Pesticide Usage in Ireland

Mushroom Crops Survey Report 2011

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MUSHROOM CROPS SURVEY REPORT 2011

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Summary

This report presents information from a survey of pesticide usage practices on mushroom crops (*Agaricus bisporus*) in Ireland in 2011. This is the first known and published survey of such practices conducted on the mushroom sector by the Department of Agriculture, Food and the Marine. Data were collected from 54 growers, representing 98% of all mushroom holdings in Ireland, with counties Monaghan, Cavan and Tipperary accounting for 60% of all mushroom crops grown in Ireland in 2011.

A total of 821 kilograms of PPPs and 3,030 kilograms of biocide chemicals were applied to mushroom production and spawn-running houses in 2011.

Fungicides accounted for the majority (92%) of the weight of PPPs used and were applied to 44% of the PPP-treated area. Prochloraz was the only fungicide active ingredient recorded during this survey period, primarily for 'general disease' control.

Insecticides accounted for 7% of the weight of PPPs used and were applied to 3% of the PPP-treated area. Diflubenzuron was the only insecticide active ingredient recorded in the survey, for the control of general flies.

The only bio pesticide recorded in this survey was the insect-pathogenic nematode *Steinernema feltiae* which was applied to 53% of the PPP-treated area.

Biocide usage on yard areas outside the mushroom houses and as part of the house sterilisation process accounts for 4789 kg of active ingredient and approximately 9,021 spray metres squared (sp m²). Due to the increased use of steam sterilisation and commercial pressure from the marketplace to reduce PPP inputs and residues, it is possible that the use of biocides will reduce over time.

A total of thirteen products, comprising two PPP active ingredients, six biocide active ingredients and one bio-pesticide were recorded in this survey.

Definitions and notes

- **‘Cropping area’** refers to the basic cropping area. (Example A: If a single mushroom house had 9 shelves and each shelf had 40m² of loose Phase III compost then the cropping area would be 40m² X 9 = 360m² per house).
- **‘Grown area’** refers to the basic cropping area multiplied by the number of growing cycles completed. (Example B: If the house in Example A was filled on 6 occasions during the year then 360m² x 6 = 2160m² = the total grown area).
- **‘Treated area’** refers to the total area treated with a pesticide, including all repeated applications to the ‘cropping area’, and is referred to in spray metres squared (sp m²).
- **‘Fills/filling’** refers to the first stage of the mushroom production cycle where the compost is put into the house. There are multiple fills of compost per year, with the number dependent on the duration of the mushroom cycle which is determined by the growing system, i.e. type of compost used (Phase II, II^{1/2}, III).
- **‘Flushes’** refers to the number of crops harvested from a single fill of compost, normally 2 to 3 crops.
- **‘Casing’** is a layer of peat mixed usually with sugar beet lime applied to the surface of the compost after the mycelium has permeated the compost, to encourage formation of the mushroom fruit bodies.
- **‘End spray’**; at the end of the mushroom cycle, a pesticide or disinfectant may be applied to the spent compost prior to disposal, to eradicate any potential disease or pest that may be present.
- **‘Reasons for use’**; the reasons reported for the use of pesticides are the growers’ stated reasons for use and may sometimes not reflect label recommendations.
- **‘Rounding’**; due to rounding of figures, there may be slight differences in totals both within and between tables.
- **‘Biopesticides’** are recorded by area treated (sp m²) only, as they are applied in units other than weight or volume (e.g. million per hectare) and this does not translate readily into a conventional weight.
- **‘Biocides’** are extensively used to maintain general hygiene levels in both the mushroom production houses and the surrounding yard areas, although they are not strictly regarded as PPPs.

- ‘PPP’ refers to plant protection products.
- ‘Mushrooms Harvested’ is calculated as a product of total growing area per farm for 2011 and the yield per square metre as reported by the grower on the day of the visit. The results are therefore an estimate rather than a direct measurement of what was actually produced.
- ‘Growing unit’ refers to an independent mushroom unit (house or number of houses) which is physically separate to other unit/s which are managed by the same grower.

Background

The regulatory system for PPPs in Ireland is based directly on EU legislation which provides a very high level of protection for man, animals and the environment. The hazard of an active substance is an inherent property which can cause a harmful effect and cannot be altered or mitigated.

Legislation has been put in place at both EU and national level to minimise the risks associated with the use of PPPs while ensuring necessary crop protection. Previously legislation has concentrated mainly on the authorisation of PPPs for specific uses and the laboratory testing of food samples for PPP residues. New legislation (Sustainable Use of Pesticides Directive) based on the EU ‘Thematic strategy on the sustainable use of pesticides’ aims to achieve a balance between ensuring human and environmental safety while maintaining continued viability of the farming and amenity sectors. This will involve training and registration of advisers, distributors, operators and inspectors of pesticide application equipment, controls on storage, supply and use, adoption of the principles of IPM and improved statistics on PPP use. To address the requirement for improved statistics, Regulation (EC) No 1185/2009 was adopted on 25 November 2009 which requires each member state to collect statistics on PPP use. It is the area identified above as “improved statistics on PPP use” that this survey and future surveys will be addressing.

While sales data can provide information on the overall amount of PPPs used in the country, surveys at farm/grower/producer level are required to quantify the amounts

used on different crops and to identify why, where and how they are being used. This type of information is required to clearly identify the risks involved and to develop and defend a strategy for the sustainable use of PPPs. Some of the specific outputs of a usage survey are as follows:

1. Provision of reliable factual data to inform policy makers.
2. Provision of information for the on-going review process of existing PPPs by providing data regarding national and regional usage of PPPs and use patterns for particular crops.
3. Monitoring farm practices to highlight areas where PPP use might be reduced by supplementation with or replacement by alternative pest control strategies e.g. use of resistant varieties, cultivation practices etc.
4. Provision of data to assess likely operator exposure to PPP and to predict environmental impact of PPP use.
5. Monitoring changes in patterns of PPP use of over time in response to government policy or economic factors.
6. Provision of information for residue monitoring programmes to assist with identifying particular areas of risk and to validate findings.

The mushroom industry in Ireland

Total mushroom production in Ireland in 2011 was estimated at 67,000 tonnes produced in 687 mushroom houses (Table A).

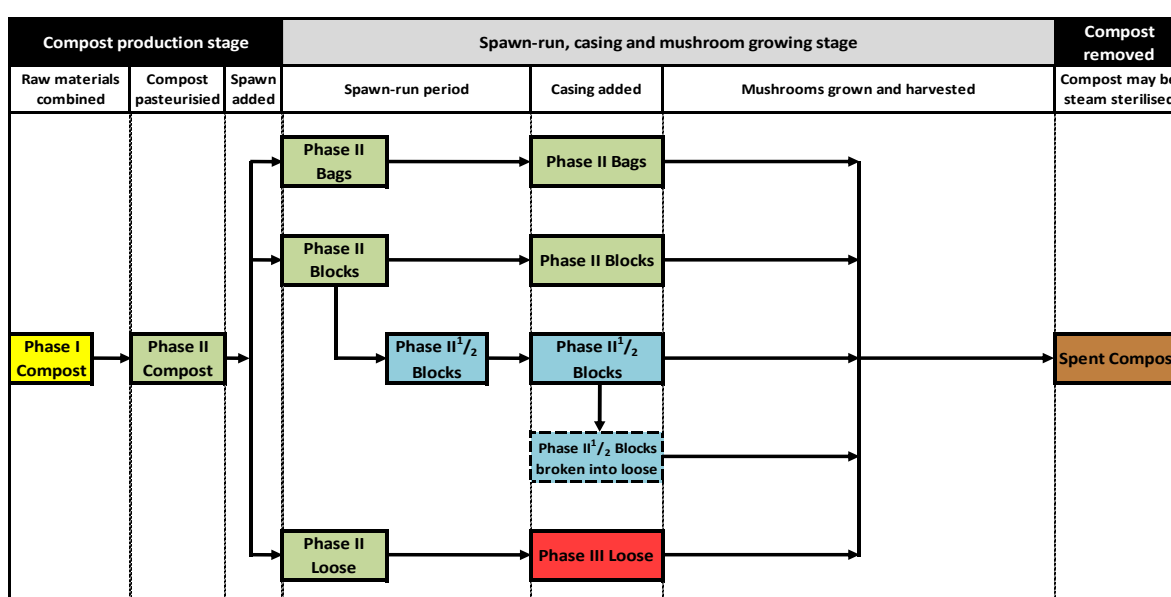
Table A: The total number of Mushroom houses, the total cropping area (x 1,000 square metres), the total area of mushrooms grown (x 1,000 square metres) and the total quantity of mushrooms harvested in Ireland, 2011.

County	Number of growing units	Number of mushroom houses*	Cropping area (x1,000 sp m ²)	Area grown (x1,000 sp m ²)	Mushrooms harvested 2011 (tonnes)
Monaghan	15	162	72.3	627.0	18,834
Cavan	8	101	45.4	393.1	11,033
Tipperary	10	115	48.8	391.1	10,711
All other counties	23	309	113.7	1005.1	26,739
Ireland	56	687	280.2	2416.2	67,316

*Includes spawning houses

The entire mushroom cropping cycle is determined by the types of compost and production system used. Typical examples of Phase II and Phase III compost systems are outlined below. A flowchart illustrating the various stages of commercial mushroom production is included (Figure 1).

Figure 1: Flowchart showing the various stages of commercial mushroom production in Ireland, 2011.



Phase 3

- Compost and casing supplied loose on the same day.
- Fully colonised compost fed directly onto shelves then casing added.
- First mushroom flush 17-18 days later.
- Second mushroom flush approximately seven days later.
- Third mushroom flush nine days later.
- House emptied and sterilised.

Phase 2

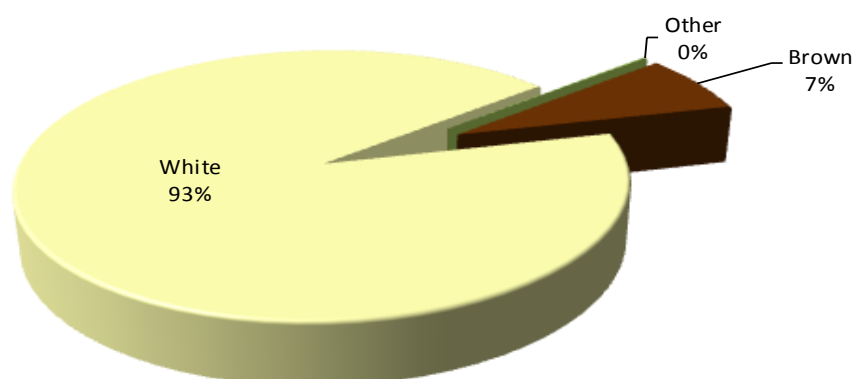
- Compost supplied normally in blocks direct from the supplier to the grower.
- Blocks/bags placed on racks/tiers/shelves to allow mycelium to colonise compost.
- Casing added 16 to 17 days later.
- First mushroom flush from day 34 onwards.
- Second mushroom flush approximately seven days later.
- Third mushroom flush nine days later.
- House emptied and sterilised.

Phase 2.5

- Compost supplied normally in blocks direct from the supplier to the grower.
- Compost blocks stored in a separate house to allow mycelium to colonise the compost
- Compost is then removed from the block and the “loose” compost is then placed on the shelves prior to the casing being added.
- This process reduces the length in the production cycle which allows additional growing cycles throughout the year in comparison to phase II.

This survey shows that there were a total of 687 mushroom houses used in Ireland for growing both white and brown mushrooms (*Agaricus bisporus*). Of this total, 9 were used exclusively for spawn-running compost (1%). White mushrooms were produced in 589 mushroom houses (85%) and brown mushrooms in 89 mushroom houses (13%). White mushrooms accounted for 93% of the total harvested weight (tonnes) of mushrooms in Ireland in 2011 (Figure 2).

Figure 2: The distribution of weight of mushrooms harvested in Ireland, 2011, by mushroom type.



Methods

Using data supplied by the Department of Agriculture, Food & Marine & commercial supplier data, the population of mushroom growers was established and selected. A preliminary letter was sent to growers explaining the purpose of the survey. Of a possible population of 55 growers, 54 participated in the survey. The sample data (98%) were raised to give estimates of regional pesticide usage. Growers were visited between March 2012 and June 2012 and data relating to growing methods and pesticide usage were collected by personal interview. This survey covers the period from 1st January 2011 to 31st December 2011. Collected data were analysed using IBM SPSS Statistics Version 19 software.

Results

PPP Usage in Mushroom Production

The active ingredients (including biopesticides) recorded in the current survey, ranked by application area and quantity applied (Tables B and C).

Table B: The active ingredients most extensively used in mushroom production in Ireland, 2011, ranked by treated area (x 1,000 sp m²)

No.	Active Ingredient	Total area treated (x1,000 sp m ²)
1	<i>Steinernema feltiae</i>	1,618
2	Prochloraz	1,345
3	Diflubenzuron	89

Table C: The active ingredients most extensively used in mushroom production in Ireland, 2011, ranked by weight (kg).

No.	Active Ingredient	Quantity applied (kg)
1	Prochloraz	761.3
2	Diflubenzuron	60.3
5	<i>Steinernema feltiae</i>	Trace

An estimated 821 kilograms of PPP active ingredients were applied to 3,052,000 spray metres squared (sp m²) of mushroom crops and mushroom houses in Ireland in 2011 (Tables D and E).

Table D: Estimated area treated (x 1,000 spray square metres) with each PPP type at different stages of mushroom production in Ireland, 2011.

<i>Production stage</i>	<i>PPP type</i>			Total area treated (x1,000 sp m²)
	Fungicides	Insecticides	Biological Controls	
House treatment	.	.	.	.
Pre-casing	.	.	.	.
Between casing and 1st flush	1,345	89	1,529	2,963
Between 1st and 2nd flush	.	.	89	89
Between 2nd and 3rd flush	.	.	.	.
End spray	.	.	.	.
All production stages	1,345	89	1,618	3,052

Table E: Estimated quantities (kg) of each PPP type applied at different stages of mushroom production in Ireland, 2011.

<i>Production stage</i>	<i>PPP type</i>		Total quantity (kg)
	Fungicides	Insecticides	
Pre-fill house treatment	.	.	.
Pre-casing	.	.	.
Between casing and 1st flush	761.3	60.3	821.6
Between 1st and 2nd flush	.	.	.
Between 2nd and 3rd flush	.	.	.
House sterilisation	.	.	.
All production stages	761.3	60.3	821.6

Fungicides accounted for 44% of the PPP-treated area and 92% of the weight of PPP applied. All of the fungicide was applied between casing and first flush. Prochloraz was the only fungicide active ingredient recorded during this survey.

Insecticides accounted for 3% of the PPP-treated area and 7% of the weight of PPPs applied.

The only biopesticide recorded in 2011 was the insect-pathogenic nematode *Steinernema feltiae*. It was applied to approximately 1,618,000 spray metres squared (sp m²) of growing medium between casing and second flush for the control of phorid (*Megaselia spp.*) and sciarid (*Lycoriella spp.*) flies representing 53% of the total PPP-treated area.

Regional PPP Usage

Of the 56 mushroom growing units, 27% were in County Monaghan, accounting for 162 mushroom houses and representing 26% of the cropping area of mushrooms grown. Mushrooms harvested in County Monaghan accounted for 28% of total mushrooms harvested nationally. County Tipperary had 18% of the growing units accounting for 115 mushroom houses, representing 17% of the cropping area of mushrooms grown and representing 16% of total mushrooms harvested nationally. A further 14% of growers were in County Cavan, accounting for 101 mushroom houses, representing 16% of the cropping area of mushrooms grown and representing 16% of total mushrooms harvested nationally. The balance of mushroom growing units (41%) was distributed between all other counties, accounting for 309 mushroom houses and representing 41% of the cropping area and 40% of total mushrooms harvested nationally (Figures 3, 4 and 5).

Figure 3: The regional distribution of mushroom growing units in Ireland, 2011.

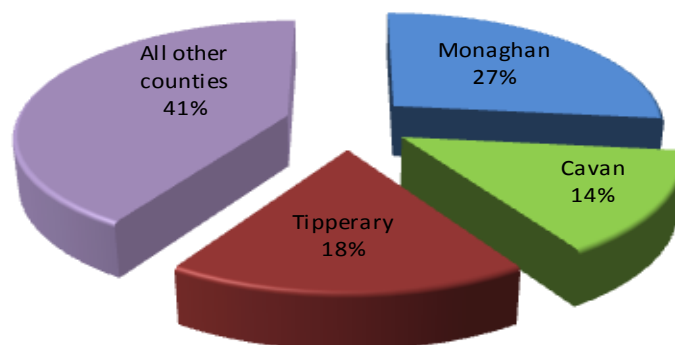


Figure 4: The regional distribution of the mushroom cropping area in Ireland, 2011.

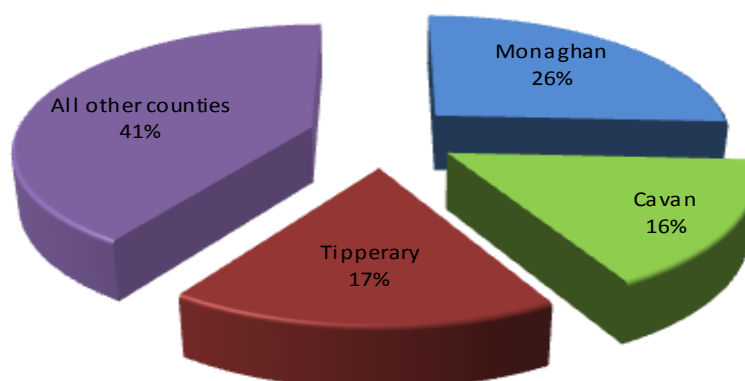
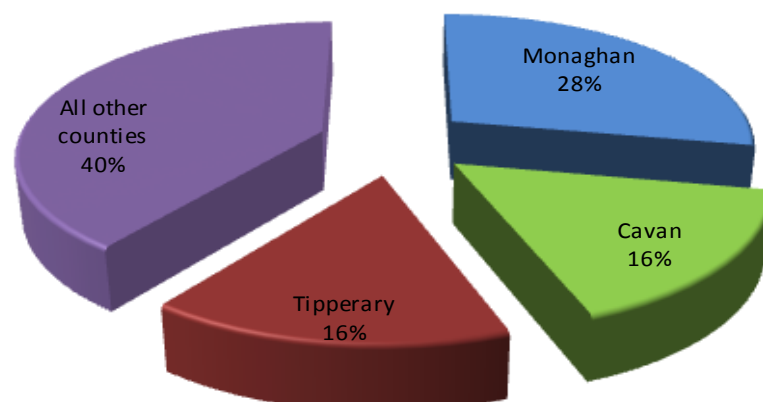


Figure 5: The proportion of mushrooms harvested by county in Ireland, 2011.



Growers in County Monaghan accounted for 32% of the total PPP-treated area, with Counties Cavan and Tipperary accounting for 19% and 9% of the total pesticide treated area respectively. 40% of all fungicide and 22% of insecticide treatment areas were applied in County Monaghan. 25% of all Biopesticides (*Steinernema feltiae*) treated area were applied in County Monaghan (Table F).

Table F: Regional distribution of PPP-treated area (x 1,000 spray square metres) of mushroom crops in Ireland, 2011.

County	PPP type			Total area treated (x1,000 sp m ²)
	Fungicides	Insecticides	Biological Controls	
Monaghan	543	20	402	965
Cavan	266	60	262	588
Tipperary	100	0	185	285
All other counties	436	9	768	1213
Ireland	1345	89	1618	3052

PPP usage on mushroom production stages

Pre-fill & pre-casing stages

The survey recorded that no PPPs were used during the pre-fill and pre-casing stages of mushroom production.

Between casing and first flush

PPP applications undertaken between the casing and 1st flush stage represent 100% of the total weight of PPPs and accounts for 97% of the total PPP treated area. (Tables G & H).

Table G: Estimated area treated (x 1,000 sp m²) with each formulation of PPP active ingredients at the different stages of mushroom production in Ireland, 2011.

PPP Type & Formulation	Stage of production						Total area treated (x1,000 sp m ²)
	Pre-fill house treatment	Pre-casing	Between casing and 1st flush	Between 1st and 2nd flush	Between 2nd and 3rd flush	House sterilisation	
Fungicides							
Prochloraz	.	.	1,345	.	.	.	1,345
All fungicides	.	.	1,345	.	.	.	1,345
Insecticides							
Diflubenzuron	.	.	89	.	.	.	89
All insecticides	.	.	89	.	.	.	89
Biopesticides							
<i>Steinernema feltiae</i>	.	.	1,529	89	.	.	1,618
All biopesticides	.	.	1,529	89	.	.	1,618
All PPPs	.	.	2,963	89	.	.	3,052

Table H: Estimated quantity (kg) of each PPP active ingredient applied at the different stages of mushroom production in Ireland, 2011.

PPP Type & Formulation	Stage of production						Total quantity (kg)
	Pre-fill house treatment	Pre-casing	Between casing and 1st flush	Between 1st and 2nd flush	Between 2nd and 3rd flush	House sterilisation	
Fungicides							
Prochloraz	.	.	761.3	.	.	.	761.3
All fungicides	.	.	761.3	.	.	.	761.3
Insecticides							
Diflubenzuron	.	.	60.3	.	.	.	60.3
All insecticides	.	.	60.3	.	.	.	60.3
Biopesticides							
<i>Steinernema feltiae</i>	.	.	Trace	.	.	.	Trace
All biopesticides	.	.	Trace	.	.	.	Trace
All PPPs	.	.	821.6	.	.	.	821.6

All fungicide applications during mushroom production were undertaken between the casing and 1st flush stage, representing 93% of the total weight of PPPs used and 44% of the total PPP treated area. The only fungicide active ingredient used was prochloraz, with approximately 99% of the fungicide treated area being for bubble control (*Verticillium spp.*) (Table I).

Insecticides applied between casing and first flush accounted for 7% of the total quantity of PPP applied and 3% of the total pesticide treated area. Diflubenzuron was the only insecticide recorded during the survey. All applications of insecticides at this stage were for the control of ‘general flies’ (Table I).

The application of the biopesticide (*Steinernema feltiae*) between casing and 1st flush stage accounted for 50% of the total treated area and was applied for the control of phorid (Diptera: *Phoridae*), sciarid (Diptera: *Sciaridae*) flies and ‘general flies’.

Table I: The PPP treated area (x 1,000 sp m²), the quantity of active ingredient formulation applied (kg) at each stage of mushroom production in Ireland, 2011, and the reason for use.

Stage	PPP Type & Formulation	Reason for use							Total area treated (x1,000 sp m ²)	Total Quantity (kg)
		Bacterial blotch	Bubble	Bubble/ Cobweb	General Flies	Phorid flies	Phorids & Sciarids	Sciarid flies		
Between casing & 1st flush	Fungicides									
	Prochloraz	2	1,333	10	.	.	.	.	1,345	761.3
	All fungicides	2	1,333	10	.	.	.	.	1,345	761.3
	Insecticides									
	Diflubenzuron	.	.	.	89	.	.	.	89	60.3
	All insecticides	.	.	.	89	.	.	.	89	60.3
	Biopesticides									
	<i>Steinernema feltiae</i>	.	.	.	323	53	1,144	9	1,529	Trace
	All biopesticides	.	.	.	323	53	1,144	9	1,529	Trace
Between 1st & 2nd flush	Biological Controls									
	<i>Steinernema feltiae</i>	.	.	.	.	.	89	.	89	Trace
	All biopesticides	.	.	.	.	.	89	.	89	Trace
All stages	All PPPs	2	1333	10	412	53	1,233	9	3,052	821.6

Between first and second flush

Only bio-pesticides (*Steinernema feltiae*) were applied between the first and second flush, accounting for 3% of the total treated area. (Table I).

Between second and third flush

No application of any PPP was recorded between the second and third flush stage.

House Sterilisation

No pesticides were used for sterilisation purposes or applied to compost during this survey period. This is primarily due to an increasing use of steam sterilisation at the end of the production cycle which destroys most microbial flora present in the compost prior to its removal. The procedure involves filling a house with steam at a consistent temperature for a set period of time to eradicate any disease that may be present. This procedure, normally referred to as ‘cooking-out’, is a very effective way to sterilise the house (including the shelves, racks, nets, ducts etc) as the steam can effectively penetrate all areas of the mushroom house.

Biocides are extensively used for general hygiene purposes outside the houses (refer to ‘*Biocide Usage on Mushroom House and Yard Areas*’). Biocides were applied to ‘spent compost’ prior to disposal to 6% of the total biocide treated area, representing 4% of the weight of disinfectants applied (Table L).

‘Spawn-running’ houses

Mushroom ‘spawn’ is a culture of *Agaricus bisporus* mycelium that is added to the compost. Generally, growers purchase compost that has been “spawned”. However, some growers “spawn-run” their own compost and dedicate houses, usually separate from the production unit, for this procedure. **A total of 4 growers “spawn-run” their own compost during this survey period, accounting for 9 mushroom houses.**

Houses dedicated to ‘spawn-running’ accounted for less than 1% of all PPP and biocide treated area to mushroom houses and less than 1% of quantity used. Biocides were the only treatments applied in the spawn-running houses. (Table J)

Table J: Estimated treated area (x 1,000 sp m²) and quantity (kg) of PPPs and Biocides applied to Mushroom house type.

PPPs and Biocides	Mushroom house type					
	Production house		Spawn-run house		Total	
	Area treated (x1,000 sp m ²)	Quantity (kg)	Area treated (x1,000 sp m ²)	Quantity (kg)	Total area treated (x1,000 sp m ²)	Quantity (kg)
Fungicides	1,345	761.3	0	0.0	1,345	761.3
Insecticides	89	60.3	0	0.0	89	60.3
Biopesticides	1,618	.	0	0.0	1,618	.
Biocides	6,530	3,017.0	29	13.5	6,559	3,030.5
All PPPs and Biocides	9,582	3,838.6	29	13.5	9,611	3,852.1

Biocide usage on mushroom house and yard areas

Biocides are extensively used to maintain general hygiene levels in both the mushroom production houses and the surrounding yard areas. Applications to the house structure, equipment (walls, floors, shelves, racks, etc,) and spent compost accounted for 73% of the area treated and represented 63% of the weight of Biocides used. The balance of 27% was applied to the yard area (concrete aprons, driveways, walkways etc,), accounting for 37% of the total weight of biocides used (Table K).

Overall, phenolic derivatives accounted for 44% of the biocide-treated area of mushroom houses and yard areas, and 36% of the quantity of biocides applied. Benzyl derivatives accounted for 35% of the biocide-treated area of mushroom houses and yard areas, and 37% of the quantity of biocides applied. Sodium hypochlorite represented 17% of the biocide-treated area and 26% of the weight applied.

Other biocides used include fatty acid and Bendiocarb which collectively account for 4% of the biocide treated area and 1% of the weight applied. (Tables K & L). It should be noted that bendiocarb is approved to be applied to the interior walls and structure of the mushroom house prior to compost being placed in the structure and is not approved for use during mushroom cultivation.

Table K: Estimated treated area (x 1,000 sp m²) and quantity applied (kg) of the different biocide types used in mushroom production in Ireland, 2011.

Biocide type	Location of treatment					
	Mushroom House		Yard		All biocide treatments	
	Area treated (x1,000 sp m ²)	Quantity (kg)	Area treated (x1,000 sp m ²)	Quantity (kg)	Total area treated (x1,000 sp m ²)	Quantity (kg)
Phenolic derivatives	2,595	1,087.0	1,369	630.0	3,964	1,717.0
Sodium hypochlorite	995	725.0	529	509.0	1,525	1,234.0
Benzyl derivatives	2,629	1,184.0	537	602.0	3,166	1,786.0
Other biocides	340	34.5	26	18.0	366	52.5
All Biocides	6,559	3,030.5	2,462	1,759.0	9,021	4,789.5

Table L: The biocide types used at the different stages of mushroom production in Ireland, 2011.(i) Estimated biocide-treated area (x 1,000 sp m²)

Biocide type	Production Stage			
	House sterilisation	Applications to spent compost	Yard treatment	Total area treated (x1,000 sp m ²)
Phenolic derivatives	2,232	363	1,369	3,964
Benzyl derivatives	2,422	207	537	3,166
Sodium hypochlorite	995	.	529	1,525
Other biocides	340	.	26	366
All biocides	5,989	570	2,462	9,021

(ii) Quantity of biocide applied (kg)

Biocide type	Production Stage			
	House sterilisation	Applications to spent compost	Yard treatment	Total quantity (kg)
Phenolic derivatives	1,014	73	630	1,717
Benzyl derivatives	1,078	106	602	1,786
Sodium hypochlorite	725	.	509	1,234
Other biocides	35	.	18	53
All biocides	2,852	179	1,759	4,790

Biocide usage in compost production process

Biocides have been used during the mushroom compost production process for cleaning machinery, equipment, yard areas and vehicles used for transporting compost, however, there was insufficient information available regarding quantities used and areas of application to enable an estimate of the biocide usage at this stage.

Other product recorded in survey

During the survey the use of calcium chloride was also recorded. Calcium chloride is not registered as a PPP or biocide. It is used as a horticultural practice in mushroom production as a quality enhancer and is applied via the watering system onto mushroom beds between the 1st and 2nd flush and between the 2nd and 3rd flush.

Acknowledgements

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