

PESTICIDE USAGE IN NORTHERN IRELAND  
SURVEY REPORT 223

# NORTHERN IRELAND MUSHROOM CROPS 2007



Agriculture, Fishing and Forestry

# PESTICIDE USAGE SURVEY REPORT 223

## Northern Ireland Mushroom Crops 2007

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## The County Regions of Northern Ireland



## SUMMARY

This report presents information from a survey of pesticide usage practices on mushroom crops in Northern Ireland in 2007. It is the fourth survey of pesticide usage practices conducted on the mushroom sector in the region. Data were collected from 52 growers, representing 95% of all mushroom holdings in Northern Ireland.

Compared with the previous survey in 1999, the number of growers decreased by 81% with the basic cropping area decreasing by 73% to approximately 10 hectares (ha). The quantity of pesticides used decreased accordingly by 86% and the area treated with pesticides decreased by 79% between 1999 and 2007.

A total of 554 kilograms of pesticides and 4.8 tonnes of disinfectant chemicals were applied to 135 and 100 spray hectares of mushroom production houses, respectively.

In common with previous surveys, fungicides applied to 40% of the pesticide-treated area accounted for the majority (91%) of the weight of pesticides used. The fungicide active ingredient prochloraz was the most extensively used pesticide overall, applied to 35% of the pesticide-treated area and 89% of the fungicide-treated area.

Applications of insecticides were applied principally to the interior walls and structure of the mushroom houses prior to crop production. The active ingredient bendiocarb accounted for 91% of insecticide usage.

The only biological control agent recorded in this survey was the insect-pathogenic nematode *Steinernema feltiae*.

Disinfectants usage on yard areas outside the mushroom houses and as part of the house sterilisation process decreased by 22% in area compared with 1999. However, the quantity of disinfectants used increased by 25%, principally due to the high concentration of chlorine active ingredient in some products.

A total of 18 products, comprising seven pesticide active ingredients, four disinfectant active ingredients and one biological control agent 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<sup>2</sup> per block, the cropping area = 192m<sup>2</sup> per house )
- **‘Area grown’** refers to the basic area multiplied by cropping periods completed. (Example B: if the house in example A was filled on 6 occasions during the year 192m<sup>2</sup> X 6 = 1152m<sup>2</sup> the total area grown).
- **‘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 mushroom cycle period length that is influenced by the growing method.
- **‘Flushes’** refers to the number of crops taking off a single fill of compost, normally three 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, if there is a disease / pest present, a pesticide or disinfectant may be applied to the spent compost prior to disposal.

## 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 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.

This is the fourth survey of pesticide usage on mushroom production in Northern Ireland. Results from the previous surveys reported on pesticide usage practices on mushroom production in 1991 (Kidd et al., 1994), 1995 (Kidd *et al.*, 1998) and 1999 (Kearns et al., 2002) are included in the report for comparative purposes. The report includes both pesticide and disinfectant usage. A list of published Northern Ireland Pesticide Usage Survey reports is shown in Appendix 1.

## THE MUSHROOM INDUSTRY IN NORTHERN IRELAND

The mushroom industry in Northern Ireland has experienced substantial changes in recent years. The number of growers has reduced from 289 in 1999 to 55 in 2007. The basic cropping area decreased by 73% when compared to 1999 and 60% when compared with 1991. However, total mushroom production in Northern Ireland in 2007 was estimated at 19,000 tonnes with a value of £21.7million, representing a similar output level to 1991 and an overall 24% decrease compared with 1999 (Anon., 2008). The maintenance of mushroom production outputs despite a reduction in the number of growers suggests an increase in unit production size and efficiency of crop production.

In addition cultivation methods have also changed since 1999. In 2007 the traditional 'bag-system' accounted for 14% of houses producing mushrooms, with 21% of growers using this system compared with 97% of growers in 1999. The 'bag-system', which uses plastic bags filled with Phase II compost has been virtually replaced by a similar system of production using rectangular compost blocks with a larger surface area than bags (0.24m<sup>2</sup> compared with 0.15m<sup>2</sup>) or a loose compost system on shelves. Approximately 50% of all mushroom houses recorded in this survey (48% of growers) employed the block system. A minority of growers (8%) used a combination of both blocks and bags.

The loose compost system on shelves involves the use of Phase II or Phase III compost filled directly onto shelves. The advantage of the shelf system is that compost-filling and casing are normally carried out simultaneously. Where Phase III compost is used, mycelium has fully colonised the compost, therefore reducing the production cycle and allowing for more production cycles per house per year. Approximately 36% of all production houses and 23% of growers used the loose compost system on shelves in 2007.

The mushroom 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.

### *Phase II*

- Compost supplied normally in blocks or bags direct from the supplier.
- Casing added 10 to 16 days later.
- First mushroom flush from day 26 to 31.
- Second mushroom flush approximately seven days later.
- Third mushroom flush seven days later.
- House emptied.

### *Phase III*

- Compost and casing supplied loose on the same day.
- First mushroom flush 16 days later.
- Second mushroom flush approximately seven days later.
- Third mushroom flush seven days later.
- House emptied.

White cap mushrooms are most commonly grown, accounting for 343 production houses. An estimated 61 production houses produced brown mushrooms.

## **METHODS**

Using a list supplied by the Department of Agriculture Northern Ireland (DARDNI) and commercial suppliers lists the population of mushroom growers were established and selected. A preliminary letter was sent to growers explaining the purpose of the survey. Of a possible population of 55 growers, 52 holdings participated in the survey. The data has been raised to give estimates of regional pesticide usage. Growers were visited during September 2007 and data relating to pesticide usage were collected by personal interview. This survey covers the period from October 2006 to September 2007.

The data collected included; the number and area of mushroom houses, method of production, number of crops per annum, type of treatment, area and number of times treated and the production stage at application. The grower's stated reasons for pesticide use were also included, but may not always seem appropriate.

The sampled data was raised to the population and the collected data were analysed using SPSS software.

## **RESULTS AND DISCUSSION**

### *Regional Pesticide Usage*

Of the 55 mushroom growers in the population, 53% were in County Armagh representing 46% of the basic area of mushroom crops grown. A further 29% of growers were in County Tyrone accounting for 31% of the area grown (Table 1; Figures 1 and 2). Conversely, growers in County Tyrone accounted for 39% (32% in County Armagh) of the total pesticide-treated area. An estimated 46% of all fungicide and 38% of insecticide treatments were applied in this county (Table 2).



### *Pesticide Usage in Mushroom Production*

The estimated area treated and weight of pesticides used at each stage of mushroom production are shown in Tables 3 (Figure 3) and 4, respectively. More than half (54%) of pesticide applications occurred from casing to first flush, accounting for 45% of the quantity of active ingredients used.

Fungicides accounted for 40% of the pesticide-treated area and 91% of the weight of pesticides applied. An estimated 67% of fungicides were applied between casing and first flush, accounting for 44% of the quantity of fungicides used. While the end of cropping spray accounted for only 9% of fungicide applications it represented 40% of the total weight of fungicides applied.

Insecticides accounted for 36% of the pesticide-treated area and 9% of the weight of pesticides applied. The majority (89%) of insecticide treatments were applied at the house sterilisation stage before compost was delivered. Casing to first flush accounted for 54% of the weight of insecticides applied and 9% of the insecticide-treated area.

Biological controls were applied to 24 % of the total pesticide-treated area in 2007, compared with 4% in 1999.

### *Total Pesticide Usage*

An estimated 0.5 tonnes of pesticide active ingredients were applied to 135 spray hectares of mushroom crops in Northern Ireland in 2007 (Tables 3 & 4).

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

Two fungicide active ingredients were recorded in this survey. Formaldehyde, applied principally as an end of cropping spray, to eliminate any potential diseases prior to disposal of the spent compost, represented 11% of the fungicide-treated area and 47% of the weight of fungicides applied. Prochloraz applied between casing and first flush, and between first and second flush accounted for 89% of the fungicide-treated area and 53% of the weight of fungicide active ingredients.

Five insecticide active ingredients were recorded. Bendiocarb, applied to the interior structure of the mushroom houses prior to 'filling', was the most frequently used active ingredient, applied to 91% of the insecticide-treated area and accounting for 45% of the weight of pesticides applied.

The only biological control agent recorded was the insect-pathogenic nematode *Steinernema feltiae*, used on approximately 33 spray hectares of mushroom crops after casing and before first flush to control flies (Tables 7 & 8).

## PESTICIDE USAGE ON MUSHROOM PRODUCTION STAGES (Table 9)

### *House sterilisation*

These treatments require the use of pesticides / disinfectants, applied to the interior structure of the mushroom house when the house is empty. Dependent upon the grower's production system this may include applications to racks/shelves/nets etc.. Insecticide paints may be applied to the interior walls.

Pesticides applied to mushroom houses prior to 'filling' represented 33% of the total pesticide-treated area, but only 10% of the total quantity of active ingredients applied (Tables 7 & 8).

The fungicide formaldehyde applied as a 'disinfectant' for general hygiene and the insecticide bendiocarb, applied to the interior walls of the mushroom houses, were the two active ingredients recorded in use at this stage.

### *Pre-casing*

When the house is filled with bags /blocks an insecticide may be applied to control flies prior to casing.

Pesticides applied at the pre-casing stage accounted for less than 1% of both the total pesticide-treated area and quantity of pesticides applied (Tables 7 & 8). The only active ingredient recorded in use was the insecticide bendiocarb, to control flies.

### *Between casing and first flush*

An estimated 54% of all pesticide applications were undertaken at the post-casing stage, accounting for 45% of the total quantity of pesticides used (Tables 7 & 8).

Approximately 67% of all fungicides applied during mushroom production were applied at this stage, representing 44% of the quantity used. The only fungicide active ingredient recorded used at this stage was prochloraz, with 50% of applications to control wet and dry bubble (*Mycogone* and *Verticillium*).

Insecticides applied post-casing accounted for only 9% of the total insecticide applications, but 54% of the quantity of insecticides used. Diflubenzuron was the most extensively used insecticide, accounting for 84% of the insecticide-treated area and 99% of the quantity used.

The biological control agent, *Steinernema feltiae*, was recorded in use post-casing to control flies and accounted for 24% of the pesticide-treated area at this stage.

### *Between First and Second Flush*

Pesticides applied between the first and second flush accounted for 9% of both the total pesticide-treated area and the quantity of pesticides applied (Tables 7 & 8).

Fungicides accounted for 96% of all pesticides applied at this stage. Prochloraz, applied principally to control bubble was the only fungicide recorded.

Bendiocarb and the formulation of pyrethrins/resmethrin were the insecticides applied at this stage, principally to control sciarid flies.

No pesticides were applied between the second and third flush.

### *End Spray*

At the end of the crop production cycle. If disease / pests are present, the grower may apply a treatment prior to disposal.

Pesticides applied to 'spent' compost at the end of crop production to prevent the release of airborne spores accounted for 4% of the total pesticide-treated area and 36% of the total quantity of pesticides applied (Tables 7 & 8).

The fungicide formaldehyde and the insecticide malathion were the active ingredients recorded in use at this stage.

### *Spawn-running houses*

Mushroom 'spawn' is a culture of *Agaricus bisporus* mycelium that is added to the compost. Generally growers buy in compost that has been spawn-run. However, some growers spawn-run their own compost and dedicate houses, usually on units separate from the production unit to this procedure. Of the 52 growers surveyed five spawn-run their own compost, accounting for 27 houses in total.

Houses dedicated to spawn-running accounted for 3% of all pesticide and disinfectant applications to mushroom houses and less than 1% of quantity of pesticide used. Disinfectants were the principal treatments applied to 89% of the treated area, with insecticides accounting for the remaining 11% of applications (Table 10).

## **PESTICIDE USAGE AND GROWING METHODS**

An estimated 43% of all pesticides were applied to production houses using loose compost on shelves, 41% to those using blocks, 9% to those using bags, 7% to houses that combined bags and blocks and 1% to spawn-running houses. A distribution of pesticide usage across growing methods is shown in Tables 11 and 12.

## **DISINFECTANT USAGE ON HOUSE AND YARD AREAS**

Disinfectants are extensively used to maintain general hygiene levels in both the mushroom production houses and the yard areas surrounding the houses. An estimated 58% of all disinfectants were applied to the yard areas with the remaining 42% of applications to the house structure and equipment (i.e. shelves, nets etc.).

Disinfection applied after the houses were emptied accounted for 92% of both the total disinfectant-treated area and quantity of disinfectants used in mushroom production houses, the remaining 8% of disinfectants were applied to 'spent compost' prior to disposal.

Phenolic derivatives were applied to 51% of the treated yard area, 19% of the quantity of disinfectants applied. Chlorine applied to 3% of the disinfectant-treated area accounted for 37% of the quantity of disinfectants used on yards (Tables 13 & 14).

The horticultural bactericide sodium hypochlorite was also recorded used on both the yard and production house areas.

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

The population of mushroom growers decreased by 81% in 2007 compared with 1999, with a consequent (73%) decrease in basic cropping area and 62% decrease in the overall area grown.

In common with previous surveys, the majority of pesticides were applied between casing and first flush. The principal stage of disinfectant application was also comparable with previous years, with treatments predominantly applied at house sterilisation. However, unlike in the previous surveys, no disinfectants were recorded applied between casing and first flush or between flushes in 2007.

The use of biological controls is continuing to increase, with a 29% increase in 2007 compared with 1999. The only biological control agent recorded was *S. feltiae*, used principally between casing and first flush.

The disinfectant-treated area decreased by 22%. However, the overall quantity of disinfectant used increased by 25% compared with that recorded in 1999. The decrease in disinfectant usage approximated to the decrease in mushroom houses. However the increase in quantity used is partly due to the increased use of chlorine. Disinfectants, applied to the yard area surrounding the houses, increased three-fold by comparison with 1999, suggesting an increased awareness of preventative hygiene in this area, possibly influenced by the increasing use of loose compost.

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## REFERENCES

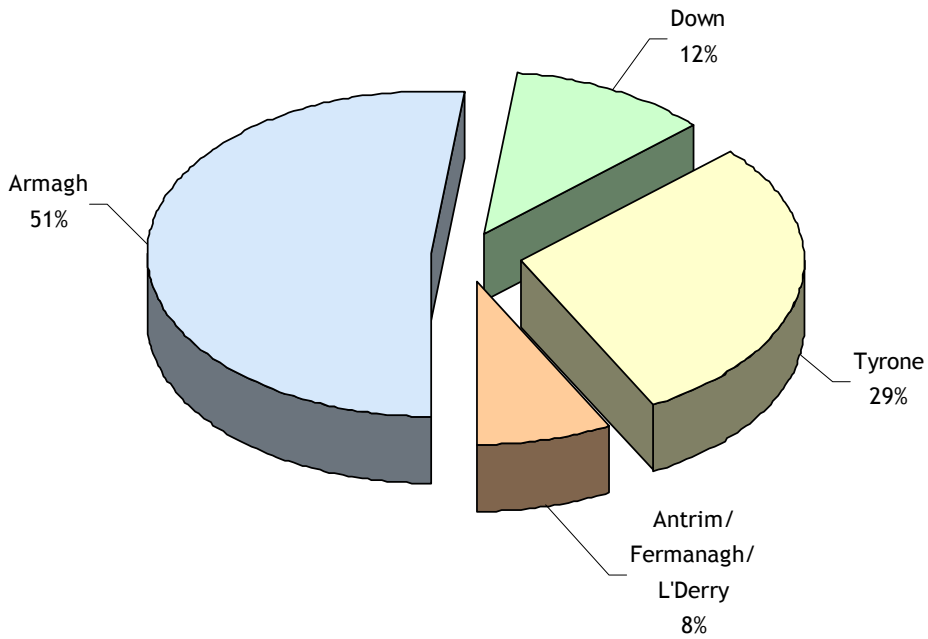
**Anon. (2008).** *Statistical Review of Northern Ireland Agriculture 2007*. Belfast: DARDNI

**Kidd, S.L.B., Jess, S., McCallion, T. (1994).** *Mushroom Crops 1991. Pesticide Usage Survey Report 111*. Belfast: HMSO.

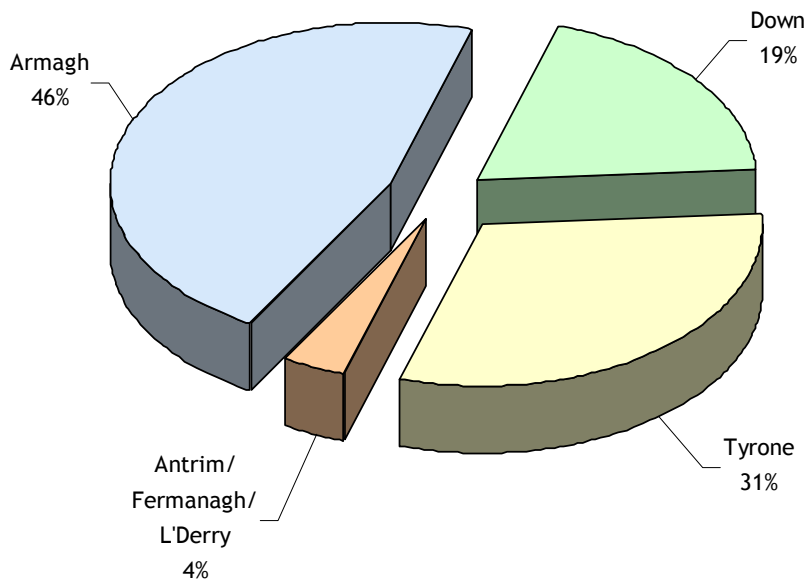
**Kidd, S.L.B., Jess, S., McCallion, T. (1998).** *Mushroom Crops 1995. Pesticide Usage Survey Report 140*. Belfast: HMSO.

**Kearns, C.A., Jess, S., McCallion, T., Matthews, D. (2002).** *Pesticide Usage Survey Report 170*. Belfast: DARDNI.

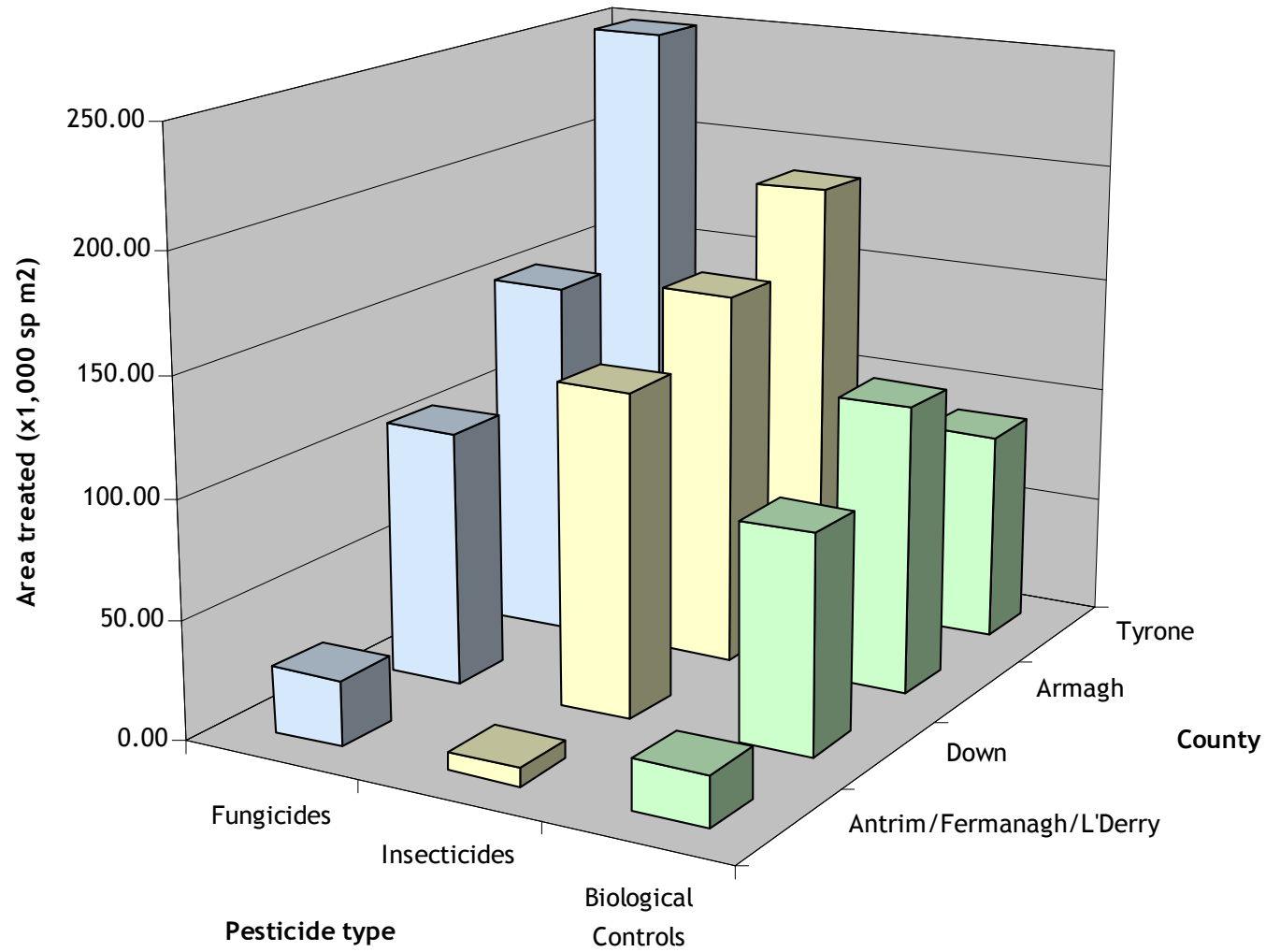
**Fig 1:** The regional distribution of mushroom growers in Northern Ireland, 2007



**Fig 2:** The regional distribution of the mushroom cropping area in Northern Ireland, 2007.



**Fig 3:** The area (x 1,000 spray square metres) of mushroom crops treated with each pesticide type in the county regions of Northern Ireland, 2007.



**Table 1:** The total number of mushroom houses, the total cropping area (x 1,000 m<sup>2</sup>) and the total area of mushrooms grown (x 1,000 m<sup>2</sup>) in Northern Ireland, 2007.

County	Growers	No. of mushroom houses	Cropping area (x1,000 m <sup>2</sup> )	Area grown (x1,000 m <sup>2</sup> )
Armagh	29	194	44.51	296.04
Down	6	77	18.36	165.83
Tyrone	16	135	29.44	236.42
Antrim/Fermanagh/L'Derry	4	26	3.51	23.74
<i>Northern Ireland</i>	<b>55</b>	<b>433</b>	<b>95.81</b>	<b>722.02</b>

**Table 2:** Regional distribution of pesticide-treated area (x 1,000 m<sup>2</sup>) of mushroom crops in Northern Ireland, 2007.

County	Pesticide type			Total area treated (x1,000 sp m <sup>2</sup> )
	Fungicides	Insecticides	Biological Controls	
Armagh	152.09	158.29	122.63	433.01
Down	108.41	136.96	92.41	337.78
Tyrone	249.52	188.43	89.17	527.13
Antrim/Fermanagh/L'Derry	27.79	7.55	21.07	56.40
<i>Northern Ireland</i>	<b>537.80</b>	<b>491.23</b>	<b>325.29</b>	<b>1,354.32</b>

**Table 3:** Estimated area treated (x 1,000 spray m<sup>2</sup>) with each pesticide type at different stages of mushroom production in Northern Ireland, 2007.

Production Stage	Pesticide type			Total area treated (x1,000 sp m <sup>2</sup> )
	Fungicides	Insecticides	Biological Controls	
House sterilisation	11.73	435.98	.	447.71
Pre-casing	.	3.38	.	3.38
Between casing and 1st flush	361.16	46.13	325.29	732.58
Between 1st and 2nd flush	117.08	5.29	.	122.37
End of cropping spray	47.83	0.44	.	48.28
<i>All production stages</i>	<b>537.80</b>	<b>491.23</b>	<b>325.29</b>	<b>1,354.32</b>

**Table 4:** Estimated quantities (kilograms) of each pesticide type applied at different stages of mushroom production in Northern Ireland, 2007.

Production stage	Pesticide type		Total quantity (kg)
	Fungicides	Insecticides	
House sterilisation	35.26	21.46	56.72
Pre-casing	.	0.16	0.16
Between casing and 1st flush	222.09	26.28	248.36
Between 1st and 2nd flush	47.95	0.45	48.40
End of cropping spray	200.20	0.02	200.22
<i>All production stages</i>	<b>505.50</b>	<b>48.36</b>	<b>553.85</b>

**Table 5:** The active ingredients most extensively used in mushroom production in Northern Ireland, 2007, ranked by treated area (x 1,000 spray m<sup>2</sup>).

Active Ingredient	Total area (x1,000 sp m <sup>2</sup> )
1. Prochloraz	478.24
2. Bendiocarb	445.29
3. <i>Steinernema feltiae</i>	325.29
4. Formaldehyde	59.56
5. Diflubenzuron	38.53
6. Deltamethrin	5.94
7. Pyrethrins	1.02
8. Resmethrin	1.02
9. Malathion	0.44

**Table 6:** The active ingredients most extensively used in mushroom production in Northern Ireland, 2007, ranked by weight (kilograms).

Active Ingredient	Quantity (kg)
1. Prochloraz	270.04
2. Formaldehyde	235.46
3. Diflubenzuron	26.19
4. Bendiocarb	21.97
5. Resmethrin	0.16
6. Pyrethrins	0.02
7. Malathion	0.02
8. Deltamethrin	0.001
9. <i>Steinernema feltiae</i>	



**Table 7:** Estimated area treated (x 1,000 spray m<sup>2</sup>) with each formulation of pesticide active ingredients at the different stages of mushroom production in Northern Ireland, 2007.

Pesticide Type & Formulation	Stage					Total area (x1,000 sp m <sup>2</sup> )
	House sterilisation	Pre-casing	Between casing and 1st flush	Between 1st and 2nd flush	End spray	
<i>Fungicides</i>						
Formaldehyde	11.73	.	.	.	47.83	59.56
Prochloraz	.	.	361.16	117.08	.	478.24
<b>All fungicides</b>	<b>11.73</b>	<b>.</b>	<b>361.16</b>	<b>117.08</b>	<b>47.83</b>	<b>537.80</b>
<i>Insecticides</i>						
Bendiocarb	435.98	3.38	1.67	4.26	.	445.29
Deltamethrin	.	.	5.94	.	.	5.94
Diflubenzuron	.	.	38.53	.	.	38.53
Malathion	.	.	.	.	0.44	0.44
Pyrethrins/resmethrin	.	.	.	1.02	.	1.02
<b>All insecticides</b>	<b>435.98</b>	<b>3.38</b>	<b>46.13</b>	<b>5.29</b>	<b>0.44</b>	<b>491.23</b>
<i>Biological Controls</i>						
<i>Steinernema feltiae</i>	.	.	325.29	.	.	325.29
<b>All biological controls</b>	<b>.</b>	<b>.</b>	<b>325.29</b>	<b>.</b>	<b>.</b>	<b>325.29</b>
<b>All pesticides</b>	<b>447.71</b>	<b>3.38</b>	<b>732.58</b>	<b>122.37</b>	<b>48.28</b>	<b>1,354.32</b>

**Table 8:** Estimated quantity (kilograms) of each pesticide active ingredient applied at the different stages of mushroom production in Northern Ireland, 2007.

Pesticide Type & Formulation	House sterilisation	Pre-casing	Production stage			Total Quantity (kg)
			Between casing and 1st flush	Between 1st and 2nd flush	End spray	
<i>Fungicides</i>						
Formaldehyde	35.26	.	.	.	200.20	235.46
Prochloraz	.	.	222.09	47.95	.	270.04
<b>All fungicides</b>	<b>35.26</b>	<b>.</b>	<b>222.09</b>	<b>47.95</b>	<b>200.20</b>	<b>505.50</b>
<i>Insecticides</i>						
Bendiocarb	21.46	0.16	0.09	0.27	.	21.97
Deltamethrin	.	.	<0.01	.	.	<0.01
Diflubenzuron	.	.	26.19	.	.	26.19
Malathion	.	.	.	.	0.02	0.02
Pyrethrins/resmethrin	.	.	.	0.18	.	0.18
<b>All insecticides</b>	<b>21.46</b>	<b>0.16</b>	<b>26.28</b>	<b>0.45</b>	<b>0.02</b>	<b>48.36</b>
<b>All pesticides</b>	<b>56.72</b>	<b>0.16</b>	<b>248.36</b>	<b>48.40</b>	<b>200.22</b>	<b>553.85</b>

**Table 9:** The pesticide-treated area (x 1,000 spray m<sup>2</sup>), the quantity of active ingredient formulation applied (kilograms) at each stage of mushroom production in Northern Ireland, 2007, and the reasons for use.

Stage	Pesticide Type & Formulation	Bubble	Cobweb	General Disease	General Flies	General Hygiene	Phorid flies	Sciariid flies	Total area treated (x1,000 sp m <sup>2</sup> )	Total Quantity (kg)	
<i>House sterilisation</i>	<i>Fungicides</i>										
	Formaldehyde	.	.	.	.	11.73	.	.	11.73	35.26	
	<i>All fungicides</i>	.	.	.	.	11.73	.	.	11.73	35.26	
	<i>Insecticides</i>										
	Bendiocarb	.	.	.	388.63	6.66	3.89	36.80	435.98	21.46	
	<i>All insecticides</i>	.	.	.	388.63	6.66	3.89	36.80	435.98	21.46	
<i>Pre-casing</i>	<i>Insecticides</i>										
	Bendiocarb	.	.	.	3.38	.	.	.	3.38	0.16	
	<i>All insecticides</i>	.	.	.	3.38	.	.	.	3.38	0.16	
<i>Between casing and 1st flush</i>	<i>Fungicides</i>										
	Prochloraz	180.13	0.55	180.49	.	.	.	.	361.16	222.09	
	<i>All fungicides</i>	180.13	0.55	180.49	.	.	.	.	361.16	222.09	
	<i>Insecticides</i>										
	Bendiocarb	.	.	.	1.67	.	.	.	1.67	0.09	
	Deltamethrin	.	.	.	.	.	5.94	.	5.94	0.00	
	Diflubenzuron	.	.	.	24.59	.	.	13.94	38.53	26.19	
	<i>All insecticides</i>	.	.	.	26.26	.	5.94	13.94	46.13	26.28	
	<i>Biological Controls</i>										
	<i>Steinernema feltiae</i>	.	.	.	209.87	.	.	.	115.42	325.29	.
	<i>All biological controls</i>	.	.	.	209.87	.	.	.	115.42	325.29	.

**Table 9 (cont):** The pesticide-treated area (x 1,000 spray m<sup>2</sup>), the quantity of active ingredient formulation applied (kilograms) at each stage of mushroom production in Northern Ireland, 2007, and the reasons for use.

Stage	Pesticide Type & Formulation	Bubble	Cobweb	General Disease	General Flies	General Hygiene	Phorid flies	Sciarid flies	Total area treated (x1,000 sp m <sup>2</sup> )	Total Quantity (kg)
<i>Between 1st and 2nd flush</i>	<i>Fungicides</i>									
	Prochloraz	67.66	.	49.42	.	.	.	.	117.08	47.95
	<b>All fungicides</b>	<b>67.66</b>	<b>.</b>	<b>49.42</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>117.08</b>	<b>47.95</b>
	<i>Insecticides</i>									
	Bendiocarb	.	.	.	.	.	.	4.26	4.26	0.27
	Pyrethrins/resmethrin	.	.	.	1.02	.	.	.	1.02	0.18
	<b>All insecticides</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>1.02</b>	<b>.</b>	<b>.</b>	<b>4.26</b>	<b>5.29</b>	<b>0.45</b>
<i>End spray</i>	<i>Fungicides</i>									
	Formaldehyde	.	.	47.83	.	.	.	.	47.83	200.20
	<b>All fungicides</b>	<b>.</b>	<b>.</b>	<b>47.83</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>47.83</b>	<b>200.20</b>
	<i>Insecticides</i>									
	Malathion	.	.	.	0.44	.	.	.	0.44	0.02
	<b>All insecticides</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>0.44</b>	<b>.</b>	<b>.</b>	<b>.</b>	<b>0.44</b>	<b>0.02</b>
	<b>All pesticides</b>	<b>247.78</b>	<b>0.55</b>	<b>277.74</b>	<b>629.61</b>	<b>18.39</b>	<b>9.83</b>	<b>170.41</b>	<b>1,354.32</b>	<b>553.85</b>

**Table 10:** The estimated area (x1,000 spray m<sup>2</sup>) and quantity (kilograms) of pesticides and disinfectants applied to mushroom house types.

Pesticides and disinfectants	Production house		Spawn run house		Total	
	Total area treated (x1,000 sp m <sup>2</sup> )	Quantity (kg)	Total area treated (x1,000 sp m <sup>2</sup> )	Quantity (kg)	Total area treated (x1,000 sp m <sup>2</sup> )	Quantity (kg)
Fungicides	537.80	505.50	.	.	537.80	505.50
Insecticides	483.88	47.32	7.35	1.04	491.23	48.36
Biological Controls	325.29	.	.	.	325.29	.
Disinfectant	934.75	4,826.47	60.40	22.96	995.14	4,849.43
<i>All pesticides and disinfectants</i>	<b>2,281.71</b>	<b>5,379.29</b>	<b>67.74</b>	<b>24.00</b>	<b>2,349.46</b>	<b>5,403.29</b>

**Table 11:** The pesticide type (x 1,000 spray m<sup>2</sup>) applied to the different growing methods for mushroom production in Northern Ireland, 2007.

	Spawn houses	Loose only	Bags only	Blocks only	Block and Bags	Total area treated (x1,000 sp m <sup>2</sup> )
<b>Fungicides</b>						
Formaldehyde	.	9.19	7.70	42.68	.	59.56
Prochloraz	.	227.70	38.70	170.87	40.97	478.24
<b>All fungicides</b>	.	<b>236.89</b>	<b>46.40</b>	<b>213.55</b>	<b>40.97</b>	<b>537.80</b>
<b>Insecticides</b>						
Bendiocarb	7.35	208.42	54.05	147.67	27.81	445.29
Deltamethrin	.	.	.	5.94	.	5.94
Diflubenzuron	.	.	5.05	24.90	8.57	38.53
Malathion	.	.	0.44	.	.	0.44
Pyrethrins/resmethrin	.	.	.	1.02	.	1.02
<b>All insecticides</b>	<b>7.35</b>	<b>208.42</b>	<b>59.55</b>	<b>179.53</b>	<b>36.38</b>	<b>491.23</b>
<b>Biological Controls</b>						
<i>Steinernema feltiae</i>	.	142.06	13.34	156.10	13.78	325.29
<b>All Biological Controls</b>	.	<b>142.06</b>	<b>13.34</b>	<b>156.10</b>	<b>13.78</b>	<b>325.29</b>
<b>All Pesticides</b>	<b>7.35</b>	<b>587.36</b>	<b>119.29</b>	<b>549.18</b>	<b>91.14</b>	<b>1,354.32</b>

**Table 12:** The quantity of pesticides (kilograms) applied to the different growing methods for mushroom production in Northern Ireland, 2007.

	Spawn houses	Loose only	Bags only	Blocks only	Block and Bags	Total quantity (kg)
<i>Fungicides</i>						
Formaldehyde	.	28.40	27.87	179.19	.	235.46
Prochloraz	.	111.89	31.72	109.36	17.07	270.04
<b>All fungicides</b>	<b>.</b>	<b>140.29</b>	<b>59.59</b>	<b>288.55</b>	<b>17.07</b>	<b>505.50</b>
<i>Insecticides</i>						
Bendiocarb	1.04	9.28	3.16	7.16	1.33	21.97
Deltamethrin	.	.	.	0.00	.	0.00
Diflubenzuron	.	.	3.49	17.37	5.33	26.19
Malathion	.	.	0.02	.	.	0.02
Pyrethrins/resmethrin	.	.	.	0.18	.	0.18
<b>All insecticides</b>	<b>1.04</b>	<b>9.28</b>	<b>6.67</b>	<b>24.71</b>	<b>6.66</b>	<b>48.36</b>
<b>All Pesticides</b>	<b>1.04</b>	<b>149.57</b>	<b>66.26</b>	<b>313.25</b>	<b>23.73</b>	<b>553.85</b>

**Table 13:** Estimated treated area (x 1,000 spray m<sup>2</sup>) and quantity applied (kilograms) of the different disinfectant types used in mushroom production in Northern Ireland, 2007.

Disinfectant type	Mushroom House		Yard		All disinfectant treatments	
	Area treated (x1,000 sp m <sup>2</sup> )	Quantity (kg)	Area treated (x1,000 sp m <sup>2</sup> )	Quantity (kg)	Area treated (x1,000 sp m <sup>2</sup> )	Quantity (kg)
Chlorine	51.69	2,980.58	46.75	764.50	98.44	3,745.08
Phenolic derivatives	689.94	616.17	696.06	381.73	1,386.00	997.90
Sodium hypochlorite	204.05	799.67	185.08	420.24	389.13	1,219.91
Unknown disinfectant	48.28	450.89	446.90	477.13	495.18	928.02
Xylenoids	1.18	2.12	.	.	1.18	2.12
<b>All disinfectants</b>	<b>995.14</b>	<b>4,849.44</b>	<b>1,374.79</b>	<b>2,043.59</b>	<b>2,369.94</b>	<b>6,893.03</b>

**Table 14:** The disinfectant types used at the different stages in mushroom production houses in Northern Ireland in 2007.

(i) Estimated disinfectant-treated area (x 1,000 spray m<sup>2</sup>)

Disinfectant type	Production Stage			Total area treated (x1,000 sp m <sup>2</sup> )
	House sterilisation	Pre-casing	End spray	
Chlorine	51.69	.	.	51.69
Phenolic derivatives	625.09	21.04	43.81	689.94
Sodium hypochlorite	200.70	.	3.35	204.05
Unknown disinfectant	34.35	.	13.94	48.28
Xylenoids	1.18	.	.	1.18
<b>All disinfectants</b>	<b>913.01</b>	<b>21.04</b>	<b>61.09</b>	<b>995.14</b>



**Table 14 (cont):** The disinfectant types used at the different stages in mushroom production houses in Northern Ireland in 2007.

**(ii) Quantity of disinfectant applied (kilograms)**

Disinfectant type	House sterilisation	Production Stage		Total quantity (kg)
		Pre-casing	End spray	
Chlorine	2,980.58	.	.	2,980.58
Phenolic derivatives	563.74	6.36	46.07	616.17
Sodium hypochlorite	742.56	.	57.12	799.67
Unknown disinfectant	162.14	.	288.75	450.89
Xylenoids	2.12	.	.	2.12
<i>All disinfectants</i>	<b>4,451.13</b>	<b>6.36</b>	<b>391.94</b>	<b>4,849.43</b>

**Table 15:** Comparison of the number of growers, the number of houses, the cropping area (x 1,000 m<sup>2</sup>) and the total area of mushroom crops grown (x 1,000 m<sup>2</sup>) in Northern Ireland, 1991-2007.

County	1991				1995			
	Number of growers	Number of mushroom houses	Cropping area (x 1,000 m <sup>2</sup> )	Area grown (x 1,000 m <sup>2</sup> )	Number of growers	Number of mushroom houses	Cropping area (x 1,000 m <sup>2</sup> )	Area grown (x 1,000 m <sup>2</sup> )
Armagh	97	486	90	402	78	385	77	360
Down	71	302	65	288	61	289	73	331
Tyrone	108	421	68	298	105	464	97	451
Antrim/Fermanagh/L'Derry	20	63	15	70	28	113	30	152
<i>Northern Ireland</i>	<b>296</b>	<b>1,272</b>	<b>238</b>	<b>1,058</b>	<b>272</b>	<b>1,252</b>	<b>278</b>	<b>1,292</b>

County	1999				2007			
	Number of growers	Number of mushroom houses	Cropping area (x 1,000 m <sup>2</sup> )	Area grown (x 1,000 m <sup>2</sup> )	Number of growers	Number of mushroom houses	Cropping area (x 1,000 m <sup>2</sup> )	Area grown (x 1,000 m <sup>2</sup> )
Armagh	88	487	109	629	29	194	45	296
Down	75	386	88	473	6	77	18	166
Tyrone	102	513	132	685	16	135	29	236
Antrim/Fermanagh/L'Derry	24	103	24	122	4	26	4	24
<i>Northern Ireland</i>	<b>289</b>	<b>1,489</b>	<b>353</b>	<b>1,909</b>	<b>55</b>	<b>433</b>	<b>96</b>	<b>722</b>

**Table 16:** Comparison of usage of the different pesticide types in mushroom houses in Northern Ireland 1991-2007.

Pesticide type	Area treated (x 1,000 sp m <sup>2</sup> )				Quantity (kilograms)			
	1991	1995	1999	2007	1991	1995	1999	2007
<i>Disinfectants</i>	1,072	2,256	2,625	995	2,554	3,568	4,915	4,849*
<i>Fungicides</i>	1,636	2,974	3,442	538	2,159	3,056	3,484	505.5
<i>Insecticides</i>								
Benzoylureas	.	.	.	39	.	.	.	26
Carbamates	567	1,018	967	445	207	343	326	22
Organochlorines	39	98	100	.	3	4	11	.
Organophosphates	716	851	33	< 0.5	1,914	1,399	15	< 0.1
Pyrethroids	859	1,125	1,085	7	17	21	59	< 0.5
Others	.	21	75	.	.	7	20	.
Unknown insecticide	52	30	.	.	.	.	.	.
<b>All insecticides</b>	<b>2,232</b>	<b>3,143</b>	<b>2,260</b>	<b>491</b>	<b>2,143</b>	<b>1,774</b>	<b>431</b>	<b>48.36</b>
<i>Biological controls</i>	.	24	251	325	.	.	.	.
Mixtures	105	.	.	.	531	.	.	.
Rodenticides	33	.	.	.	< 0.5	.	.	.
<b>All pesticides</b>	<b>4,007</b>	<b>6,141</b>	<b>6,318</b>	<b>1,354</b>	<b>4,834</b>	<b>4,830</b>	<b>3,915</b>	<b>554</b>
<b>Area grown (x 1,000 m<sup>2</sup>)</b>	<b>1,059</b>	<b>1,292</b>	<b>1,909</b>	<b>722</b>				

\* Value high due to inclusion of chlorine

**Table 17:** Comparison of pesticide usage on mushroom crops in Northern Ireland 1991-2007, area treated (x 1,000 spray m<sup>2</sup>) and quantity applied (kilograms).

Mushroom production stage	Area treated (x 1,000 sp m <sup>2</sup> )				Quantity (kilograms)			
	1991	1995	1999	2007	1991	1995	1999	2007
House sterilisation	256	394	689	448	1,567	1,718	2066	57
Pre-casing	1571	1,458	566	3	2,307	1,457	165	< 0.5
Between casing and 1st flush	1,260	2,103	2693	733	565	1,021	887	248
Between 1st and 2nd flush	268	817	1064	122	72	229	237	48
Between 2nd and 3rd flush	379	931	797	.	84	251	122	.
After 3rd flush	199	387	36	.	53	70	1	.
End spray (bags/compost)	71	51	110	48	168	84	437	200
<i>All mushroom production stages</i>	<b>4,004</b>	<b>6,141</b>	<b>5,955</b>	<b>1,354</b>	<b>4,816</b>	<b>4,829</b>	<b>3,915</b>	<b>554</b>

**Table 18:** Comparison of disinfectant usage in mushroom houses in Northern Ireland 1991-2007, area treated (x 1,000 spray m<sup>2</sup>) and quantity applied (kilograms).

Mushroom production stage	Area treated (x 1,000 sp m <sup>2</sup> )				Quantity (kilograms)			
	1991	1995	1999	2007	1991	1995	1999	2007
House sterilisation	920	1,727	2,072	913	1,708	2,808	4135	4451.13
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 (bags/compost)	69	388	447	61	749	679	768	391.94
<i>All mushroom production stages</i>	<b>1,051</b>	<b>2,256</b>	<b>2,625</b>	<b>995</b>	<b>2,542</b>	<b>3,568</b>	<b>4,915</b>	<b>4,849</b>

**Table 19:** Comparison of usage of the different disinfectant types in mushroom production in Northern Ireland 1991-2007.

**(i) Treated area (x 1,000 spray m<sup>2</sup>)**

Disinfectant type	Mushroom house area				Yard treatment				All disinfectant treatments			
	1991	1995	1999	2007	1991	1995	1999	2007	1991	1995	1999	2007
Chlorine	.	.	.	52	.	.	.	47	.	.	.	98
Phenolic derivatives	586	1,167	1,391	690	274	471	273	696	860	1,638	1,664	1,386
Sodium hypochlorite	224	701	855	204	11	106	90	185	235	807	945	389
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	.
<b>All disinfectants</b>	<b>1,070</b>	<b>2,252</b>	<b>2,625</b>	<b>995</b>	<b>322</b>	<b>737</b>	<b>419</b>	<b>1,375</b>	<b>1,392</b>	<b>2,989</b>	<b>3,044</b>	<b>2,370</b>

**(ii) Quantity used (kilograms)**

Disinfectant type	Mushroom house area				Yard treatment				All disinfectant treatments			
	1991	1995	1999	2007	1991	1995	1999	2007	1991	1995	1999	2007
Chlorine	.	.	.	2,981	.	.	.	765	.	.	.	3,745
Phenolic derivatives	653	1,402	1504	616	324	433	210	382	977	1,835	1,715	998
Sodium hypochlorite	279	1,059	2548	800	8	107	126	420	287	1,166	2,674	1,220
Xylenoids	1,622	1,107	862	2	341	558	255	.	1,963	1,665	1,117	2
Unknown disinfectant	.	.	.	451	.	.	.	477	.	.	.	928
<b>All disinfectants</b>	<b>2,554</b>	<b>3,567</b>	<b>4,914</b>	<b>4,849</b>	<b>673</b>	<b>1,099</b>	<b>591</b>	<b>2,044</b>	<b>3,227</b>	<b>4,666</b>	<b>5,506</b>	<b>6,893.0</b>

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