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PESTICIDE USAGE IN NORTHERN IRELAND
SURVEY REPORT 245

NORTHERN IRELAND MUSHROOM CROPS 2011

A National Statistics Publication

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PESTICIDE USAGE SURVEY REPORT 245

NORTHERN IRELAND MUSHROOM CROPS 2011

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SUMMARY

This report presents information from a survey of pesticide usage practices on mushroom crops (*Agaricus bisporus)* in Northern Ireland in 2011. It is the fifth survey of pesticide usage practices conducted on the mushroom sector in this region. Results from the previous surveys, which reported on pesticide usage practices on mushroom production in 1991 (Kidd *et al*; 1994), 1995 (Kidd *et al*; 1998), 1999 (Kearns *et al*; 2002) and 2007 (Kearns *et al*; 2008), are included in the report for comparative purposes. Data were collected from 35 growers, representing 92% of all mushroom holdings in Northern Ireland, with counties Armagh and Tyrone accounting for 94% of all mushroom crops grown in Northern Ireland in 2011.

When compared with the previous survey in 2007, the number of growers decreased by 31%, the area treated with pesticides decreased by 13% and the quantity of pesticides used decreased by 58%. Conversely, during the same period, the cropping area increased by approximately 10% to 105,000m^2. A total of 231 kilograms of pesticides and 1,700 kilograms of disinfectant chemicals were applied to mushroom production and spawn-running houses in 2011.

In common with previous surveys, fungicides accounted for the majority (91%) of the weight of pesticides used and were applied to 33% of the pesticide-treated area. Prochloraz was the only fungicide active ingredient recorded during this survey period, primarily for 'general disease' control.

Insecticides were principally used for the control of phorid (Diptera: *Phoridae*) and sciarid (Diptera: *Sciaridae*) flies. Applications of bendiocarb to the interior walls and structure of the mushroom houses, primarily at the pre-fill house treatment stage, accounted for 59% of the insecticide-treated area and 83% of the weight of insecticides applied. Bendiocarb does not have approval for use during mushroom cultivation, however, it does have approval for use on structures in which mushrooms are grown, i.e. on internal walls and frames of mushroom houses prior to compost being placed in them.

The only biopesticide recorded in this survey was the insect-pathogenic nematode *Steinernema feltiae* which was applied to 38% of the pesticide-treated area. Proportionately, biopesticides have increased in use from less than 5% of total area treated in 1999 to almost 40% in 2011 (Figure 12).

Disinfectant usage on yard areas outside the mushroom houses and as part of the house sterilisation process increased by 34% in area compared with 2007, making it comparable to the area treated in both 1995 and 1999 at approximately 3,180 spray metres squared (sp m^2). However, the quantity of disinfectants used decreased by 70% compared with 2007, possibly due to the increased use of steam sterilisation and commercial pressure from the marketplace to reduce pesticide inputs and residues.

A total of ten products, comprising four pesticide active ingredients, three disinfectant active ingredients and one biopesticide were recorded in this survey.

DEFINITIONS AND NOTES

- **'Cropping area'** refers to the basic cropping area. (Example A: If a single mushroom house was filled with 800 blocks @ 0.24m^2 per block, the cropping area = 192m^2 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 192m^2 x 6 = 1152m^2 = 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 m^2).
- **'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 m^2) 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.
- **'Disinfectants'** 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 Pesticides.
- **'Salt'** (sodium chloride) has been used as a spot treatment for mould and disease problems, but due to the unreliability of information regarding areas covered and quantities applied, an accurate assessment on the extent of its use cannot be provided.

INTRODUCTION

As a participant in the UK Working Party on Pesticide Usage Surveys, the Agri-Food and Biosciences Institute (AFBI), on behalf of the Department of Agriculture and Rural Development for Northern Ireland (DARDNI), conducts a cyclical programme of surveys to examine pesticide usage in all sectors of the agricultural and horticultural industries. Principally, the data collected provides information for consideration by the Advisory Committee on Pesticides. In addition, the information may also be used by those involved in residue testing, for public information and to evaluate the impact of policy and trends in pesticide usage.

A list of published Northern Ireland Pesticide Usage Survey reports is shown in Appendix 1.

THE NORTHERN IRELAND MUSHROOM INDUSTRY

The Northern Ireland mushroom industry has experienced substantial changes in the twenty years since the first pesticide usage survey was carried out in 1991. The number of growers has reduced from 296 in 1991 (1,272 mushroom houses) to 38 in 2011 (357 mushroom houses). The basic cropping area has decreased by 56% when compared with 1991, and 70% when compared with 1999. However, the cropping area has increased by almost 10% when compared with 2007 (Table 15).

Total mushroom production in Northern Ireland in 2011 was estimated at 22,000 tonnes, an increase of 16% since 2007. This represented a farm-gate value of £28 million[1], an increase of 29% since 2007. The increase in mushroom production outputs, despite a reduction in the number of growers, is possible through changes in growing systems and the availability of quality compost, both of which contribute to the efficiency of crop production.

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 21).

Growers using Phase III compost fed directly onto shelves accounted for 22% of all growers and 58% of the total weight of mushrooms harvested. The advantage with the shelf system is that compost and casing are carried out on the same day, usually by specially designed conveyer systems for ease of loading from lorry to shelf. As with Phase II$^{1}/_{2}$ compost, this reduces the length of the production cycle and allows for additional production cycles per house per year. Phase III compost converted in aerated tunnels under controlled conditions and used on a shelf system currently provides the optimum cultivation process for producing mushrooms[2].

The number of growers using Phase II compost blocks has increased from 48% of growers in 2007 to 62% in 2011. This figure also includes the use of Phase II$^{1}/_{2}$ compost, where Phase II compost blocks are placed in separate spawn-running houses to allow the mycelium to colonise the compost before being transferred to the final mushroom production house.

The 'bag-system', which in 1995 was the sole method used for growing mushrooms, is now only used by 8% of growers, a decrease of 62% since 2007.

Phase II

- Compost supplied normally in blocks or bags direct from the supplier.
- Blocks/bags placed on racks/tiers/shelves to allow mycelium to colonise compost.
- Casing added 12 to 17 days later.
- First mushroom flush from day 30 onwards.
- Second mushroom flush approximately seven days later.
- Third mushroom flush seven days later.
- House emptied and sterilised.

Phase III

- Compost and casing supplied loose on the same day.
- Fully colonised compost fed directly onto shelves then casing added.
- First mushroom flush 16 days later.
- Second mushroom flush approximately seven days later.
- Third mushroom flush seven days later.
- House emptied and sterilised.

There was a total of 357 mushroom houses used in Northern Ireland during this survey period for growing both white and brown mushrooms (*Agaricus bisporus*). Of this total, 24 were used exclusively for spawn-running compost (7%). White mushrooms were produced in 255 mushroom houses (71%) and brown mushrooms in 78 mushroom houses (22%). White mushrooms accounted for 82% of the total harvested weight (tonnes) of mushrooms in Northern Ireland in 2011 (Figure 8).

Disinfectants 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 disinfectant usage at this stage.

METHODS

Using data supplied by the Department of Agriculture and Rural Development Northern Ireland (DARDNI), commercial supplier data and a database of growers from previous surveys, 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 38 growers, 35 participated in the survey. The sample data (92%) were raised to give estimates of regional pesticide usage. Growers were visited between November 2011 and January 2012 and data relating to growing methods and pesticide usage were collected by personal interview. This survey covers the period from September 2010 to September 2011. Collected data were analysed using IBM SPSS Statistics Version 19 software.

RESULTS AND DISCUSSION

Pesticide Usage in Mushroom Production

The active ingredients (including biopesticides) recorded in the current survey, ranked by application area and quantity applied, are listed in Tables 5 & 6.

An estimated 231 kilograms of pesticide active ingredients were applied to 1,173,000 spray metres squared (sp m^2) of mushroom crops and mushroom houses in Northern Ireland in 2011 (Tables 3 & 4).

Fungicides accounted for 26% of the pesticide-treated area and 91% of the weight of pesticides applied. An estimated 98% of fungicide was applied between casing and first flush. Prochloraz was the only fungicide active ingredient recorded during this survey.

Insecticides accounted for 44% of the pesticide-treated area and 9% of the weight of pesticides applied. An estimated 30% of insecticide treatments (bendiocarb only) were applied at the pre-fill house treatment stage, representing 39% of the weight of insecticides applied. A further 28% (bendiocarb and pyrethrins) were applied prior to casing, accounting for 18% of the weight of insecticides applied. A further 30% of insecticides (bendiocarb, pyrethrins and diflubenzuron) were applied between casing and first flush, representing 36% of the weight of insecticides used at this stage. The remaining 12% of insecticide treatments (bendiocarb and pyrethrins) were applied between first and second flush, accounting for 7% of the weight of insecticides applied (Figure 16). *N.B*. Bendiocarb is only used on the structure of the mushroom house (i.e. walls, doors, frames etc;) and not on the growing medium at any stage.

The only biopesticide recorded in 2011 was the insect-pathogenic nematode *Steinernema feltiae.* It was applied to approximately 445,000 spray metres squared (sp m^2) of growing medium between casing and first flush for the control of phorid (*Megaselia spp.*) and sciarid (*Lycoriella spp.*) flies representing 30% of the total pesticide-treated area, compared with 24% in 2007. Figure 12 shows the proportional increase in the use of biopesticides since 1999 and the decrease in conventional pesticides during the same period. Changes in pesticide approvals, regular audits of growing practices and the influence of the large supermarket chains in Northern Ireland have led to significant decreases in pesticide usage.

Regional Pesticide Usage

Of the 38 mushroom growers in Northern Ireland, 68% were in County Armagh, accounting for 242 mushroom houses and representing 69% of the cropping area of mushrooms grown. A further 26% of growers were in County Tyrone, accounting for 77 mushroom houses and 15% of the cropping area (Table 1; Figures 2 and 3).

Growers in County Armagh accounted for 49% of the total pesticide-treated area, with Tyrone accounting for 33%. An estimated 61% of all fungicide and 25% of insecticide treatments were applied in County Armagh. Conversely, 62% of all insecticides (including the use of bendiocarb) and 17% of fungicide treatments were applied in County Tyrone (Table 2). Biopesticides (*Steinernema feltiae*) were primarily used in County Armagh, resulting in reduced use of conventional insecticide treatments.

PESTICIDE USAGE ON MUSHROOM PRODUCTION STAGES (Table 9, Figures 19 & 20)

Pre-fill house treatment

The only treatment applied at this stage was bendiocarb, for controlling phorid (Diptera: *Phoridae*), sciarid (Diptera: *Sciaridae*) flies and ‘general flies’. Almost 8kg of active ingredient was applied to 101,000 sp m^2 of interior walls, structural frames and doors prior to compost being placed inside the house.

Bendiocarb applications to mushroom houses prior to ‘filling’ represented 9% of the total pesticide-treated area and 3% of the total quantity of active ingredients applied (Tables 7 & 8).

Pre-casing

After the house has been filled with compost, an insecticide may be applied to control flies prior to casing. Insecticides applied at the pre-casing stage accounted for 8% of the total pesticide-treated area but only 2% of the weight of pesticides applied (Tables 7 & 8).

Bendiocarb was applied to the interior walls and doors to control phorid (Diptera: *Phoridae*), sciarid (Diptera: *Sciaridae*) and 'general flies'. Pyrethrins were applied direct to the compost to control 'general flies' and accounted for 5% of the weight of insecticides used at this stage.

Between casing and first flush

An estimated 79% of all pesticide applications were undertaken between the casing and first flush stage, accounting for 92% of the total quantity of pesticides used (Tables 7 & 8).

Almost all fungicide application during mushroom production occurred at this stage, representing 98% of both the area treated and quantity used. The only fungicide active ingredient used was prochloraz, with approximately 87% of applications for 'general disease' and 11% for the treatment of soil-borne fungi (*Verticillium* spp.).

Insecticides applied between casing and first flush accounted for 30% of the total insecticide applications, and 36% of the quantity of insecticides used. Diflubenzuron, which in 2007 represented 84% of post-casing treatments and 99% of the weight of insecticides applied, accounted for only 4% of the treated area but 42% of the weight applied. Pyrethrins, which were not used at this stage in 2007, represented 52% of the insecticide-treated area but only 3% of the weight of insecticides applied. Bendiocarb was the only other insecticide applied at this stage, accounting for 45% of the insecticide-treated area and 57% of the weight of insecticides applied. This was an increase from 2007 when only 4% of the area was treated with this active ingredient representing less than 1% of the quantity of insecticides applied. Approximately 96% of insecticides used at this stage were for the control of 'general flies'.

A possible explanation for the decreased use of diflubenzuron could be the increased availability of Phase III compost, changes in production systems and an increased use of biopesticides, all of which would reduce the need for conventional pesticides.

The only recorded use of biopesticides on mushroom crops in 2011 occurred at this stage of production, with the biological control agent *Steinernema feltiae* being applied to 38% of the treated area for the control of phorid (Diptera: *Phoridae*) and sciarid (Diptera: *Sciaridae*) flies, an increase of 37% from 2007.

Between first and second flush

Insecticides were the only pesticide group applied between the first and second flush, accounting for 3% of the total pesticide-treated area and 1% of the quantity of all pesticides applied at this stage (Tables 7 & 8).

Pyrethrins, used for 'general fly' control, accounted for 66% of the insecticide-treated area and 7% of the quantity used, while the carbamate insecticide bendiocarb accounted for the remaining 34% of treated area and 93% of the quantity of insecticides applied, with phorid (Diptera: *Phoridae*) and sciarid (Diptera: *Sciaridae*) flies being the only reason given for use.

Between second and third flush

The only pesticide used at this stage was the protectant and eradicant imidazole fungicide prochloraz, representing 1% of the total pesticide-treated area and 2% of the quantity of pesticides applied. The only reason stated for use was 'general disease' control.

House Sterilisation

No pesticides were used for sterilisation purposes or applied to compost during this survey period, in contrast to 2007, when active ingredients applied to 'spent' compost at the end of crop production accounted for 4% of the total pesticide-treated area and 36% of the total quantity of pesticides applied.

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, a procedure that 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.

Disinfectants are extensively used for general hygiene purposes (refer to *'Disinfectant Usage on House and Yard Areas'*). Only 5% of disinfectants were applied to 'spent compost' prior to disposal, representing 2% of the weight of disinfectants applied.

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'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 5 growers "spawn-run" their own compost during this survey period, accounting for 24 mushroom houses in counties Armagh and Tyrone.

Houses dedicated to 'spawn-running' accounted for 4% of all pesticide and disinfectant applications to mushroom houses and 13% of quantity used. Disinfectants were the principal treatments applied, accounting for 83% of the treated area, with insecticides accounting for the remaining 17% of applications (Table 10).

DISINFECTANT USAGE ON MUSHROOM HOUSE AND YARD AREAS

Disinfectants are extensively used to maintain general hygiene levels in both the mushroom production houses and the surrounding yard areas. Applications to the house structure and equipment (walls, floors, shelves, racks, etc,) accounted for 72% of the area treated and represented 82% of the weight of disinfectants used. A further 23% was applied to the yard area (concrete aprons, driveways, walkways etc,), accounting for 16% of the total weight of disinfectants used. Only 5% of disinfectants were applied to "spent compost" prior to disposal, representing 2% of the weight of disinfectants applied.

Overall, phenolic derivatives accounted for 73% of the disinfectant-treated area of mushroom houses and yard areas, and 67% of the quantity of disinfectants applied. Sodium hypochlorite represented 12% of the disinfectant-treated area and 31% of the weight applied (Tables 13 & 14).

COMPARISON WITH PREVIOUS SURVEYS OF PESTICIDE AND DISINFECTANT USAGE IN MUSHROOM PRODUCTION (Tables 15 to 19)

The population of mushroom growers decreased by 31% in 2011 compared with 2007, however, the basic cropping area increased by approximately 10% as did the overall area grown, which increased by 17%.

In common with previous surveys, the majority of pesticides were applied between casing and first flush. The principal stage of disinfectant application to mushroom houses was also comparable with previous years, with all treatments being applied at end-of-crop house sterilisation stage.

The use of biopesticides is continuing to increase, with a 37% increase in the area treated compared with 2007. The only biopesticide recorded was *Steinernema feltiae,* used solely between casing and first flush.

The disinfectant-treated area increased by 34%, even though the number of mushroom houses decreased by 18%. However, the overall quantity of disinfectant active ingredients used decreased by 70%, possibly due to a substantial decrease in the use of chlorine based products since 2007. Disinfectants, applied to the yard area surrounding the houses, decreased by 47% when compared with 2007, as did the quantity used, which decreased by 85% during the same period.

ACKNOWLEDGEMENTS

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Figure 1 **The regional distribution of mushroom growers in Northern Ireland, 2011.**

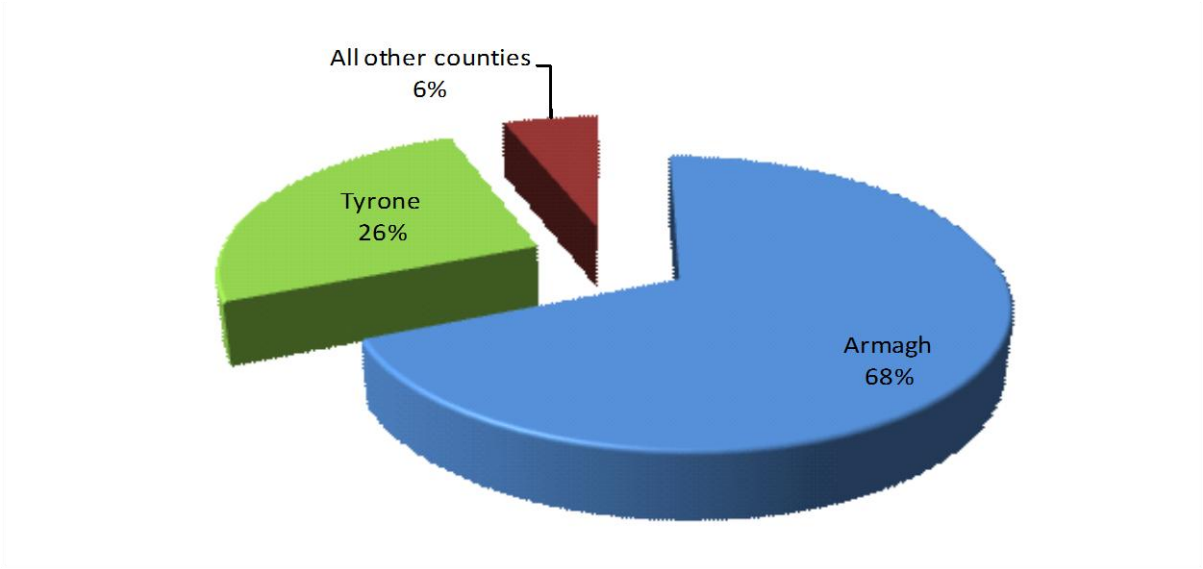

Figure 2 **The regional distribution of the mushroom cropping area in Northern Ireland, 2011.**

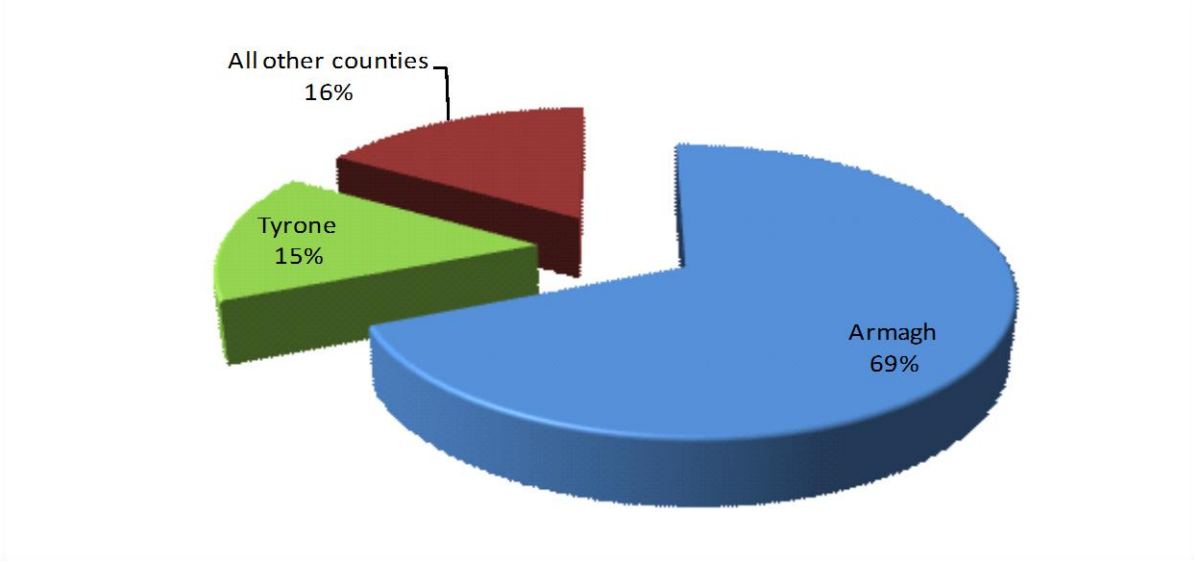

Figure 3 **The proportion of mushrooms harvested in Northern Ireland, 2011, by county.**

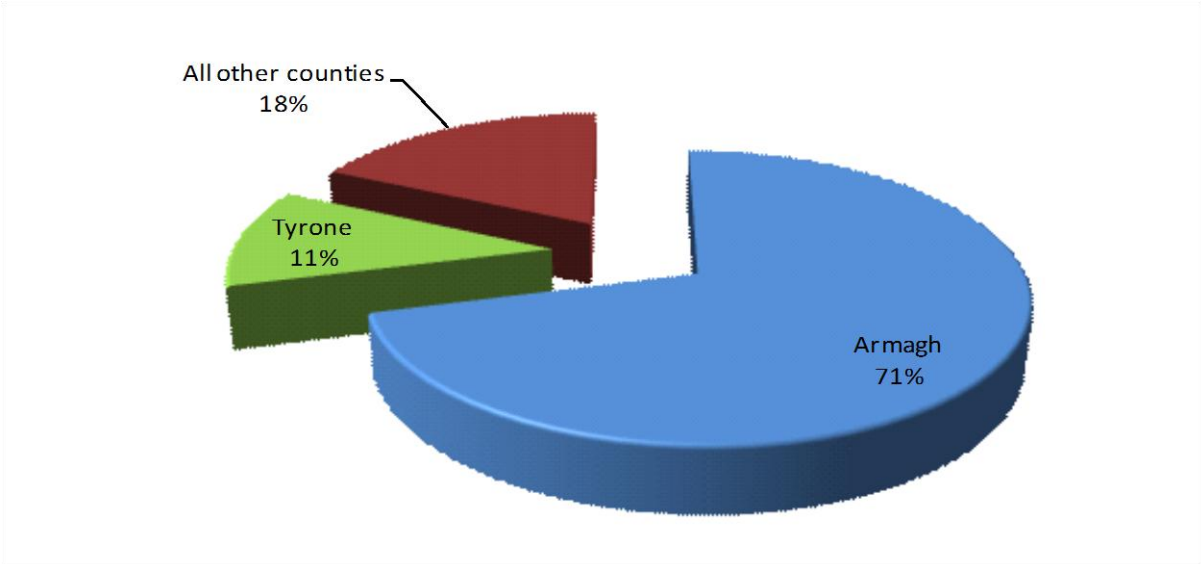

Figure 4 **The proportion of growers using different growing systems to produce mushrooms in Northern Ireland, 2011.**

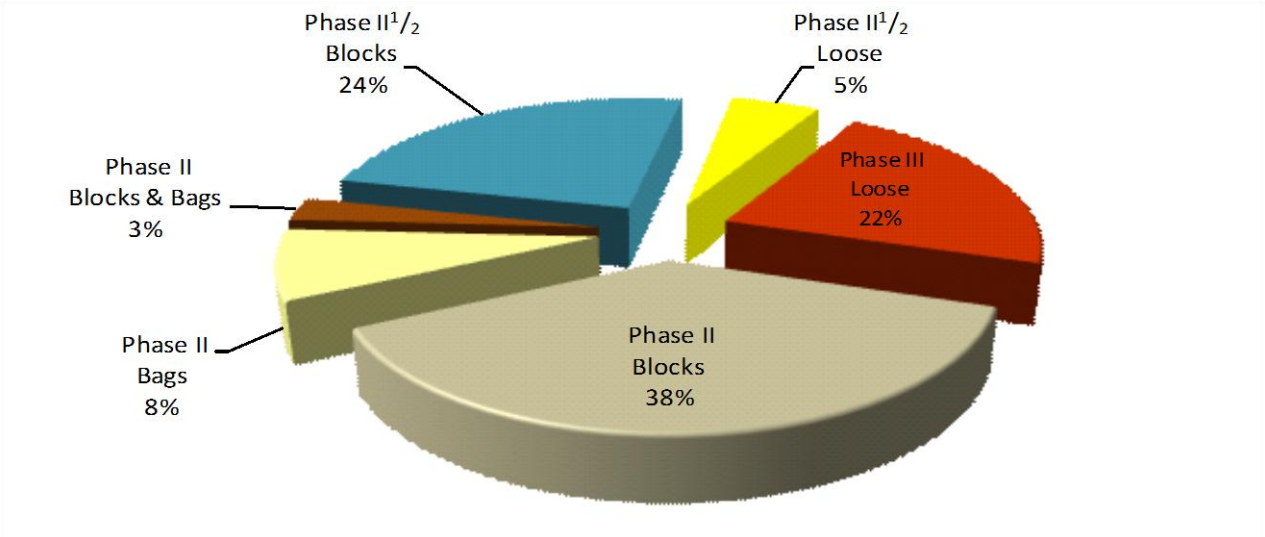

Figure 5 **The proportional area of mushroom houses treated with pesticide active ingredients (including biopesticides) in Northern Ireland, 2011, by growing method.**

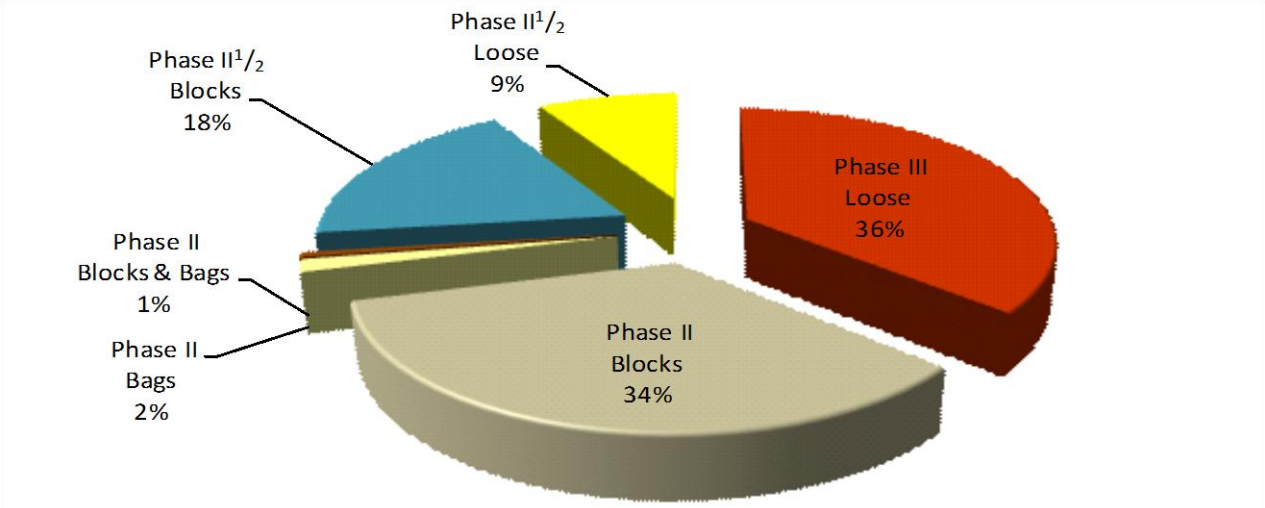

Figure 6 **The proportional weight of pesticide active ingredients applied to mushroom houses in Northern Ireland, 2011, by growing method.**

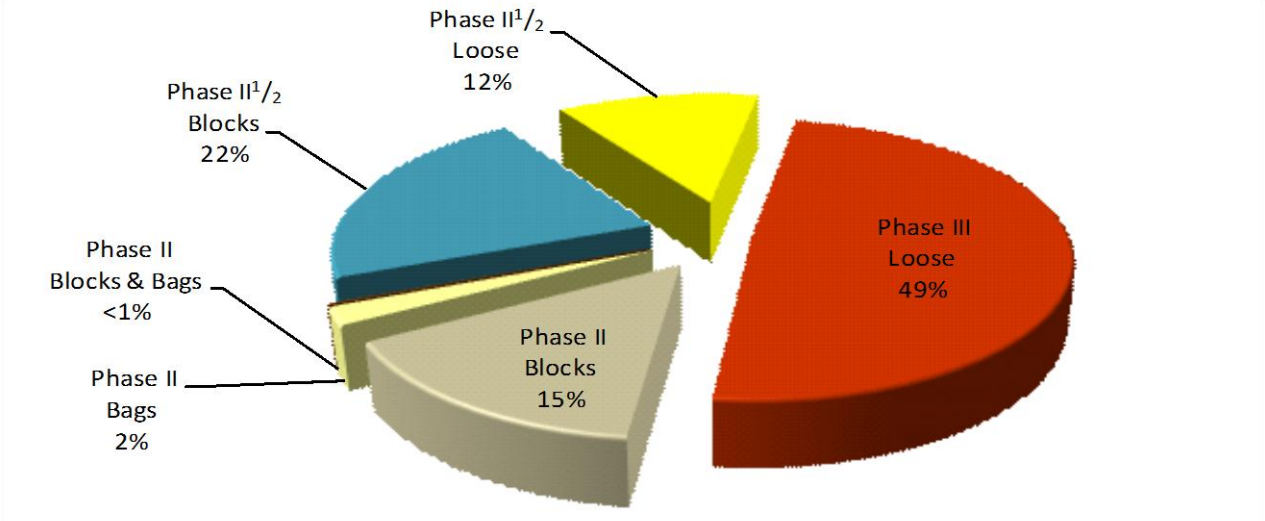

Figure 7 **The proportional weight of mushrooms harvested per growing method in Northern Ireland, 2011.**

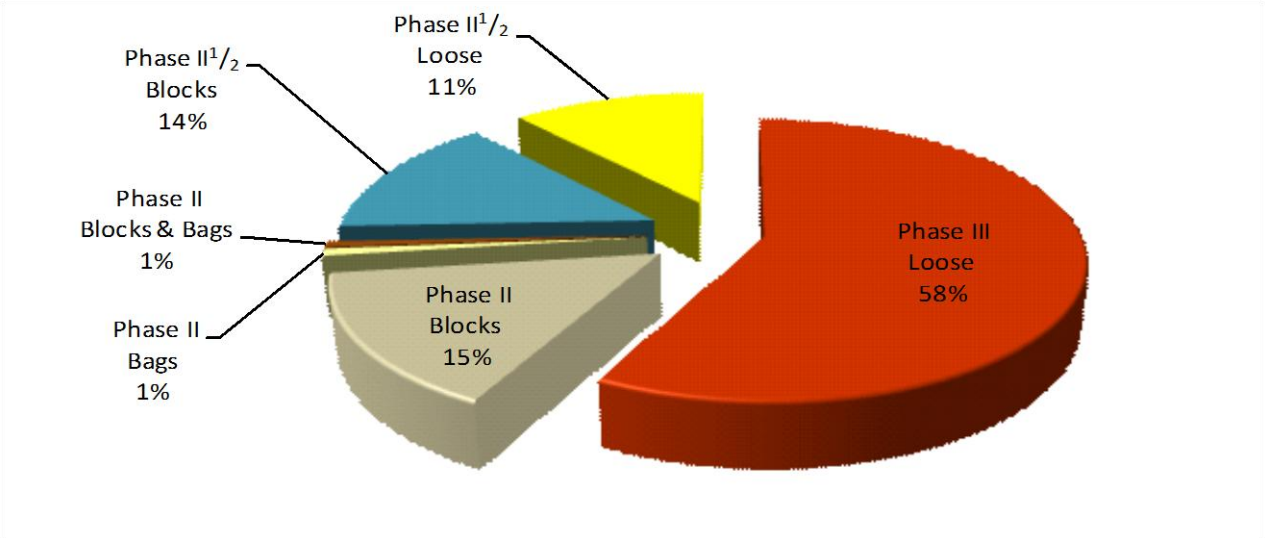

Figure 8 **The distribution of weight of mushrooms harvested in Northern Ireland, 2011, by mushroom type.**

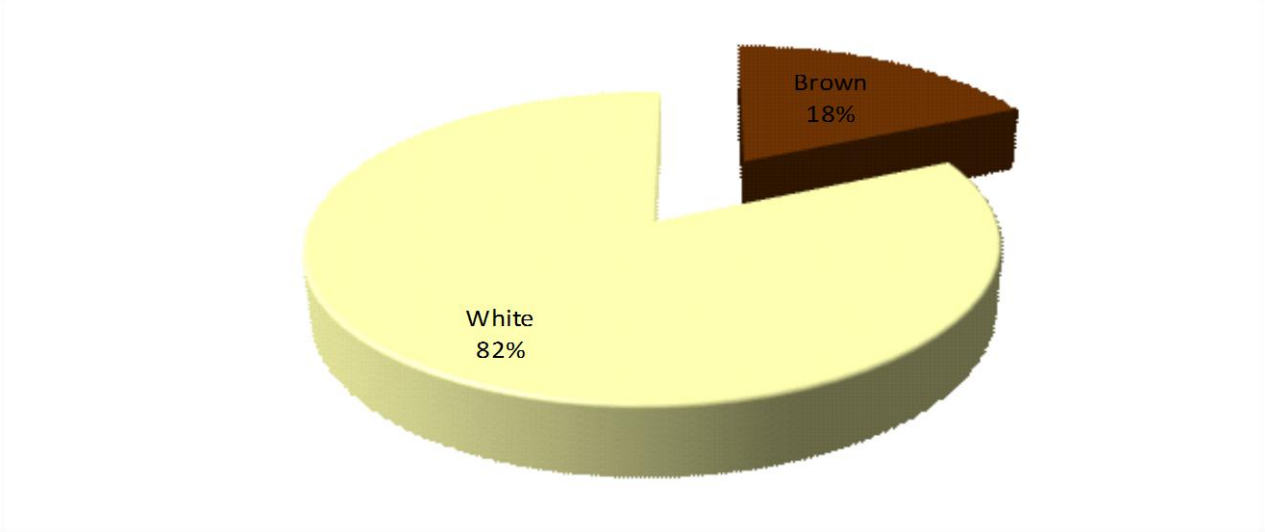

Figure 9 **Average weight (kg/lbs) of mushrooms produced per tonne of compost for each of the growing systems in Northern Ireland, 2011.**

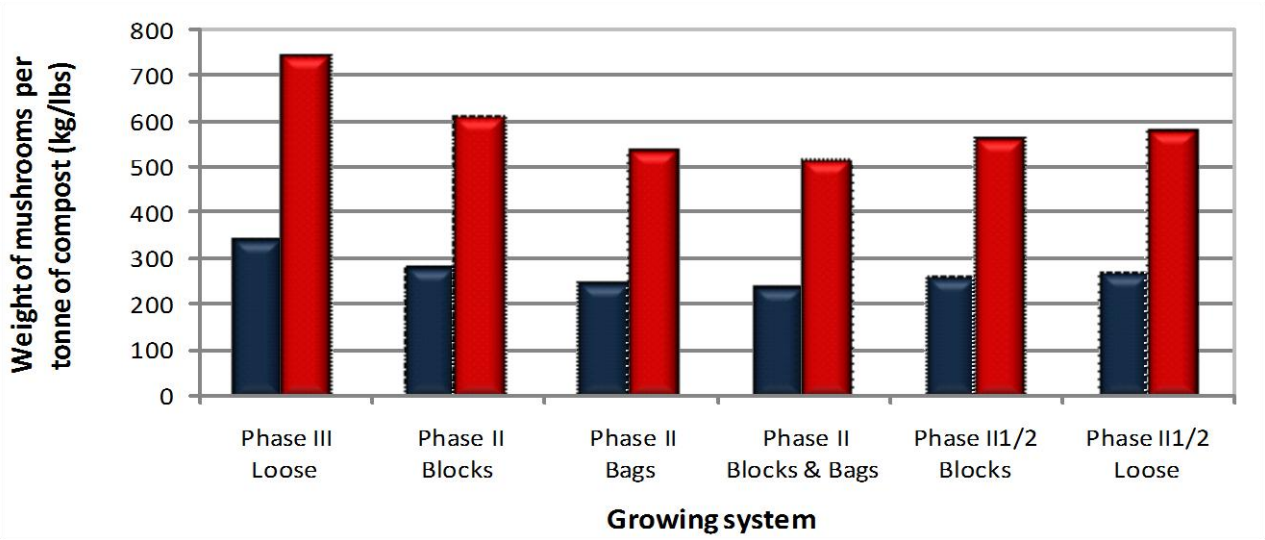

Figure 10 **Comparison of the area (sp m^2) of mushroom houses treated with each pesticide type in Northern Ireland between 1991 and 2011.**

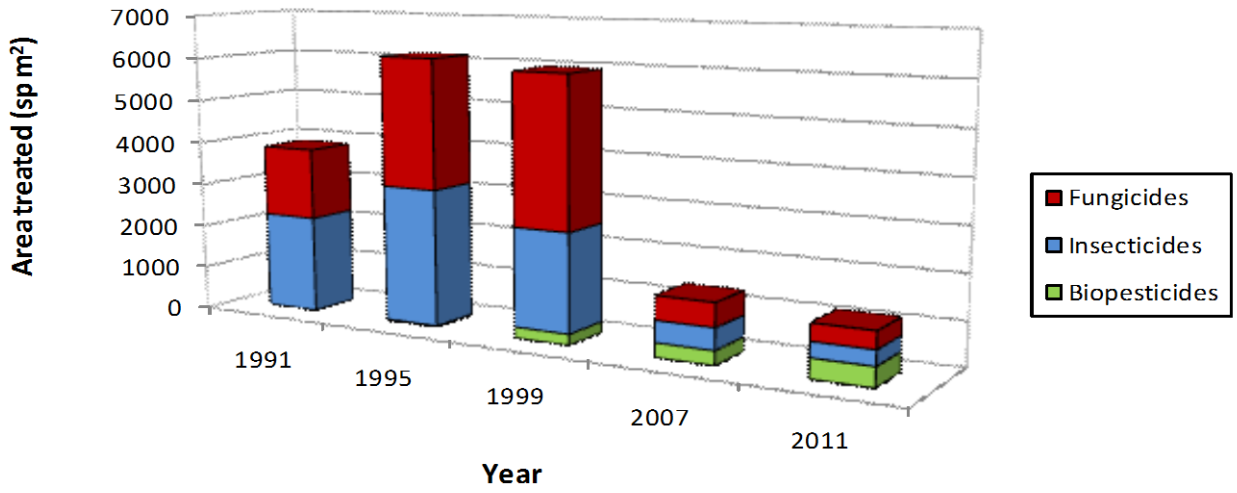

Figure 11 **Comparison of the quantity (kg) of each pesticide type applied to mushroom houses in Northern Ireland between 1991 and 2011.**

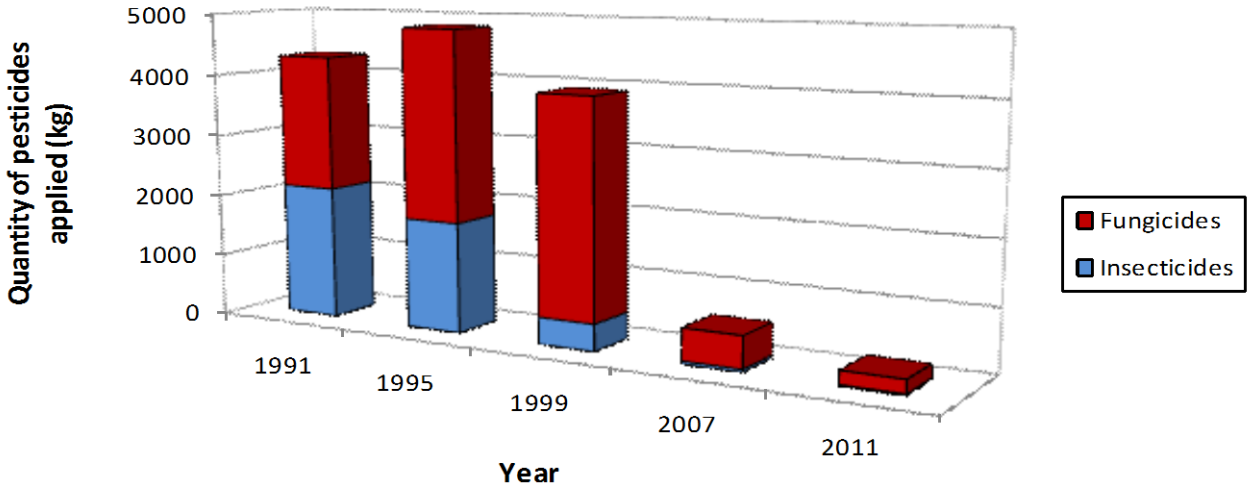

Figure 12 **Proportional change to the area of mushroom houses treated with each pesticide type in Northern Ireland between 1991 and 2011.**

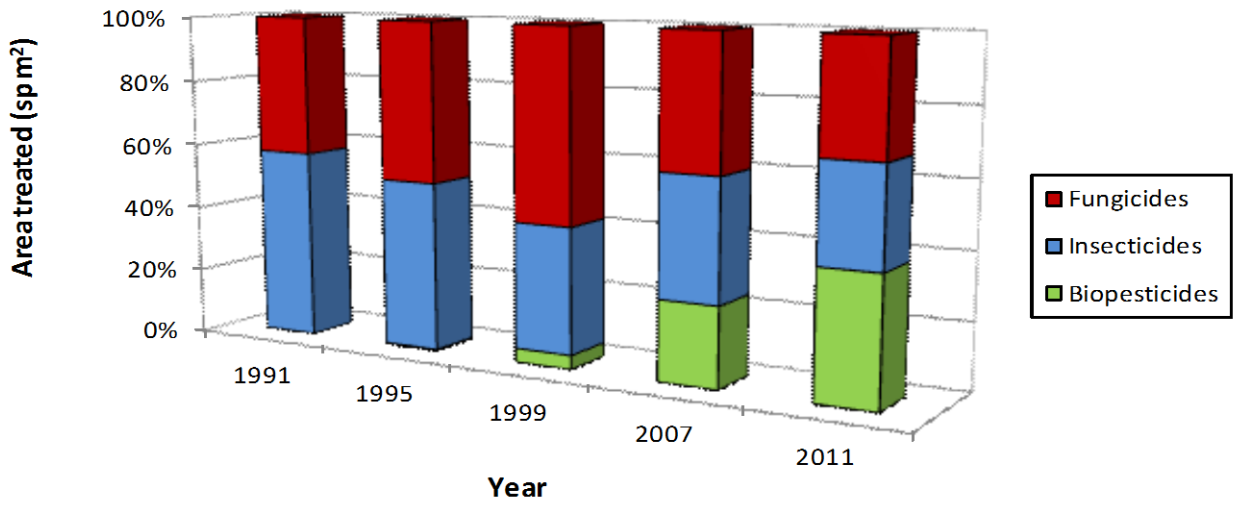

Figure 13 **Comparison of the number of mushroom growers in Northern Ireland between 1991 and 2011.**

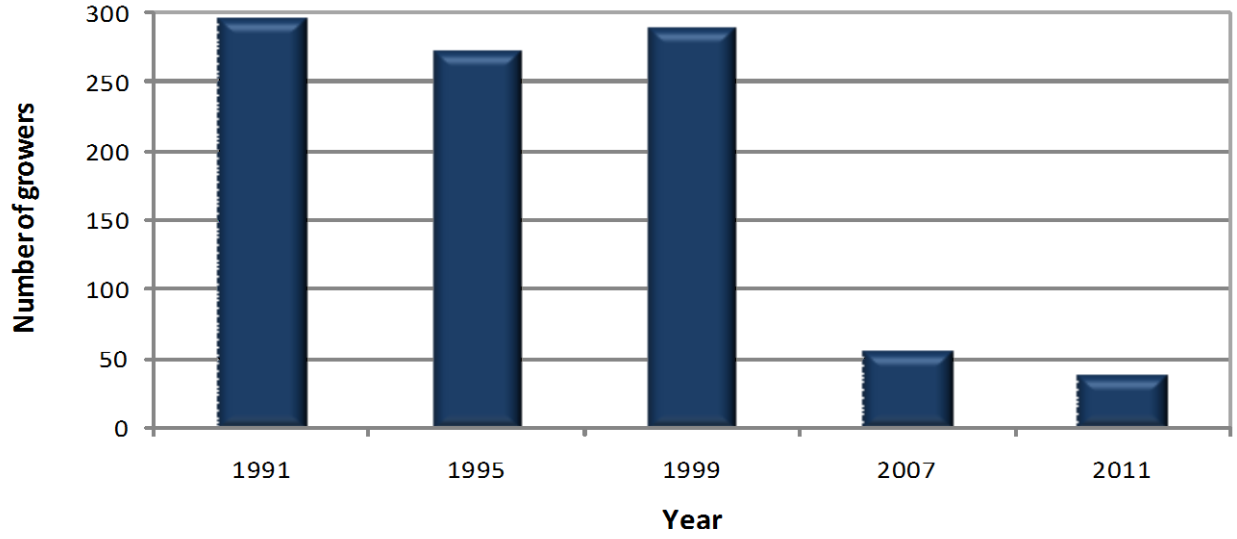

Figure 14 **Comparison of the total area (m^2) of mushrooms grown in Northern Ireland between 1991 and 2011.**

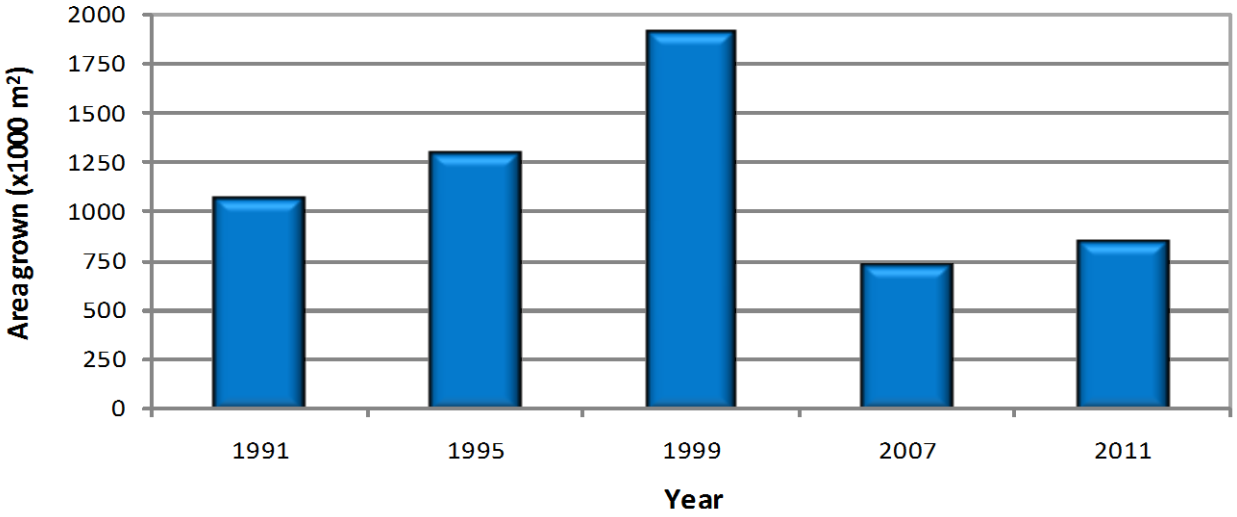

Figure 15 **Comparison of the total farm-gate value (£m) of mushrooms grown in Northern Ireland between 1991 and 2011[1].**

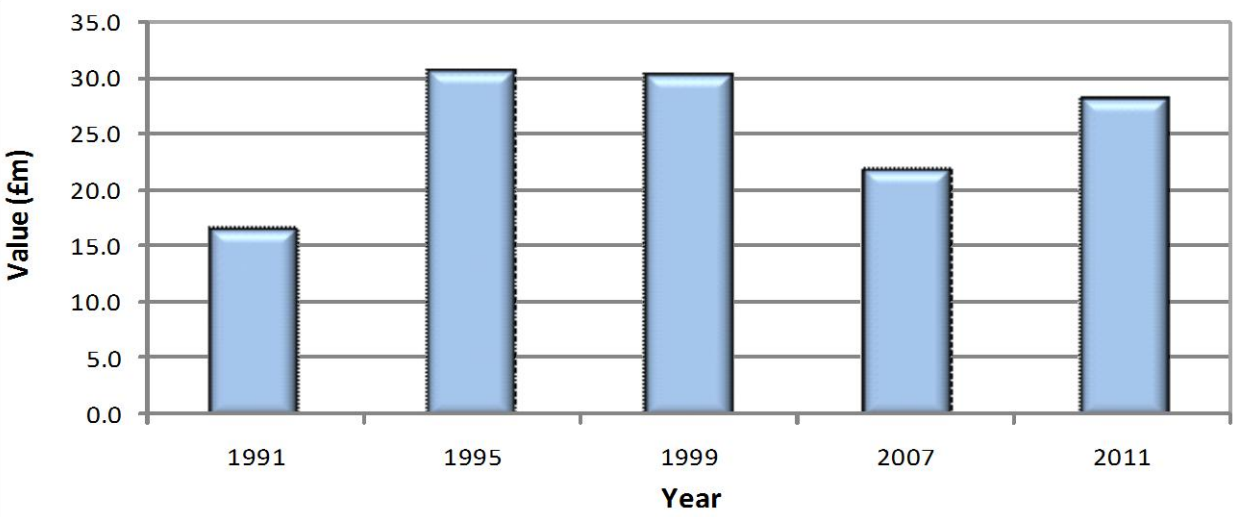

Figure 16 **The proportional area of mushroom production and 'spawn-running' houses treated with pesticide and disinfectant active ingredients in Northern Ireland, 2011.**

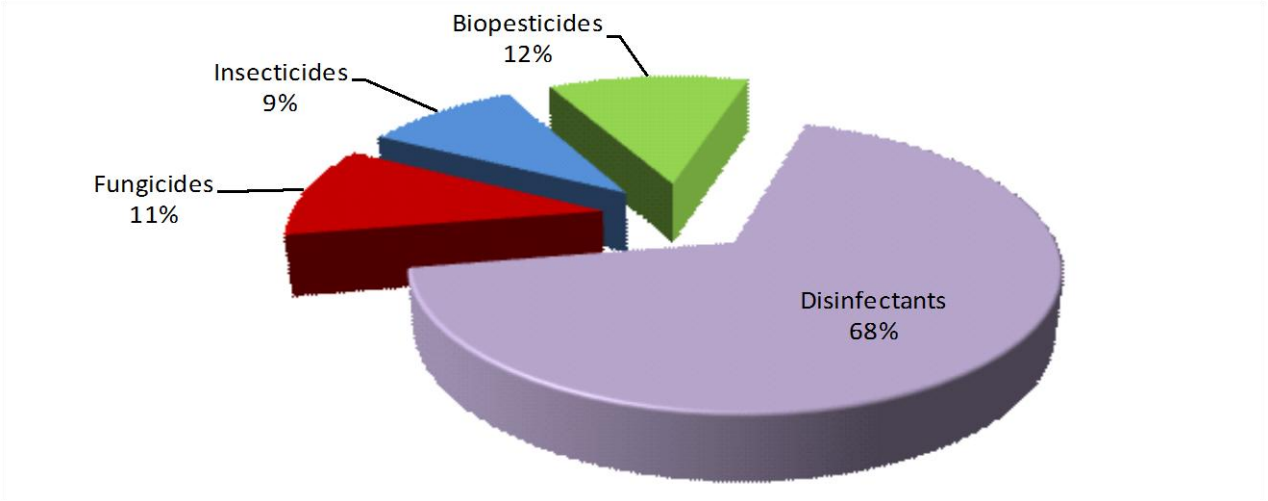

Figure 17 **The proportional weight of pesticide and disinfectant active ingredients applied to mushroom production and 'spawn-running' houses in Northern Ireland, 2011.**

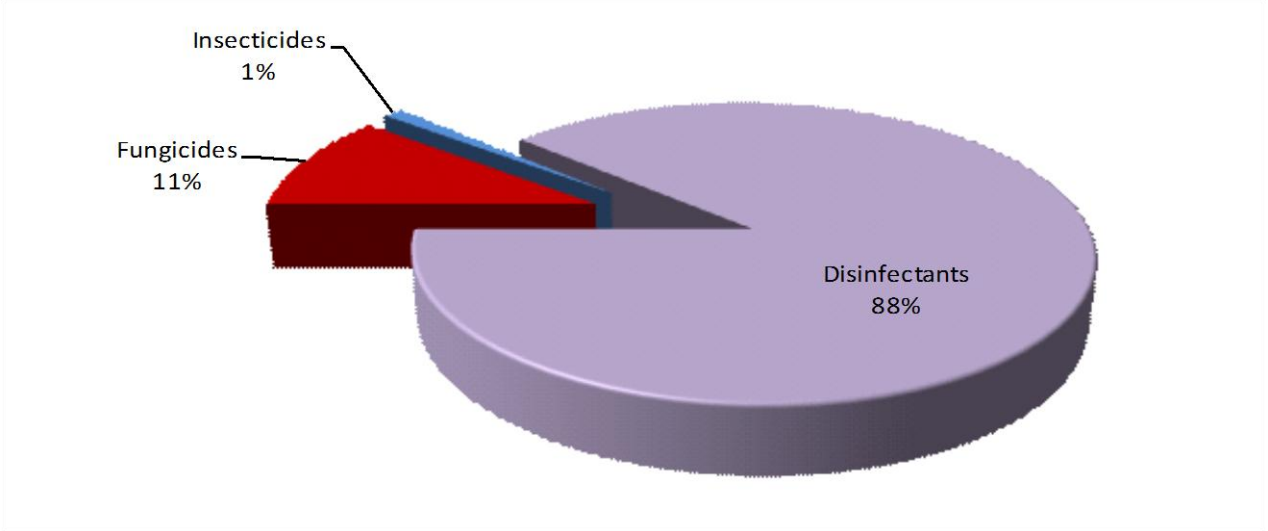

Figure 18 **The proportional area of mushroom production and 'spawn-running' houses treated with disinfectant active ingredients in Northern Ireland, 2011.**

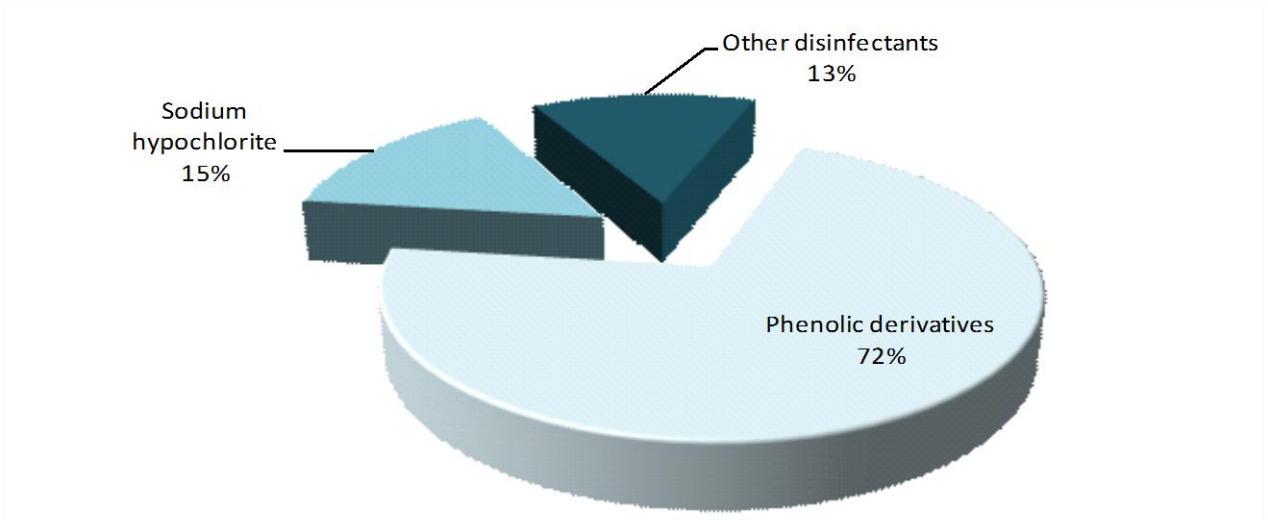

Figure 19 **The area (x 1000 sp m^2) of mushroom crops treated with each pesticide type during the various stages of mushroom production in Northern Ireland, 2011.**

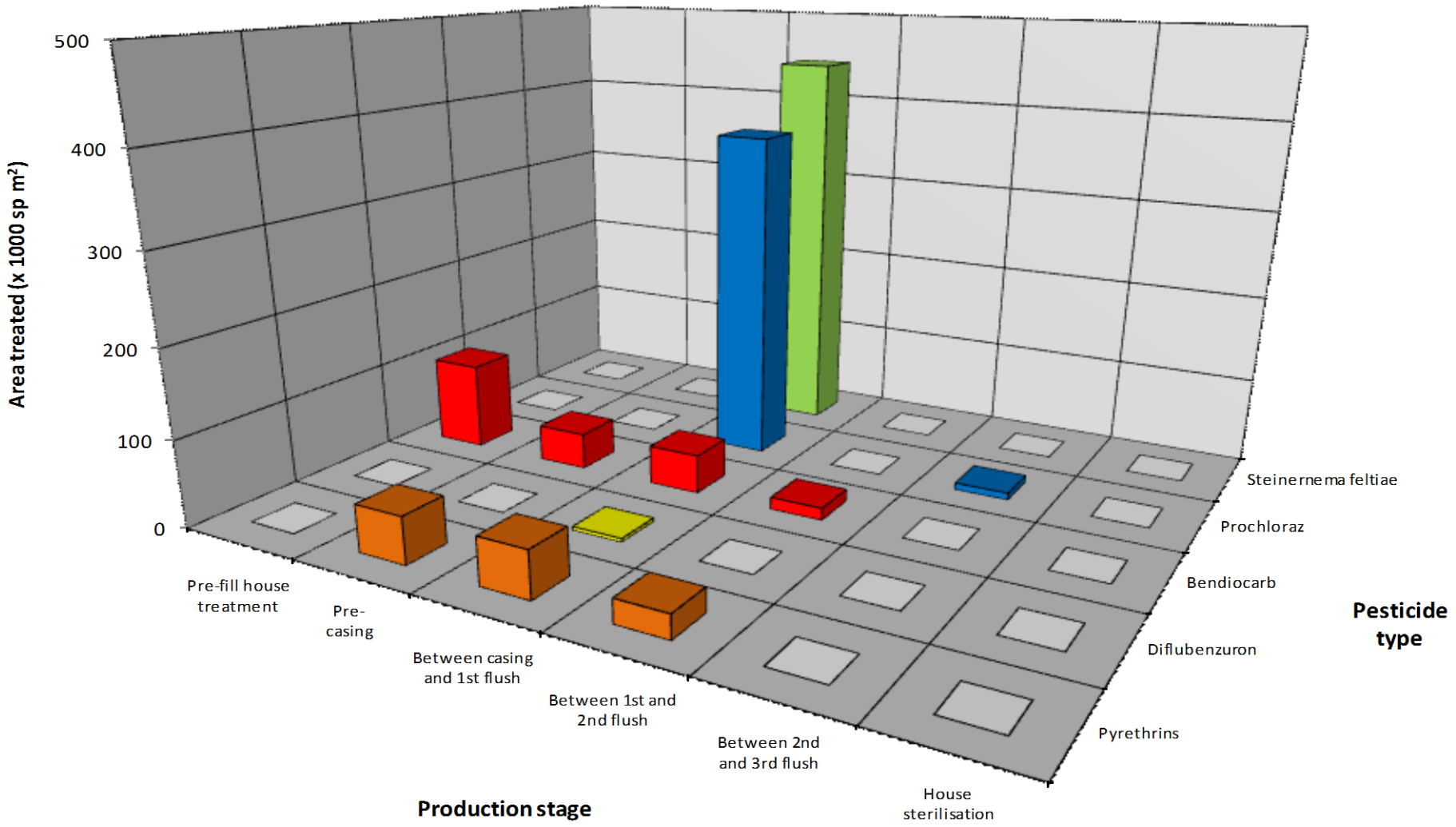

Figure 20 **Estimated quantity (kg) of each pesticide active ingredient applied at the different stages of mushroom production in Northern Ireland, 2011.**

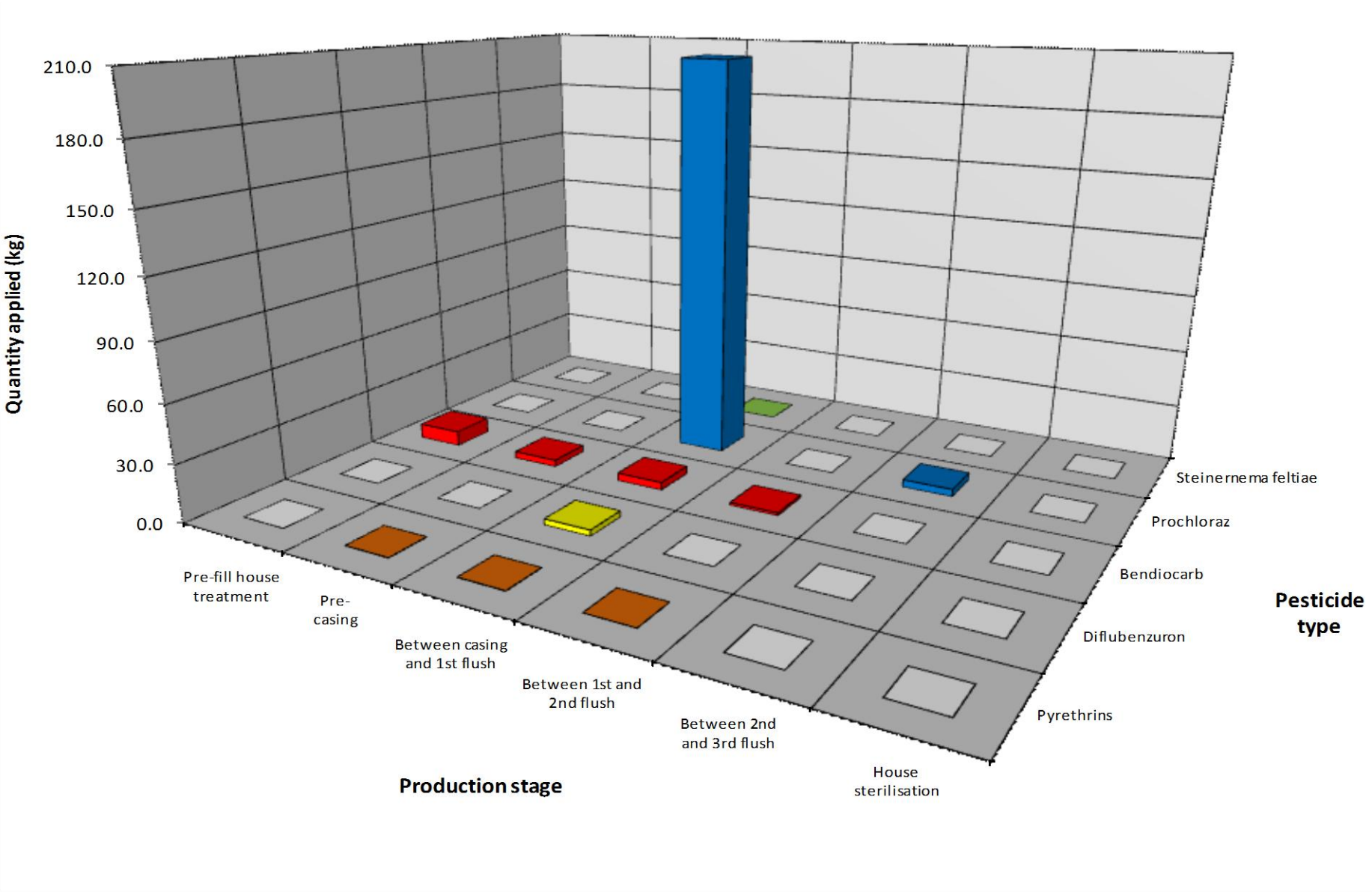

Figure 21 **Flowchart showing the various stages of commercial mushroom production in Northern Ireland, 2011.**

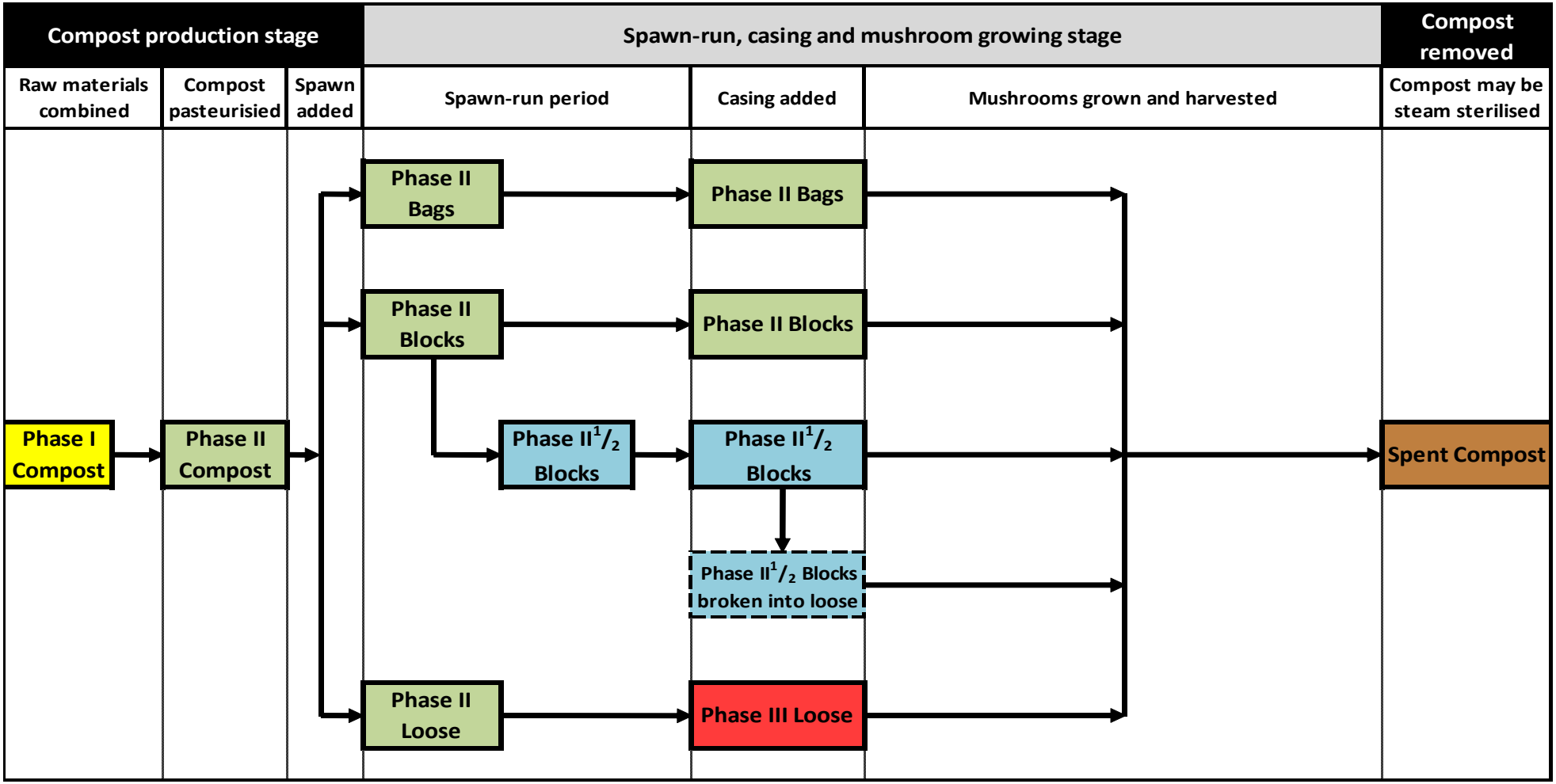

Table 1 The total number of growers, the total number of mushroom houses, the total cropping area (x 1,000 m^2), the total area of mushrooms grown (x 1,000 m^2) and the total quantity (tonnes) of mushrooms harvested in Northern Ireland, 2011.

County	Number of growers	Number of mushroom houses *	Cropping area (x1,000 m^2)	Area grown (x1,000 m^2)	Total quantity of mushrooms harvested 2011 (tonnes)
Armagh	26	242	72	584	15,568
Tyrone	10	77	16	110	2,513
All other counties	2	38	17	149	3,919
Northern Ireland	**38**	**357**	**105**	**843**	**22,000**

Includes spawning houses

Table 2 Regional distribution of pesticide-treated area (x 1,000 sp m^2) of mushroom crops in Northern Ireland, 2011.

	Pesticide type			
County	Fungicides	Insecticides	Biopesticides	Total area treated (x1,000 sp m^2)
Armagh	235	86	257	578
Tyrone	65	212	103	380
All other counties	86	43	86	215
Northern Ireland	**386**	**342**	**445**	**1,173**

Table 3 Estimated area treated (x 1,000 sp m^2) with each pesticide type at different stages of mushroom production in Northern Ireland, 2011.

	Pesticide type			
Production stage	Fungicides	Insecticides	Biopesticides	Total area treated (x1,000 sp m^2)
Pre-fill house treatment	.	101	.	101
Pre-casing	.	97	.	97
Between casing and 1st flush	377	104	445	926
Between 1st and 2nd flush	.	41	.	41
Between 2nd and 3rd flush	8	.	.	8
House sterilisation	.	.	.	.
All production stages	**386**	**342**	**445**	**1,173**

Table 4 **Estimated quantities (kg) of each pesticide type applied at different stages of mushroom production in Northern Ireland, 2011.**

	Pesticide type		
Production stage	**Fungicides**	**Insecticides**	**Total quantity (kg)**
House treatment	.	7.9	7.9
Pre-casing	.	3.8	3.8
Between casing and 1st flush	206.4	7.4	213.8
Between 1st and 2nd flush	.	1.4	1.4
Between 2nd and 3rd flush	3.9	.	3.9
End spray	.	.	.
All production stages	**210.2**	**20.6**	**230.9**

Table 5 **The active ingredients most extensively used in mushroom production in Northern Ireland, 2011, ranked by treated area (x 1,000 sp m^2).**

No.	Active Ingredient	Total area treated (x1,000 sp m^2)
1	*Steinernema feltiae*	445
2	Prochloraz	386
3	Bendiocarb	202
4	Pyrethrins	135
5	Diflubenzuron	4

Table 6 **The active ingredients most extensively used in mushroom production in Northern Ireland, 2011, ranked by weight (kg).**

No.	Active Ingredient	Quantity applied (kg)
1	Prochloraz	210.2
2	Bendiocarb	17.0
3	Diflubenzuron	3.1
4	Pyrethrins	0.5
5	*Steinernema feltiae*	Trace

Table 7 **Estimated area treated (x 1,000 sp m^2) with each formulation of pesticide active ingredients at the different stages of mushroom production in Northern Ireland, 2011.**

	Stage of production						
Pesticide Type & Formulation	**Pre-fill house treatment**	**Pre-casing**	**Between casing and 1st flush**	**Between 1st and 2nd flush**	**Between 2nd and 3rd flush**	**House sterilisation**	**Total area treated (x1,000 sp m^2)**
Fungicides							
Prochloraz	.	.	377	.	8	.	386
All fungicides	**.**	**.**	**377**	**.**	**8**	**.**	**386**
Insecticides							
Bendiocarb	101	42	45	14	.	.	202
Diflubenzuron	.	.	4	.	.	.	4
Pyrethrins	.	54	54	27	.	.	135
All insecticides	**101**	**97**	**104**	**41**	**.**	**.**	**342**
Biopesticides							
Steinernema feltiae	.	.	445	.	.	.	445
All biopesticides	**.**	**.**	**445**	**.**	**.**	**.**	**445**
All pesticides	**101**	**97**	**926**	**41**	**8**	**.**	**1,173**

Table 8 **Estimated quantity (kg) of each pesticide active ingredient applied at the different stages of mushroom production in Northern Ireland, 2011.**

	Stage of production						
Pesticide Type & Formulation	**Pre-fill house treatment**	**Pre-casing**	**Between casing and 1st flush**	**Between 1st and 2nd flush**	**Between 2nd and 3rd flush**	**House sterilisation**	**Total quantity (kg)**
Fungicides							
Prochloraz	.	.	206.4	.	3.9	.	210.2
All fungicides	**.**	**.**	**206.4**	**.**	**3.9**	**.**	**210.2**
Insecticides							
Bendiocarb	7.9	3.6	4.1	1.4	.	.	17.0
Diflubenzuron	.	.	3.1	.	.	.	3.1
Pyrethrins	.	0.2	0.2	0.1	.	.	0.5
All insecticides	**7.9**	**3.8**	**7.4**	**1.5**	**.**	**.**	**20.6**
Biopesticides							
Steinernema feltiae	.	.	Trace	.	.	.	Trace
All biopesticides	**.**	**.**	**Trace**	**.**	**.**	**.**	**Trace**
All pesticides	**7.9**	**3.8**	**213.8**	**1.5**	**3.9**	**.**	**230.9**

Table 9 The pesticide-treated area (x 1,000 sp m^2), the quantity of active ingredient formulation applied (kg) at each stage of mushroom production in Northern Ireland, 2011, and the reasons for use.

		Reason for use								
Stage	**Pesticide Type & Formulation**	**General disease**	**General flies**	**Bubble**	***Mycogone***	***Verticillium***	**Phorid flies**	**Phorids & Sciarids**	**Total area treated (x1,000 sp m^2)**	**Total Quantity (kg)**
Pre-fill house treatment	***Insecticides***									
	Bendiocarb	.	65	.	.	.	14	23	101	7.9
	All insecticides	**.**	**65**	**.**	**.**	**.**	**14**	**23**	**101**	**7.9**
Pre-casing	***Insecticides***									
	Bendiocarb	.	29	.	.	.	.	14	42	3.6
	Pyrethrins	.	54	.	.	.	.	.	54	0.2
	All insecticides	**.**	**83**	**.**	**.**	**.**	**.**	**14**	**97**	**3.8**
Between casing and 1st flush	***Fungicides***									
	Prochloraz	329	.	3	3	42	.	.	377	206.4
	All fungicides	**329**	**.**	**3**	**3**	**42**	**.**	**.**	**377**	**206.4**
	Insecticides									
	Bendiocarb	.	45	.	.	.	.	.	45	4.1
	Diflubenzuron	4	.	.	.	.	.	.	4	3.1
	Pyrethrins	.	54	.	.	.	.	.	54	0.2
	All insecticides	**4**	**99**	**.**	**.**	**.**	**.**	**.**	**104**	**7.4**
	Biopesticides									
	Steinernema feltiae	.	.	.	.	.	.	445	445	Trace
	All biopesticides	**.**	**.**	**.**	**.**	**.**	**.**	**445**	**445**	**Trace**

Table 9 (cont) **The pesticide-treated area (x 1,000 sp m^2), the quantity of active ingredient formulation applied (kg) at each stage of mushroom production in Northern Ireland, 2011, and the reasons for use.**

		Reason for use								
Stage	**Pesticide Type & Formulation**	**General disease**	**General flies**	**Bubble**	***Mycogone***	***Verticillium***	**Phorid flies**	**Phorids & Sciarids**	**Total area treated (x1,000 sp m^2)**	**Total Quantity (kg)**
Between 1st and 2nd flush	***Insecticides***									
	Bendiocarb	.	.	.	.	.	.	14	14	1.4
	Pyrethrins	.	27	.	.	.	.	.	27	0.1
	All insecticides	**.**	**27**	**.**	**.**	**.**	**.**	**14**	**41**	**1.4**
Between 2nd and 3rd flush	***Fungicides***									
	Prochloraz	8	.	.	.	.	.	.	8	3.9
	All fungicides	**8**	**.**	**.**	**.**	**.**	**.**	**.**	**8**	**3.9**
All stages	***All pesticides***	**342**	**274**	**3**	**3**	**42**	**14**	**495**	**1,173**	**230.9**

Table 10 **The pesticide type (x 1,000 sp m^2) applied to the different growing systems used for mushroom production in Northern Ireland, 2011.**

	Growing system						
Pesticide type & formulation	Bags Phase II	Blocks Phase II	Blocks Phase II $^1/_2$	Blocks & bags Phase II	Loose Phase II $^1/_2$	Loose Phase III	Total area treated (x1,000 sp m^2)
Fungicides							
Prochloraz	7	44	86	.	51	198	386
All fungicides	**7**	**44**	**86**	**.**	**51**	**198**	**386**
Insecticides							
Bendiocarb	6	101	29	3	.	63	202
Diflubenzuron	.	4	.	.	.	.	4
Pyrethrins	.	136	.	.	.	.	136
All insecticides	**6**	**241**	**29**	**3**	**.**	**63**	**342**
Biopesticides							
Steinernema feltiae	5	119	101	3	51	167	445
All biopesticides	**5**	**119**	**101**	**3**	**51**	**167**	**445**
All pesticides	**17**	**404**	**216**	**6**	**102**	**427**	**1,173**

Table 11 **The quantity of pesticides (kg) applied to the different growing systems used for mushroom production in Northern Ireland, 2011.**

	Growing system						
Pesticide type & formulation	Bags Phase II	Blocks Phase II	Blocks Phase II 1/2	Blocks & bags Phase II	Loose Phase II 1/2	Loose Phase III	Total quantity (kg)
Fungicides							
Prochloraz	4.2	22.8	47.6	.	28.2	107.5	210.3
All fungicides	**4.2**	**22.8**	**47.6**	**.**	**28.2**	**107.5**	**210.3**
Insecticides							
Bendiocarb	0.5	8.1	2.3	0.2	.	5.8	16.9
Diflubenzuron	.	3.1	.	.	.	.	3.1
Pyrethrins	.	0.5	.	.	.	.	0.5
All insecticides	**0.5**	**11.8**	**2.3**	**0.2**	**.**	**5.8**	**20.6**
Biopesticides							
Steinernema feltiae	Trace	Trace	Trace	Trace	Trace	Trace	Trace
All biopesticides	**Trace**	**Trace**	**Trace**	**Trace**	**Trace**	**Trace**	**Trace**
All pesticides	**4.7**	**34.6**	**49.9**	**0.2**	**28.2**	**113.3**	**230.9**

Table 12 **The estimated area (x1,000 sp m^2) and quantity (kg) of pesticides and disinfectants applied to mushroom house types.**

	Mushroom house type					
	Production house		Spawn-run house		Total	
Pesticides and disinfectants	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	386	210.2	.	.	386	210.2
Insecticides	317	19.3	25	1.4	342	20.6
Biopesticides	446	.	.	.	446	.
Disinfectants	2,331	1,474.6	121	250.5	2,452	1,725.1
All pesticides and disinfectants	**3,480**	**1,704.1**	**145**	**251.8**	**3,625**	**1,956.0**

Table 13 **Estimated treated area (x 1,000 sp m^2) and quantity applied (kg) of the different disinfectant types used in mushroom production in Northern Ireland, 2011.**

	Location of treatment					
	Mushroom House		Yard		All disinfectant treatments	
Disinfectant type	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	1,753	1,076.7	583	293.9	2,336	1,370.6
Sodium hypochlorite	367	615.4	6	9.4	373	624.8
Other disinfectants	331	32.9	141	14.0	472	46.9
All disinfectants	**2,452**	**1,725.1**	**730**	**317.2**	**3,182**	**2,042.3**

Table 14 **The disinfectant types used at the different stages of mushroom production in Northern Ireland, 2011.**

(i) Estimated disinfectant-treated area (x 1,000 sp m^2)

	Production Stage			
Disinfectant type	**House sterilisation**	**Applications to spent compost**	**Yard treatment**	**Total area treated (x1,000 sp m^2)**
Phenolic derivatives	1,605	148	583	2,336
Sodium hypochlorite	367	.	6	373
Other disinfectants	331	.	141	472
All disinfectants	**2,304**	**148**	**730**	**3,181**

(ii) Quantity of disinfectant applied (kg)

	Production Stage			
Disinfectant type	**House sterilisation**	**Applications to spent compost**	**Yard treatment**	**Total quantity (kg)**
Phenolic derivatives	1,032	45	294	1,371
Sodium hypochlorite	615	.	9	625
Other disinfectants	33	.	14	47
All disinfectants	**1,681**	**45**	**317**	**2,042**

Table 15 **Comparison of the number of growers, the number of houses, the cropping area (x 1,000 m^2) and the total area of mushroom crops grown (x 1,000 m^2) in Northern Ireland, 1991-2011.**

	1991			
County	Number of growers	Number of mushroom houses	Cropping area (x 1,000 m^2)	Area grown (x 1,000 m^2)
Armagh	97	486	90	402
Down	71	302	65	288
Tyrone	108	421	68	298
Antrim/Fermanagh/L'Derry	20	63	15	70
Northern Ireland	**296**	**1,272**	**238**	**1,058**

	1995			
	Number of growers	Number of mushroom houses	Cropping area (x 1,000 m^2)	Area grown (x 1,000 m^2)
	78	385	77	360
	61	289	73	331
	105	464	97	451
	28	113	30	152
	272	**1,252**	**278**	**1,292**

	1999			
County	Number of growers	Number of mushroom houses	Cropping area (x 1,000 m^2)	Area grown (x 1,000 m^2)
Armagh	88	487	109	629
Down	75	386	88	473
Tyrone	102	513	132	685
Antrim/Fermanagh/L'Derry	24	103	24	122
Northern Ireland	**289**	**1,489**	**353**	**1,909**

	2007			
	Number of growers	Number of mushroom houses	Cropping area (x 1,000 m^2)	Area grown (x 1,000 m^2)
	29	194	45	296
	6	77	18	166
	16	135	29	236
	4	26	4	24
	55	**433**	**96**	**722**

	2011			
County	Number of growers	Number of mushroom houses	Cropping area (x 1,000 m^2)	Area grown (x 1,000 m^2)
Armagh	26	242	72	584
Tyrone	10	77	16	110
All other counties	2	38	17	149
Northern Ireland	**38**	**357**	**105**	**843**

Table 16 **Comparison of usage of the different pesticide types and disinfectants in mushroom houses in Northern Ireland 1991-2011.**

	Area treated (x 1,000 sp m^2)					Quantity (kg)				
	1991	1995	1999	2007	2011	1991	1995	1999	2007	2011
Disinfectants	1,072	2,256	2,625	995	2,452	2,554	3,568	4,915	4,849	1,726
Pesticide type										
Fungicides	1,636	2,974	3,442	538	386	2,159	3,056	3,484	506	210
Insecticides										
Benzoylureas	.	.	.	39	.	.	.	.	26	.
Carbamates	567	1,018	967	445	200	207	343	326	22	17
Organochlorines	39	98	100	.	.	3	4	11	.	.
Organophosphates	716	851	33	<1	.	1,914	1,399	15	<1	.
Pyrethroids	859	1,125	1,085	7	140	17	21	59	<1	4
Others	.	21	75	.	.	.	7	20	.	.
Unknown insecticide	52	30	.	.	.	.	.	.	.	.
All insecticides	2,232	3,143	2,260	491	342	2,143	1,774	431	48	21
Biopesticides	.	24	251	325	445	.	.	.	.	.
Mixtures	105	.	.	.	.	531	.	.	.	.
Rodenticides	33	.	.	.	.	<1	.	.	.	.
All pesticides	4,007	6,141	6,318	1,354	1,173	4,834	4,830	3,915	554	231
Area grown (x 1,000 m^2)	1,059	1,292	1,909	722	843					

Table 17 **Comparison of pesticide usage on mushroom crops in Northern Ireland 1991-2011, area treated (x 1,000 sp m^2) and quantity applied (kg).**

	Area treated (x 1,000 sp m^2)					Quantity (kg)				
Mushroom production stage	**1991**	**1995**	**1999**	**2007**	**2011**	**1991**	**1995**	**1999**	**2007**	**2011**
Pre-fill house treatment	256	394	689	448	101	1,567	1,718	2,066	57	8
Pre-casing	1,571	1,458	566	3	97	2,307	1,457	165	< 0.5	4
Between casing and 1st flush	1,260	2,103	2,693	733	926	565	1,021	887	248	214
Between 1st and 2nd flush	268	817	1,064	122	41	72	229	237	48	1
Between 2nd and 3rd flush	379	931	797	.	8	84	251	122	.	4
After 3rd flush	199	387	36	.	.	53	70	1	.	.
End spray/house sterilisation	71	51	110	48	.	168	84	437	200	.
All insecticides	**4,004**	**6,141**	**5,955**	**1,354**	**1,173**	**4,816**	**4,829**	**3,915**	**554**	**231**

Table 18 **Comparison of disinfectant usage on mushroom crops in Northern Ireland 1991-2011, area treated (x 1,000 sp m^2) and quantity applied (kg).**

	Area treated (x 1,000 sp m^2)					Quantity (kg)				
Mushroom production stage	**1991**	**1995**	**1999**	**2007**	**2011**	**1991**	**1995**	**1999**	**2007**	**2011**
Pre-fill house treatment	920	1,727	2,072	913	.	1,708	2,808	4,135	4,451	.
Pre-casing	4	36	.	21	.	4	4	.	6	.
Between casing and 1st flush	16	31	7	.	.	3	3	9	.	.
Between 1st and 2nd flush	1	28	40	.	.	< 0.5	21	.	.	.
Between 2nd and 3rd flush	32	40	59	.	.	9	33	3		.
After 3rd flush	9	8	.	.	.	69	19	.	.	.
End spray/house sterilisation	69	388	447	61	2,452	749	679	768	392	1,726
All insecticides	**1,072**	**2,256**	**2,625**	**995**	**2,452**	**2,554**	**3,568**	**4,915**	**4,849**	**1,726**

All disinfectant treatments in 2011 were applied at the end of each cropping cycle or 'End spray/house sterilisation' stage.

Table 19 **Comparison of usage of the different disinfectant types in mushroom production in Northern Ireland 1991-2011.**

(i) Estimated disinfectant-treated area (x 1,000 sp m^2)

	House treatment					Yard treatment					All disinfectant treatments				
Disinfectant type	**1991**	**1995**	**1999**	**2007**	**2011**	**1991**	**1995**	**1999**	**2007**	**2011**	**1991**	**1995**	**1999**	**2007**	**2011**
Chlorine	.	.	.	52	.	.	.	.	47	.	.	.	.	98	.
Phenolic derivatives	586	1,167	1,391	690	1,753	274	471	273	696	583	860	1,638	1,664	1,386	2,336
Sodium hypochlorite	224	701	855	204	367	11	106	90	185	6	235	807	945	389	373
Xylenoids	212	375	253	1	.	35	160	52	.	.	247	534	305	1	.
Unknown disinfectant	48	10	26	48	.	2	.	4	447	.	50	10	30	495	.
Unknown fumigant	.	.	100	.	.	.	.	.	.	.	.	.	100	.	.
Other disinfectants	.	.	.	.	331	.	.	.	.	141	.	.	.	.	472
All disinfectants	**1,070**	**2,252**	**2,625**	**995**	**2,452**	**322**	**737**	**419**	**1,375**	**730**	**1,392**	**2,989**	**3,044**	**2,370**	**3,182**

(ii) Quantity of disinfectant applied (kg)

	House treatment					Yard treatment					All disinfectant treatments				
Disinfectant type	**1991**	**1995**	**1999**	**2007**	**2011**	**1991**	**1995**	**1999**	**2007**	**2011**	**1991**	**1995**	**1999**	**2007**	**2011**
Chlorine	.	.	.	2,981	.	.	.	.	765	.	.	.	.	3,745	.
Phenolic derivatives	653	1,402	1,504	616	1,077	324	433	210	382	294	977	1,835	1,715	998	1,371
Sodium hypochlorite	279	1,059	2,548	800	615	8	107	126	420	9	287	1,166	2,674	1,220	624
Xylenoids	1,622	1,107	862	2	.	341	558	255	.		1,963	1,665	1,117	2	.
Unknown disinfectant	.	.	.	451	.	.	.	.	477		.	.	.	928	.
Other disinfectants	.	.	.	.	33	.	.	.	.	14	.	.	.	.	47
All disinfectants	**2,554**	**3,567**	**4,914**	**4,849**	**1,726**	**673**	**1,099**	**591**	**2,044**	**317**	**3,227**	**4,666**	**5,506**	**6,893**	**2,042**

Northern Ireland Pesticide Usage Survey Published Reports Appendix 1

Report No.	Report title	ISBN
99	Grassland & Fodder Crops 1989	1-855 27 079 X
105	Arable Crops 1990	1-855 27 130 3
106	Soft Fruit Crops 1990	1-855 27 149 4
109	Vegetable Crops 1991	1-855 27 137 0
110	Protected Crops 1991 (edible & ornamental)	1-855 27 283 0
111	Mushroom Crops 1991	1-855 27 150 8
117	Arable Crops 1992	1-855 27 193 1
118	Top Fruit Crops 1992	1-855 27 194 X
124	Grassland & Fodder crops 1993	1-855 27 221 0
131	Forestry 1993	1-855 27 282 2
132	Arable Crops 1994	1-855 27 314 4
139	Vegetable Crops 1995	1-855 27 346 2
140	Mushroom Crops 1995	1-855 27 347 0
146	Arable Crops 1996	1-855 27 469 8
147	Top fruit 1996	1-855 27 470 1
156	Grassland & Fodder Crops 1997	1-855 27 506 6
157	Sheep Treatments 1997	1-855 27 425 6
167	Soft Fruit 1998	1-855 27 540 6
168	Arable Crops 1998	1-855 27 536 8
169	Vegetable Crops 1999	1-855 27 561 9
170	Mushroom Crops 1999	1-855 27 549 X
177	Arable Crops 2000	1-855 27 670 4

Northern Ireland Pesticide Usage Survey Published Reports Appendix 1 (contd.)

Report No.	Report title	ISBN
178	Top Fruit Crops 2002	1-855 27 618 6
194	Arable Crops 2002	1-855 27 674 7
198	Grassland & Fodder Crops 2003	1-855 27 797 2
199	Hardy Nursery Stock Crops 2003	1-855 27 789 1
201	Protected Ornamental Crops 2003	1-855 27 739 5
206	Arable Crops 2004	1-855 27 833 2
207	Vegetable crops 2004	1-855 27 869 3
208	Grassland & Fodder Crops 2005	1-855 27 998 8
209	Sheep Treatments 2005	1-855 27 999 5
216	Arable Crops 2006	1-848 07 035 6
217	Top Fruit Crops 2006	1-848 07 019 6
218	Soft Fruit Crops 2006	1-848 07 036 3
222	Vegetable Crops 2007	1-848 07 062 2
223	Mushroom Crops 2007	1 848 07 061 5
230	Arable Crops 2008	1 848 07 135 3
231	Top Fruit Crops 2008	1-848 07 134 6
238	Grassland & Fodder Crops 2009	1-848 07 186 5
239	Hardy Nursery Stock Crops 2009	1-848 07 187 2
240	Soft Fruit Crops 2010	1-848 07 251 0
241	Top Fruit Crops 2010	1-848 07 250 3
242	Arable Crops 2010	1-848 07 252 7

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