REGIONAL ANALYSIS OF USE PATTERNS OF PLANT PROTECTION PRODUCTS IN SIX EU COUNTRIES

PES - A/Phase 2

EXECUTIVE SUMMARY

REGIONAL ANALYSIS OF USE PATTERNS OF PLANT PROTECTION PRODUCTS IN SIX EU COUNTRIES PES - A/Phase 2

1.0 BACKGROUND

This study followed a review conducted by LEI-DLO in Phase 1 of the project on possibilities for future EU environmental policy on plant protection products (PES-A).

In their review LEO-DLO suggested three avenues for investigation:

1. Areas of more than moderate use of plant protection products:

Germany	-	Nordrhein Westfallen, Rheinland Pfalz, Berlin
France	-	Champagne-Ardennes, Alsace, Haute Normandie, Centre, Provence-Alpes-Cote d'Azur, Ile de France, Picardie, Nord-Pas de Calais, Languedoc-Rouissillon
Belgium	-	Belgium
Netherlands	-	Netherlands
Spain	-	Rioja, Murcia, Canarias, Valencia
United Kingdom	-	East Anglia

2. The intensity of use of plant protection products which vary substantially between countries.

3. Possible crops to be studied were given as:

   - Soft wheat
   - Barley
   - Vegetables
   - Fruit

With this as a background the following sub-project terms of reference were issued.

2.0 TERMS OF REFERENCE

Through a basis of agronomic analysis at farm level, the objective was to study:

2.1 Differences at farm level (within regions)

- What differences in use between farms can be found within a region?
- What are the reasons for these differences?
- What is the scope for reduction that is economically acceptable?
- What are the possible future developments or trends related to the use of plant protection products?

2.2 Differences at crop level (between regions)

- What are the reasons for these differences?
- Are these differences merely explained by variations in natural conditions, diseases, crop rotations, plant protection product prices or other reasons?
- Are there other differences that might give scope for reduction?

3.0 CROP AND REGIONAL SELECTION

It was evident at the outset that budgetary constraints would not permit as wide a geographical review as suggested by the LEI-DLO study and that, as a consequence, the crops studied might have to be modified.

3.1 Crop selection

Landell Mills' in-house agrochemical database showed the following crops to be of importance in total agrochemical load across the EU.

Table 3.1 The top 10 EU crops for agrochemicals

Crop	Crop area '000 ha	Total Active Ingredient Volumes tonnes				Average dose Active Ingredient
		Fungicides	Herbicides	Insecticides	Total	kg/ha
Vines	**3,936**	**100,906**	**5,124**	**2,150**	**108,181**	**27.5**
Cereals	**27,323**	**15,840**	**34,449**	**1,301**	**51,590**	**1.9**
Vegetables	1,330	8,566	1,217	25,619	35,402	26.6
Potatoes	**1,509**	**9,556**	**10,236**	**9,237**	**29,030**	**19.2**
Pome/stone fruit	**782**	**11,384**	**1,003**	**6,649**	**19,037**	**24.3**
Corn	3,986	*	15,091	2,676	17,767	4.5
Citrus	526	1,630	824	8,599	11,053	21.0
Beets	2,107	1,714	6,827	1,148	9,689	4.6
Tobacco	198	833	141	5,478	6,454	32.6
Oilseed rape	2,295	1,282	3,229	119	4,631	2.0

* some seed treatment

Crops emboldened are those selected for study.

Source: Landell Mills Agrochemical Database
Data year: 1992
Countries: Belgium, Denmark, Netherlands, France, Germany, Greece, Italy, Portugal, Spain, United Kingdom.

Vegetables were regarded as too fragmented a crop for satisfactory review at farm level so the four crops selected were:

- Vines
- Winter wheat (the major agrochemical user in cereals)
- Potatoes
- Apples (the major agrochemical user in pome and stone fruit).

3.2 Regional selection

Regions were selected across Europe where it was believed that there was above-average use of plant protection products for the crop and country concerned.

The target regions and eventual selection for study were the following:

Table 3.2 Regional selection

Crop	Country	Target	Actual
Cereals (winter soft wheat)	Germany UK France Italy	S Niedersachsen East Anglia Centre Piemonte	Hannover Cambridgeshire, Norfolk, Suffolk Eure, Eure-et-Loire, Oise, Loiret, Loir-et-Cher, Yonne Piemonte
Potatoes	Germany Netherlands UK France	N Niedersachsen Flevoland East Anglia Nord/Pas de Calais	Lüneburg Flevoland Cambridgeshire, Norfolk, Suffolk Nord, Pas de Calais, Somme
Pome/ stone fruit	France Italy Spain	Languedoc-Rouissillon Trentino Cataluña	Bouche du Rhône, Vaucluse, Gard, Herault, Drome Trentino Lerida
Vines	France Spain Italy	Bordeaux Rioja Veneto	Gironde, Charente and Charente Maritime Rioja Verona

These regions proved satisfactory though in hindsight a better choice for wheat in

Italy would have been Emilia Romagna, where the crop is grown more intensively than in Piemonte.

4.0 METHODOLOGY

The basis of the method used in the study was face-to-face farmer interviews in each of the 14 regions. Preceded by a restricted number of farmer group discussions, a questionnaire of approximately one hour in length was developed (presented in the crop review volumes). Fieldwork was conducted in mid-1995 and details were asked regarding product use in the previous season (1994) as well as qualitative and attitudinal aspects. Approximately 60 farmers were interviewed in each region.

Once results had been provisionally analysed, a series of interviews were held with key extension personnel in the regions in order to deepen the discussion and obtain models of growing costs and returns where possible. The sources of information used were:

Table 4.0 Sources of information

Crop	Group discussions No.	Farm survey		Local specialists No.
		No.	Area - ha	
Wheat				
Hannover (D)	-	60	1,956	3
East Anglia (UK)	1	61	4,627	7
N Central France	-	65	2,603	5
Piemonte (I)	-	59	563	4
Sub total	1	245	9,749	19
Potatoes				
Lüneburg (D)	-	60	1,076	4
Flevoland (NL)	-	60	897	8
E Anglia (UK)	1	60	2,060	5
N E France	-	62	862	5
Sub total	1	242	4,895	22
Apples				
S E France	-	62	862	5
Trentino (I)	1	60	213	3
Lerida (E)	1	60	676	4
Sub total	2	182	1,751	12
Vines				
Bordeaux (F)	1	59	1,420	6
Rioja (E)	-	62	1,383	4

Verona (I)	1	61	412	5
Sub total	2	182	3,215	15
Total	**6**	**851**	**19,610**	**68**

5.0 MAIN FINDINGS

Cross-regional reviews are presented by crop in this volume. These are in turn supported by more detailed individual regional crop studies provided in Volumes II-V.

The main findings are summarised below, both generally across crops and by individual crop.

5.1 Cross crop summary

5.1.1 Chemical loads

Taking a very simplistic approach for broad comparative purposes, the chemical loads in the regional sample of farms surveyed were:

Table 5.1.1 Chemical loads by crop

Crop	Region	Chemical load per hectare of crop grown per farm kg ai/ha	
		Average	Range
Wheat	Hannover (D)	4.5	0.08 - 8.5
	E Anglia (UK)	4.6	0 - 10.1
	N Central France	3.8	0.7 - 13.7
	Piemonte (I)	2.1	0.02 - 7.3
Potatoes	Lüneburg (D)	9.8	2.7 - 22.3
	Flevoland (NL)	12.6	1.6 - 34.6
	E Anglia (UK)	13.1*	2.0 - 26.7
	N E France	32.0	9.0 - 73.7
Apples	S E France	41.4	1.7 - 146.7
	Trentino (I)	33.7	0.6 - 83.4
	Lerida (E)	27.4	1.4 - 109.6
Vines	Bordeaux (F)	45.0	7.9 - 87.3

	Rioja (E) Verona (I)	16.8 (42)** 33.6 (43)**	2.9 - 146.9 0.8 - 142.4

* Excludes the use of sulphuric acid as a desiccant.

** There was suggestion by local specialists that farmers' use of sulphur was understated. Figures in brackets are computed as if all farms used sulphur.

Chemical load is the cumulative weight of active ingredient applied per hectare of crop per farm. Definitions may be found in the appendices of each crop section.

Chemical loads per crop varied widely between farms and regions. Comparative differences between regions are discussed in the sections below. Individual reasons for variability between farms were more difficult to identify specifically as there were so many variables in play. These are also discussed below. Not the least of these variables is the difference in inherent activity between chemicals. This can result in dose rate differences varying often by a factor of 100 and up to 6,000 (sulphur compared to pyrethroids).

The difference in inherent activity of chemicals makes the broad comparison by weight of active ingredient of limited value. However, in the absence any other parameter, this measure has been used consistent with other pan European studies.

Fungicides dominated the chemical load in all crops except wheat.

In potatoes, apples and vines, season-long disease protection is required. Given the chemicals available, this necessitates a series of prophylactic treatments throughout the season. In wheat, which shows relatively modest total chemical loads, herbicides were the major contributor closely followed by fungicides. Fewer applications are required compared to the other three crops.

5.1.2 Provisos

The difference in inherent activity together with the factors discussed in section 5.1.3 are the reasons for the great range of chemical loads presented in Table 5.1.1. Three general factors governing variability should be mentioned at the outset:

Managerial expertise:

Specialists emphasised the effect that good management can have on pesticide use. This covers particularly the choice of chemicals and the timing of applications. A mistimed application can lead to spiralling pest infestations later in the season and result in a requirement for excessive remedial use of chemicals as a consequence.

Pest incidence and infestation levels:

The study reported on the incidence of major pests at farm and regional level. However, it was not possible to determine the differences in intensity of infestations between farms.

Control achieved:

It was not possible to measure the level of control achieved by different pesticide application regimes. For example, farms using lower levels of pesticides may have achieved lower levels of control of the pests.

5.1.3 Agronomic variables

The following agronomic variables were found to have substantial influence on use of pesticides between both farms and regions.

Crop types

This is primarily of significance in potatoes.

Ware: Long growing season, blemish-free produce required, hence high fungicide use.

Seed: Shorter growing season, hence less disease protection required but high insecticide requirement to control the aphid virus vectors.

Starch: A lower priced, lower input crop.

All crop types may be grown on the same farm and the most sensitive crop type may dictate the regime for the whole farm in order to reduce reservoirs of infection. This attitude may be taken at times for all the crops studied.

Varieties

Variety choice is determined by end-use market demand. Only as a second priority are disease and pest susceptibility considered.

In all crops, varieties differ markedly in their susceptibility to disease, attacks from insects, nematodes, etc, the need for growth regulators and, in the case of potatoes, for desiccants. As with crop types, in certain circumstances for diseases and insecticides, the most susceptible variety on a farm can determine the spray regime.

In many instances, crops in a region are dominated by a single variety often susceptible to particular diseases. It is suggested that widening variety shares would lead to considerable easing of the pesticide load. However, this in turn is determined by market demand.

Target pests and levels of pest control required

The target pests are obviously the determining factor in chemical use. Technical levels of control required varied by pest and crop types (aphids in seed potatoes or ware, etc). Farmers were asked for the levels of control they were seeking. Weed control showed the greatest variation with regions showing considerable differences in willingness to accept less than complete weed control. This was particularly marked in vines in Verona whose farmers were least demanding in the levels of weed control sought.

Treatment timing

In all crops and in all the regions, an official warning system exists to help time the start of applications against major diseases and insects. Some of the systems are less than optimal or geographically restricted and more sophisticated techniques are being developed. Farmers make use of these systems to varying degrees employing them alongside less targeted techniques such as crop stage or date. It is felt that this area could be developed with advantage to assist improved targeting of fungicide and insecticide use and reduce any unnecessary treatments.

Dose rates

Dose rates generally followed recommended rates except in wheat, where considerable reductions were made in herbicides and fungicides, and in potatoes with herbicides. Specialists felt this practice had reached its maximum.

Application volumes and dose rates

For fungicide and insecticide applications in apples and vines, volumes of spray applied per hectare increase throughout the season as the leaf canopy develops. Differences in planting density, crop height and training architecture also influence spray volume per hectare. Seasonal average volumes of application were found to vary substantially.

Chemical dose rates are generally given in concentration of product per volume of spray mix though for vines in France this is only partially practised.

Given the variation in spray volume used, it is suspected that some unnecessary use of chemical is occurring.

Herbicide placement

In the perennial crops, application of herbicides along the crop rows was widely practised. Variations occurred between farms and regions suggesting that there was some room to increase the practice and further reduce the herbicide load.

Part-crop spraying

In all crops and chemical sectors, targeted spraying of parts of the crop most prone to or infected by a pest were evidently undertaken. This varied widely and it is suggested offers opportunity together with closer crop monitoring to wider exploitation.

Mechanical weed control

Only practised specifically for weed control in potatoes, this technique tentatively showed lower use of herbicides where it was practised. Soils vary considerably in their ability to permit this technique. Most widely practised in East Anglia, it is under further development there, and in Flevoland for potatoes.

5.1.4 Crop economics and pesticides

The majority of farmers felt that the profitability of their crops was satisfactory or above in most crops and regions in the study year (1994). However, for wheat in Hannover and apples in S E France and Trentino, the majority of farmers were dissatisfied with their profitability.

Anticipated levels of profitability for a given crop had no influence on product choice or use for the great majority of farmers.

The chemical sector contributing the most to profitability was seen by the majority of farmers as fungicides in all crops and regions except for apples in the Lerida (E) where insecticides were nominated. Farmers were divided as to the sector contributing the least in wheat and potatoes though in apples and vines this was identified as herbicides.

The majority of farmers in all crops and regions felt that no reduction in chemical use would be possible without reducing profitability. However, among those that did feel it was possible, fungicides were most proposed in apples and vines with insecticides also featuring in apples.

Consumer demand for blemish-free quality produce, particularly in potatoes and apples and by processors in potatoes, makes growers of these crops particularly risk-averse.

5.1.5 Pesticides and the environment

Product labelling

In all regions, a large majority of farmers believed that label restrictions on handling and the environment were important or very important with regard to their choice and use of products. In some sectors, local specialists felt that these responses were not genuine, particularly with regard to the environment.

Environmental factors influencing product choice

Consideration for environmental factors when choosing pesticides was not high on the agenda of most farmers. Among wheat farmers, greatest attention was paid to these factors in Hannover and Piemonte for ground water considerations. In the potato growing areas, most attention to these factors was paid by farmers in Lüneburg, where a wide range of factors was considered. In the apple regions, only farmers in Trentino demonstrated reasonable consideration for factors of soil protection, ground and surface water. Similarly for vines, farmers in the Verona area showed the greatest attention, in this case for soil protection.

5.1.6 Alternative crop protection systems

Aspects of Integrated Crop Management (ICM), Integrated Pest Management (IPM) and Organic Production (OP) methods were put to farmers. Replies were unsatisfactory as terminology appeared to be interpreted differently or not understood by respondents, despite definitions being supplied (see crop appendices).

Though ICM or IPM techniques were practised, or under development, to some degree in all crops and regions, this was particularly the case in apples and vines.

In apples, Trentino is renowned for its local IPM/ICM protocol which can be seen to be working when the region is compared to others in this study. In vines, local trials in Rioja have shown that better adherence to advisory/warning systems can halve the number of fungicide applications.

There is undoubted scope for these systems to be more widely introduced. However, they need commitment and technical awareness on the part of the farmers and growers as well as considerable support from the extension network.

5.1.7 Opportunities to reduce chemical loads

Given the foregoing summary across crops, the following opportunities for chemical load reduction are suggested for the main chemical sectors.

Seed treatment

This is a low dose environmentally sound way of plant protection which, with recent technological innovations and chemicals, now offers enhanced protection. It can reduce the need for early field applications of fungicides and insecticides.

Pre-storage treatment of potatoes can be substantially reduced through use of cold storage techniques**.**

Herbicides

Dose rates are at a minimum in all crops. Opportunities for reduction in load in wheat are suggested through increased use of selective targeting of fields. This can be enabled by greater use of the newer postemergence chemicals available, increased use of mechanical weed control where soils permit in potatoes and continuing the move away from residual soil acting herbicides in favour of contact acting chemicals in apples and vines. Increased use of treatments along the crop rows would also have benefits in some vineyards.

Fungicides

Varieties differ considerably in their susceptibility to diseases. This factor, however, is of a secondary priority to suitability for the end-user and so choice is consumer driven. In potatoes particularly, the most dominant varieties are especially susceptible to disease. In the short term, reducing this dominance would help reduce fungicide requirements. In the longer term, newer breeding techniques may be able to marry up end-user demands with disease resistance. Influencing the consumer to accept some skin blemish would also help.

In all crops, increased use and continued development of disease warning systems would help to better target treatments and reduce load though certain of the systems under development are some way off practical application.

In apples and vines the optimisation of spray volumes would appear to offer additional opportunities for reducing unnecessary load.

Insecticides

As with fungicides, increased use of local warning systems could tighten up use in all crops. Extension of IPM/ICM techniques, particularly in apples and vines, could also reduce load as would the optimisation of spray volumes.

CROP SUMMARIES

5.2 Wheat

Relative to the other crops in this study the chemical loads per hectare of crop grown in wheat were modest. Main sectors contributing to the loads were:

Table 5.2 Main sectors contributing to the chemical load in wheat

	Hannover (D)	East Anglia (UK)	North Central France (F)	Piemonte (I)
Average crop yields t/ha	7.7	6.5	7.2	4.4
Average chemical load per hectare of crop grown per farm kg ai/ha	4.5	4.6	3.8	2.1
Main sectors	% of average load			
Herbicides	38	36	44	69
Fungicides	27	24	29	8
Anti lodging agents	28	26	15	4
Others	7	14	12	19

Herbicides provided most to the loads in all regions with fungicides also substantial in the three northerly regions. In addition, anti-lodging agents were important in Hannover and East Anglia.

5.2.1 Main agronomic variables affecting the chemical sectors

Herbicides

Chemicals and dose rates:

In the three northern regions considerable experimentation has taken place with dose rates. In practice this has resulted in 20 - 30% reductions from registered rates. Variations in load were largely due to the difference between use of older low activity (heavier dose) chemicals compared to use of the more modern higher activity (lower dose) chemicals which tend to be applied post emergence and can therefore be more targeted to appropriate areas of infestation. Dose rate reduction was judged to be at its maximum in these regions. Piemonte was just starting this process.

Part-crop spraying:

Targeted spraying of selected parts of the crop was undertaken by 40 - 50% of farmers in the three intensive regions and 24% in Piemonte. This suggests a selective approach to herbicide use where practised. In Piemonte the smaller farm units probably make this less applicable.

Fungicides

Diseases:

In the three intensive regions disease pressure appeared similar though varying in spectra between regions. Piemonte had little disease.

Varieties:

Varieties differ in their disease susceptibility/resistance but this is a secondary priority for the farmer (and breeder) whose aim is to provide good yields of quality produce for the intended end-use.

Chemicals and dose rates:

As in herbicides, dose rates used were 20 - 30% lower than registered rates.

Part-crop spraying:

Spot and partial crop spraying was undertaken to a varying degree (35% of farms in Hannover - 23% of farms in East Anglia). This may be a symptom of lack of a selective attitude or widespread disease infestation.

Decision support and disease management:

Considerable research is being undertaken in all three intensive regions towards managing the diseases rather than eradicating them and on better decision support systems. These latter are not yet fully developed.

Seed treatment:

Seed treatment technology is developing fast and was seen in all regions as being able to reduce the need for some early fungicide treatments as well as early insecticide applications.

Anti-lodging agents

Risk and use:

Risk of lodging is high in all three intensive regions. Anti-lodging agent use was widespread ranging from about half the crop in North Central France to near total use in Hannover. They are seen as cheap and protecting the investment made in the crop.

Varieties:

Varietal resistance is available but, as with disease resistance, it is a secondary consideration to yield and quality. Varieties, local conditions and practice induce considerable variation in dose rates.

5.2.2 Effect of pesticides on profitability

The wheat crop was regarded as profitable by a majority of farmers in all regions except Hannover.

The chemical sectors contributing the greatest and least to profitability were seen as the following:

Greatest effect:

Fungicides were regarded by farmers in Hannover and East Anglia as having the greatest effect on profitability while herbicides were indicated in North Central France and Piemonte. Specialists disagreed with farmers in France and suggested fungicides.

Least effect:

Opinion was more divided as to the sector having the least effect on profitability.

The majority of farmers in all regions felt that it would not be possible to reduce their level of pesticide use without lowering profitability. Least sure in this area were the farmers in Hannover.

5.2.3 Environmental aspects

The majority of farmers in all regions felt that handling and environmental restrictions on the label were important.

Concerning the environmental considerations farmers took into account when choosing chemicals, these ranged widely though ground water considerations were prominent in Hannover and Piemonte.

5.2.4 Alternative crop protection systems

It was difficult to obtain adequate responses on questions concerning awareness and attitude to alternative crop protection systems, as understanding of the terms varied considerably. The systems reviewed were Integrated Crop Management (ICM), Integrated Pest Management (IPM) and Organic Production (OP). Definitions were supplied and can be found in the individual cross regional crop appendices.

Greatest interest in developing the systems was demonstrated in North Central France for ICM (85%) though it is understood that this is interpreted as 'following locally advised practice'. In Hannover both ICM and IPM received support from just over 40% of the farmers. Elsewhere support was weaker.

5.2.5 Opportunities to reduce pesticide load

Few possibilities are seen that are not already being worked upon. Opportunities in the main chemical sectors are:

Seed treatments:

> An environmentally and toxicologically sound way of using pesticides which, with recent technological advances, can help reduce early field applications of fungicides and insecticides.

Herbicides:

> Dose rates have been reduced to a minimum for satisfactory weed control and may have to increase. It is suggested that greater targeted spraying of portions of the crop offers opportunities.

Fungicides:

In addition to seed treatments, further development of the holistic approach to disease management and the spray decision support systems in process in all the intensive regions should offer opportunities for reduction. However, these are still some way off practical application.

Insecticides:

In addition to seed treatments, further development of work on infestation thresholds, crop monitoring and greater use of official warning systems should reduce or better target insecticide use.

Anti-lodging agents:

Specialists in the three northern regions where these products are employed felt that there was no justification for reducing their use.

5.3 Potatoes

Fungicides dominated the chemical load as may be seen from Table 5.3.

Table 5.3 Main sectors contributing to the chemical loads in potatoes

	Lüneburg (D)	Flevoland (NL)	East Anglia (UK)	N E France (F)
Average chemical load per hectare of crop grown per farm kg ai/ha	9.8	12.6	13.1*	32.0
Main sectors	% of average load			
Fungicides	67	67	60	87
Herbicides	15	12	13	8
Insecticides/Nematicides	10	9	19	1
Desiccants	3	10	2*	2
Others	5	2	6	2

Yields are not compared owing to different crop type mixes.

* Ignores additional desiccant use of sulphuric acid at an estimated 115 kg ai/ha on 47% of crop.

5.3.1 Main agronomic variables affecting the chemical sectors

Fungicides

All potatoes must be protected from *Phytophthora infestans* (late blight) throughout the season. A programme of contact protectant fungicides is the basis of treatments to which may be added systemic, partially curative chemicals. The difference in fungicide load was largely a result of the number of applications modified by the inherent activity (dose rate) of the chemical employed. The main variables affecting this were:

Crop type:

The ware crop tends to be in the ground longer than the other two crop types (seed, starch) and therefore requires longer protection. Flevoland and N E France had the highest proportion of ware in the crop-type mix and received similar numbers of applications. The difference in

fungicide load resulted from Flevoland using a more modern lower dose chemical.

Varieties:

Varieties are chosen for their marketability but vary widely in their tolerance of *Phytophthora*. The variety Bintje is particularly sensitive and dominated the regions of Flevoland and N E France accounting for about half the area in each case. Similarly in East Anglia, Maris Piper, also regarded as sensitive to *Phytophthora*, was grown on over 40% of the sampled area.

Climatic region:

The more maritime climates of Flevoland, East Anglia and N E France tend to induce greater disease incidence compared to Lüneburg.

Soil/irrigation:

Organic and clay soils tend to create a micro-climate favouring *Phytophthora*. Sandy soils require more irrigation than other soil types which in turn favours *Phytophthora*. In Lüneburg, however, it was claimed that irrigation induced greater resistance to the disease by encouraging crop growth.

Fertiliser use:

Excess nitrogen can increase incidence of blight. However all regions appeared to have refined this use.

Spray timing:

Farmers at present use a mix of plant stage and weather to determine when to start spraying. Official warning systems exist but appeared only well used in the Lüneburg region. Better spray decision support systems are being developed in all regions but are still some way off practical use.

Part-crop spraying:

Farmers spraying parts of their crop with a given treatment were highest in Flevoland (27%) and lowest in N E France (7%). While this will relate to the crop and variety mix on farms it is understood that some farmers tend to time their fungicide rounds by the needs of the most susceptible variety.

Herbicides

The main factors affecting variation in herbicide use were:

Weed flora:

Broadly similar across regions though individual field flora obviously differ.

Control levels sought by farmers:

Considerable variation between farmers and regions. Lüneburg and Flevoland appear satisfied with lower levels of weed control than the other two regions.

Proportion of the regional crop sprayed:

This varied from 100% in Lüneburg and N E France to 90% in Flevoland and 78% in East Anglia.

Mechanical weed control:

Weed control is a mix of herbicide use and mechanical hoeing. The latter was practised most in East Anglia (65% of farms) and least in Flevoland (27% of farms). The practice was encouraged most in East Anglia though not all soil types are suitable. Results tend to show that, where practised, the herbicide load was lower.

Chemicals used and dose rates:

The mixture of active ingredients used across the regions varied considerably. Herbicide load was lightest in Lüneburg and heaviest in N E France. This reflects:

- Soil type - lightest in Lüneburg
- Crop type - highest starch content in Lüneburg with lower inputs
- Chemicals - heavier dose chemicals in N E France. In Lüneburg, Flevoland and N E France dose rates had been cut substantially over recent years using a strategy of split treatments (pre and post emergence) and mixtures. In East Anglia there has been a trend for increase.

Part-crop spraying:

Farmers selectively spraying portions of their crop were highest in Lüneburg 40% and lowest in Flevoland 10%. This appears largely to be linked to the proportion of different crop types on a farm.

Insecticides and nematicides

Mainly of importance in East Anglia, Lüneburg and Flevoland, variation in use was largely a consequence of:

Pests:

Myzus persicae (aphids) were seen as important in all areas. *Globodera spp* (nematodes) were regarded as a problem in East Anglia (65% of crop) and to a lesser degree in Lüneburg (25 % of crop). Aphid treatments dictated the most widespread use of insecticides though nematode treatments used high dose rates where employed.

Crop types:

Seed crops require complete freedom from aphids while the starch and ware crops can withstand limited populations before requiring treatment.

Seed crops were least represented in N E France and most in East Anglia correlating with insecticide use.

Varieties and nematicides:

Some varieties have in-bred resistance to one nematode species though, in East Anglia at least, a species to which there is very little in-bred resistance (*G pallida*) is increasing. In all regions, except N E France where nematodes do not appear to be a problem, it was felt that nematicide levels had been reduced to a minimum and an increase in use was inevitable.

Chemicals and dose rates:

The variation in inherent activity was a factor in the chemical loads.

For aphids, the chemicals employed tended to favour the heavier dose chemicals. A specific aphicide, pirimicarb, was widely used in all regions. In addition, low dose pyrethroids were more present in N E France than elsewhere.

Heavy dose nematicides were used most in East Anglia accounting for the chemical load there.

Part-crop spraying:

Highest in Lüneburg at 46% of farms and lowest in N E France at 11% this is obviously determined largely by crop type (seed requiring greater attention).

Desiccants

Desiccants are used to burn off the foliage to prevent ingress of disease to the tubers and to facilitate harvesting.

Proportion of regional crops treated:

This varied from 59% in Lüneburg to 98% in Flevoland.

Varieties:

Varieties differ in the volume of their foliage and, as a consequence, the necessity for desiccation.

Chemicals and dose rates:

Dose rates were modest but conditions varied requiring 1 - 5 applications. East Anglia presented a particular case where 47% of the crop was treated with sulphuric acid at very high volumes/dose rates.

5.3.2 Effect of pesticides on profitability

A substantial majority of farmers in all regions were satisfied with crop profitability in the study year. The chemical sectors contributing the greatest and least to profitability were seen as:

Greatest effect:

Fungicides were regarded in each region as having the greatest effect on profitability.

Least effect:

Opinion was divided.

The great majority of farmers felt that it was not possible to reduce pesticides without reducing profitability. Farmers in Flevoland were least adamant on this point.

5.3.3 Environmental aspects

A substantial majority of farmers in all regions regarded handling and environmental restrictions on the label as important.

Farmers in Lüneburg showed the most attention to environmental considerations when choosing chemicals. Ground water aspects were mentioned frequently. This was supported by the fact that 27% claimed to be in restricted water catchment areas. In the other regions, environmental considerations featured at low levels. Specialists felt that farmers would think that governmental departments should evaluate products and permit use of only those that were environmentally sound.

5.3.4 Alternative crop protection systems

Awareness of and interest in developing the three alternative systems (ICM, IPM and OP) was investigated but suffered from poor interpretation of the definitions.

Greatest interest was shown in ICM across all regions with farmers in N E France providing greatest support. However as already stated their interpretation of ICM was very broad.

Specialists in all regions stressed that potato production was a high risk

enterprise and that farmers were very risk-averse.

5.3.5 Opportunities to reduce pesticide load

Opportunities to reduce the pesticide load in potatoes are seen as:

Seed treatment:

An environmentally sound and efficient low dose means of disease control. No reductions in use seem necessary for pre-sowing treatments. The necessity for pre-storage treatments can be substantially reduced by cold storage.

Herbicides:

Low dose or split dose regimes, where practised, appear to have reached their minimum and may have gone too far in Lüneburg and N E France. Mechanical weed control is limited by soil type and risk of damage to the crop but can reduce herbicide demand. Work in East Anglia and Flevoland is in progress to optimise this.

Fungicides:

Varietal susceptibility to disease is of secondary importance to the farmer compared to marketability. Future breeding technologies may be able to link these more closely. Meanwhile with the present chemicals available, a prophylactic spray strategy is fundamental. Warning systems to help time these applications are available but are not fully satisfactory and only seem to have a reasonable following in the Lüneburg region. Better decision support systems are under development but are some way off practical use.

Insecticides/nematicides:

Aphid control offers little opportunity for reduction except possibly through better use of the warning systems.

Nematicide use had been reduced substantially in Lüneburg and Flevoland. In these regions and in East Anglia there was felt to be little chance of a reduction indeed, rather the reverse given the threat of increasing populations.

Desiccants:

Cultural techniques including varietal choice can minimise the need for desiccation. This process, however, is important and specialists see little room for reduction. Non-chemical techniques have been tried but

have not proved satisfactory.

5.4 Apples

Fungicides also dominated the chemical load in apples as evident from Table 5.4.

Table 5.4 Main sectors contributing to the chemical load in apples

	Provence/Languedoc /Rhone Alps (F)	Trentino (I)	Lerida (E)
Average chemical load per hectare of crop grown per farm kg ai/ha	41.4	33.7	27.4
Main sectors	% of average load		
Fungicides	79	82	40
Insecticides/acaricides	11	5	23
Herbicides	5	2	5
Plant growth regulators	4	1	1
Spray oils	2	10	30
Others	-	-	-

The reduced importance of insecticides/acaricides in Trentino is of interest given that region's particular emphasis on their Integrated Crop Management protocol.

5.4.1 Main agronomic variables affecting the chemical sectors

Fungicides

Diseases:

Apples have to be protected from two main diseases - *Venturia inaequalis* (scab) and *Podosphaera leucotricha* (powdery mildew). Differences in fungicide load between regions were largely as a result of differences in the relative importance of these diseases and the chemicals used to combat them.

In Provence/Languedoc/Rhone Alps and Trentino, *Venturia* was regarded as more important than *Podosphaera* while in the drier Lerida region the reverse was the case.

Varieties:

The Golden Delicious group dominated all regions from 56% of the sample area in Lerida to 77% in Trentino. Disease resistance has been good but there are signs that this is reducing.

Chemicals used and dose rates:

Traditional high dose contact protectant fungicides were used for *Venturia* control with regional differences on choice. For *Podosphaera* control, sulphur was widely used at high doses as well as low dose systemic fungicides. Some of these latter are active against both main diseases and were used most in Lerida. Disease resistance management dictates against too many applications of systemics.

Applications volumes and dose rates:

Volumes of spray applied increase throughout the season as the leaf canopy develops. Average application volumes centred around 1000 l/ha in the French and Spanish regions and 1500 l/ha in Trentino. Wide variations were recorded around these averages. With fungicide dose rates given as concentration per volume of spray, variation in application volume leads to variation in chemical dose per hectare. Differences in planting density and training architecture influence the spray volume requirements. Given the range of application rates, however, it is suspected that some unnecessary use of chemical may be occurring.

Part-crop spraying:

Farmers appeared to target their spraying to a greater degree in the French region (16% of farmers) and Spanish region (13% of farmers) than in Trentino (3% of farmers). This may also be linked to the size of crop holding or disease incidence (variety mix).

Application timing:

Farmers used a selection of factors to determine their spray timing. Some of these are not related to the disease such as date or plant stage, others are closely linked to the disease such as disease stage, weather etc. Official warning systems exist for timing *Venturia* sprays and are an established part of ICM or IPM programmes. These were followed to a greater degree in Trentino and Lerida than in the French region.

Insecticides/acaricides

A substantial list of pests was noted in each region but *Carpocapsa pomonella*

(codling moth), Aphids (various) and *Panonychus ulmi* etc (spider mites) were regarded as important in all regions though to varying degrees. *Quadraspidiotus perniciosus* (San Jose Scale) was also important in Lerida.

Mites were least widespread in Trentino possibly reflecting the success of their ICM/IPM protocol.

Other factors creating variability were:

Chemicals used:

A very wide selection of chemicals was used in all areas. Improvement in timing has reduced codling moth treatments in all regions and specific aphicides and acaricides were also used in all regions. Trentino, following its ICM/IPM protocol, used no pyrethroids which are known to cause mite resurgence due to their effect on beneficial predators. These were most widely used in the French region.

High dose petroleum oils were used most widely in Lerida (36% of sampled area treated) and least in the French region (3% of sampled area treated).

Application volumes:

As insecticides are often applied in tank mixes with fungicides, application volumes vary correspondingly. This lead one to believe that some waste of insecticides may be occurring.

Spray timing:

Warning systems are available in each region particularly for timing *Carpocapsa* treatments. Good use was made of them in Trentino and Lerida though in the French region there was widespread use of date for triggering applications with farmers unwilling to run risks of an uncontrolled attack.

Part-crop spraying:

This was only undertaken by a limited number of farmers in all regions.

Herbicides

Herbicide loads were low compared to other main chemical sectors. Almost all the crop (98%) was treated in Lerida while 90% and 82% respectively were treated in the French region and Trentino. Mechanical weed control was rarely practised. Variations in load were due largely to:

Chemicals used:

There has been a move away from residual soil acting chemicals towards contact treatments. The change was most apparent in Trentino while in Lerida and the French region farmers were still using substantial quantities of residual herbicides.

Herbicide placement:

The great majority of farmers applied herbicides only to the tree rows. The area between the rows being mowed.

Part-crop spraying:

Some farmers treated their orchards selectively applying chemicals to certain areas. This was most employed in Lerida (22% of farms) and least in Trentino (4% of farms) but, as commented earlier, the low figure in Trentino may be due to the small size of holdings.

5.4.2 Effect of pesticides on profitability

Only a minority judged their profits to be satisfactory or above in the French region and Trentino for the study year (1994). In Lerida just over half felt their profits had been satisfactory or above.

The chemical sectors contributing the greatest and least to profitability were seen as:

Greatest effect:

Fungicides in the French region and Trentino. Insecticides in Lerida.

Least effect:

The great majority answering this indicated that herbicides had the least influence.

In all regions a majority of farmers felt that they could not reduce pesticide use without reducing profitability. However, particularly in Lerida and Trentino, there was a substantial body (ca 40%) who felt that there were possibilities. Fungicides and insecticides were mostly mentioned.

5.4.3 Environmental aspects

Handling and environmental restrictions on the label were regarded as important by the great majority of farmers in all regions.

Concerning the environmental considerations taken into account when choosing pesticides, only a minority paid attention to these in the French region and Lerida. However in Trentino there was a higher proportion (up to 58%) who considered environmental factors. Soil protection, ground water and surface water appeared to be considered most. This evidently reflected the local ICM/IPM protocol.

5.4.4 Alternative crop protection systems

Farmers appeared generally well aware of the alternative crop protection systems though the differences between ICM and IPM may have been confused. They also expressed interest in developing them on their own farms. This latter point conflicted with specialist experience in the case of Lerida.

5.4.5 Opportunities to reduce pesticide load

Opportunities to reduce the pesticide load in apples are seen as:

Herbicides:

Herbicides were predominantly sprayed only along the tree rows and so limited further reduction in load appears possible from wider use of this technique. Continued reduction of soil acting residual chemicals in favour of contact herbicides will help reduce load and permit increased use of targeted spraying of portions of the orchards.

Fungicides:

Specialists felt there was little scope for reduction. However it is suggested that increased use of the *Venturia* warning system might offer opportunities particularly in the French region.

Attention to optimising application volumes may also reduce any unnecessary use of fungicides.

Insecticides/acaricides:

In Trentino, specialists confirmed that most growers were using ICM procedures. Though frequency of spray application was near to optimum, further fine tuning could lead to minor reductions in load. IPM/ICM techniques were less developed in the other regions. Improved use of the warning system and greater adoption of IPM/ICM procedures could lead to reduced use.

Plant growth regulators:

Market demand for blemish free fruit of optimum size determines the use of these products. The dominant variety (Golden Delicious group) needs both fruit thinning and russet control. Variety diversification and consumer education could reduce the need for this sector.

5.5 Vines

The relative importance of the main chemical sectors in vines is given in Table 5.5. Fungicides dominate the picture in all regions.

Table 5.5 Main sectors contributing to the chemical load in vines

	Bordeaux (F)	Rioja (E)	Verona (I)
Average chemical load per hectare of crop grown per farm kg ai/ha	45.0	16.8*	33.6*
Main sectors	% of average load		
Fungicides	90	61*	95*
Insecticides/acaricides	2	27	3
Herbicides	8	11	3
Others	-	1	-

* It was suggested by local specialists that use of sulphur had often been under reported which, if added in, brings the load up to the level in Bordeaux (see Table 5.1).

5.5.1 Main agronomic variables affecting the chemical sectors

Fungicides

Diseases:

Two main diseases *Plasmopara viticola* (downy mildew) and *Uncinula necator* (powdery mildew) dictate the necessity to protect vines throughout the season. Other diseases, particularly *Botrytis cinerea* (grey mould) are also of importance.

The relative importance of the two main diseases varies by region:

Plasmopara - more prevalent in Bordeaux and Verona.

Uncinula - more prevalent in Rioja.

Chemicals used:

Disease control relies on a succession of prophylactic treatments. These may be contact or systemic in action. The variation in chemical load results from a mix of number of applications and dose rate of the chemicals employed. Contact fungicides tend to be used at heavy doses and systemic chemicals at lower doses. Disease resistance management, however, dictates against too frequent use of systemics.

Bordeaux and Verona used a greater proportion of contact fungicides while Rioja used more systemics, which tend to have greater activity on the main disease there - *Uncinula* .

Application volumes and dose rates:

Volumes of spray applied increase as the season progresses and the leaf canopy develops. Seasonal average application volumes were lowest and varied least in Bordeaux and Rioja. In Verona, volumes were highest and varied most between farms. Dose rates are given in concentrations per hectolitre of spray rather than on a hectare basis in Italy and Spain. In France in vines this is less practised. Where this occurs, dose rate per hectare varies with spray volume. While size and architecture of the vines influences the spray volume required, the extent of variation suggests that some waste of chemical may be occurring.

Application timing:

Farmers used a number of factors to determine the start of fungicide applications. These include date, plant stage, weather and the local warning system. In Bordeaux and Rioja more attention was paid to the local warning system than in Verona.

Part-crop spraying:

The proportion of farmers spraying parts of their crop selectively was highest in Rioja (24%) and lowest in Verona where the practice was not used probably due to the small size of holdings.

Insecticides and acaricides

Pests:

A large number of insects and mites can attack vines. The main pests were:

Grape berry moths	(*Clysia ambiguella*) (*Lobesia botrana*)	Present in all areas and the main pests.
Leaf hopper	(*Empoasca flavescens*)	Present mainly in Bordeaux and to a lesser extent in Verona.
Spider mites	(various)	Present in Bordeaux and Rioja though understood to be less of a problem than growers claimed.

Proportion of regional crop treated:

Over 95% of the crop was treated in Bordeaux and Rioja while only around 60% was treated in Verona. An average of 2 applications were made in Verona rising to 3.7 in Rioja.

Chemicals used:

IPM was practised to some degree in all regions. Product mixes however varied.

Bordeaux - tended to use more sophisticated chemicals with a strong acaricidal bias.

Rioja - largely used traditional insecticides with heavy use of sulphur and parathion ethyl + petroleum oil. This accounted in large part for the higher load than in the other regions.

Verona - the selection of chemicals used indicated greater reliance on IPM techniques than in the other two regions.

Application volumes:

Variation in dose per hectare follows variation in spray volumes and, as with fungicides (tank mixes), suggests some unnecessary use.

Part-crop spraying:

About 20% of farmers in Rioja and Verona and 30% in Bordeaux sprayed their crops selectively.

Application timing:

Responses were inconclusive as to the factors taken into account to time applications. For the main pests, the grape berry moths, growers in Bordeaux and Rioja used the warning system together with monitoring the pest. In Verona few growers appeared to use this method despite the greater use of products applicable to IPM regimes.

Herbicides

Proportion of regional crop treated:

Herbicides were used over 80% of the crop in Bordeaux and Rioja and only on half in Verona.

Chemicals used and dose rates:

Contact and soil acting residual chemicals were used in all regions though in different proportions. In Rioja and Bordeaux substantial use was made of the soil acting residuals while in Verona use was practically all contact chemicals. Dose rates for all chemicals and in all regions were at the lower end of the registered range with Bordeaux below this.

Herbicide placement:

Herbicides were either applied over the entire vineyard surface (overall), along the vine rows or just spot treated. 'Overall' treatment was highest in Rioja (55% of farms) and lowest in Verona (13% of farms). Where spraying along the rows is practised the soil area covered ranges between 25 - 30% of the vineyard area. This method leads to substantial load reduction compared to overall treatments. Spot treatment, which accounts for the lowest herbicide load when used as the only technique, was most widely practised in Verona.

Mechanical weed control:

Mechanical cultivation (not always for weed control) was practised on the following proportion of farms:

Rioja	90%
Bordeaux	75%
Verona	57%

Given the wide use of herbicide treatment along the rows and the fact that some mechanical passes were more for soil aeration purposes than weed control, no relationship could be found to exist between mechanical cultivation and herbicide load.

Part-vineyard spraying:

The proportion of growers selectively treating parts of their vineyards was high ranging from 19% in Verona to 44% in Bordeaux suggesting a well targeted approach.

5.5.2 Effect of pesticides on profitability

A substantial majority of growers in all regions estimated the profitability of their vines as satisfactory or above.

The chemical sectors judged to contribute the greatest and least to profitability were clearly nominated by a majority in all regions:

Greatest effect - fungicides.

Least effect - herbicides.

A majority of farmers in all regions felt that no reduction in chemical use could be made without affecting profitability. However, between 26% in Verona and 38% in Bordeaux felt that it might be possible. There was overwhelming agreement across all regions that it was in the fungicide sector where reductions might be made. In Rioja, 29% of the growers questioned felt this to be the case and mirrors the local specialists' findings that well targeted fungicide applications could halve the number of treatments.

5.5.3 Environmental aspects

Handling and environmental restrictions on the labels were regarded as important by the great majority of growers. Specialists in Bordeaux and Rioja, however, felt that growers were being 'polite' in their answers on environmental aspects. They intimated that environment meant little to growers when choosing a chemical to use.

This latter point is borne out when reviewing the specific environmental considerations influencing choice of chemical. In Bordeaux and Rioja very few farmers indicated that they paid attention to specific environmental considerations. Verona provided the highest score with 42% of farmers taking 'soil protection' into consideration.

5.5.4. Alternative crop protective systems

As with other crops, questions on alternative crop protection systems were confused by lack of clear understanding of the terms.

Awareness of all systems (IPM, ICM, OP) was greatest in Bordeaux.

Growers in Bordeaux were most interested in developing ICM though the understanding of the term there is believed to be 'following advised practice'. In the other regions some interest was indicated in IPM, for example, in Rioja this was expressed by several larger growers who represented 47% of the crop area.

Grower responses did not correspond well with specialist opinion. In Rioja the local specialists indicated that there was little interest in IPM/ICM. In Verona, where little interest was demonstrated by the growers, specialists reported that elements of IPM/ICM had been practised for many years - a fact borne out by the insecticides used.

5.5.5 Opportunities to reduce pesticide load

Opportunities to reduce the pesticide load in vines are seen as:

Herbicides:

Soil acting residual chemicals which by their nature tend to be used prophylactically were still used in some vineyards and regions. A move away from these to the contact herbicides would enable more

targeted/spot spraying to be undertaken. 'Overall' treatment is still practised by 55% of farms in Rioja and 32% in Bordeaux and does appear to offer some scope for reduction.

Fungicides:

Fungicides dominated the chemical load and general opinion seems to recognise that better adherence to advisory/warning systems (ICM) could reduce use. In some areas this could be substantial (Rioja).

It is suggested that some increased targeted spraying of portions of the crop and optimisation of the application volumes could also help.

Insecticides/acaricides:

IPM was practised to a greater or lesser degree in all regions but most in Verona. Wider use of the official warning systems in association with IPM/ICM techniques would appear to offer possibilities for reduction.

As with fungicides, it is suggested that increased targeted spraying of portions of the crop and optimisation of application volumes should also help reduce load.

6.0 CONCLUSIONS

Pesticide use and pesticide loads varied widely across the crops and regions surveyed. Pesticide load has been measured by weight of ai/ha. It must be appreciated that differences in the inherent activity of individual chemicals account for a substantial degree of the variability in load.

The principal load sectors and suggested opportunities for use reduction are highlighted below:

Wheat

- Herbicides were the most important sector accounting for approximately 40% of use in the Northern European regions and 69% in Piemonte.

- A continued reduction in dose rates over recent years has resulted in a significant lowering of herbicide load. Scope for further reduction appears limited.

- For fungicides, a holistic approach to disease management is developing in all intensive regions (Northern Europe). This approach, coupled with the development of improved decision support systems, offers scope for fungicide reduction in the future.

Potatoes

- Fungicides accounted for around two-thirds of the total chemical load and large regional variations were demonstrated by use of chemicals with different inherent activity.

- Varietal susceptibility to disease is a major factor influencing fungicide use. This was exaggerated in some regions by the widespread use of popular varieties with poor disease resistance.

- The prospect of better decision support systems offers a way forward for improved disease targeting and load reduction.

Apples

- Fungicides dominated, particularly in France and Italy, and scope for reduction is limited due to the consumer demand for unblemished fruit.

- Trentino, through its IPM/ICM protocol, is a good demonstration of insecticide/ acaricide use restriction. This technique offers potential for wider adoption in other regions.

Vines

- The heavy pesticide load was dominated by fungicides although insecticides were also important in Rioja. Season long protection is required to prevent loss of crop and a very wide range of chemicals were used including traditional products such as copper salts and sulphur.

- Specialists indicated that improved application timing, through greater use of advisory/warning systems, could result in significant reductions.

- IPM/ICM was practised to some degree in all regions - most extensively in Verona. Wider application of these techniques appears to offer possibilities for further use reduction.