SECTION 5

An Assessment of the Benefits of Plant Protection Products

(Sub-report prepared by Eyre Associates)

5.1 INTRODUCTION

This sub-Report contains a full description of its origins, Terms of Reference, study approach and methodology. In summary, the research for the sub-Report was limited to four case studies: Apples in Trentino-Adige (Italy) Potatoes in Flevoland (Netherlands); Wheat in Schleswig-Holstein (Germany) and Wine in Bordeaux (France). Priority has been given to the **economic** dimension of PPP use, although social and environmental benefits are also considered.

5.2 STARTING PREMISE

The basic assumption on which this sub-Report has been based is that the benefits of PPPs can only be assessed by comparison between the present day "standard" system with alternatives which use less pesticides, namely integrated and organic systems. The organic system has therefore been used as a baseline in terms of yields and costs from which the benefits of PPP are measured. Thus this sub-Report provides an assessment of the benefits of systems in which PPPs are used, rather than the gains of PPPs use for which data mostly do not exist.

5.3 BACKGROUND AND KEY ISSUES

5.3.1 Present extent of PPP use

No reliable and comprehensive data on the size and breakdown of the world and EU agrochem markets are publicly available. Accordingly, the data supplied in the sub-Report have been taken from the authors' own world agrochemical database. In summary, the world market for chemical PPPs was worth approximately 23.1 billion ECU in 1995 at end user prices, while the market in Western Europe (including Switzerland) is estimated to account for approximately 25 percent of the total, fractionally more than the North American share. The number of hectares treated and the value of the agrochemical market in the four countries in which the case studies were carried out are shown in Table 1 below.

Table 1: Agrochemical market in four EU Member States, 1995

	Crop area [1] grown 000's ha	Product area treated[2] 000's ha	Product value (end user) ECU m
France	14,371.0	82,338.1	1,806.7
Germany	9402.0	44,876.0	977.1
Italy	7739.0	38,609.1	721.9
Netherlands	6468.0	36,936.0	79.6
Total	337,980.0	202,809.2	4,288.1

Source : Landell Mills

Table 2 below summarises the data on "product area" in the four countries for the four crops covered in the case studies (the area sprayed multiplied by the number of applications given). It can be seen that wheat dominates the area treated, except in Italy where relatively little of the cereals area is treated with fungicides.

Table 2: Agrochemical use on case study crops (ha treated), 1995

	France 000's ha	Germany 000's ha	Italy 000's ha	Netherlands 000's ha
Wheat	30,847	16,094	3,772	1,012
Pome/stone fruit	2,517	834	5,068	440
Potatoes	2,091	2,448	511	1,883
Vines/grapes	14,012	1,367	13,483	0

Source : Landell Mills

Expenditure by farmers on PPPs in the four crop/country case studies is shown below.

Table 3: Agrochemical market value for case study crops, 1995

	France ECUm	Germany ECUm	Italy ECUm	Netherlands ECUm
Wheat	735	280	59	20
Pome/stone fruit	56	24	115	14
Potatoes	39	58	10	46
Vine/grapes	294	39	190	0
Total	1,124	401	374	80

Source : Landell Mills

1 Includes set-aside

2 The "product area treated" is the total number of hectares which were sprayed, multiplied by the average number of treatments. The average number of spray treatments per hectare varies greatly from crop to crop and is "high" in particular for some perennial crops including apples and vines.

5.3.2 Reasons for use

Essentially, PPPs are used by farmers for two main reasons, (a) to improve yields by eliminating or reducing the competition from weeds and attacks by disease and pest organisms; and (b) to improve or protect product quality. PPPs are used both **prophylactically** and **therapeutically** or curatively when a problem has arisen. The focus of much present research and development effort is to improve diagnostic and "threshold" analysis systems.

5.4 ECONOMIC ISSUES

5.4.1 Summary

The economic performance of the three different systems in each case study is summarised in Table 4 below. This shows the yields and gross margins at current prices, and also estimates what they would be if the organic price premium fell (a) to 20 percent, and (b) to zero.

Table 4

	Apples	**Potatoes**	**Wheat**	**Wine**
Standard	100	100	100	100
Integrated	89	100	90	100
Organic	70	59	48	73

The standard and integrated systems were found to have performed similarly; where the integrated yields are a little lower, this reflects a reduction or elimination of prophylactic treatments against diseases and pests, as well as of reduced fertiliser applications, nitrogen in particular. In contrast, yields under the organic systems are dramatically lower, especially with arable crops grown in a rotation. With wine the yields in Bordeaux under all systems are restricted to well below the technically feasible level, for quality and market management reasons.[3]

The profitability of the various systems was compared chiefly at the gross margin level, for each crop studied and at the rotation level for the two arable crops. The gross margin indices at the case study price levels (data came mostly from the 1995 crop year) gave a rather variable picture.

[3] One important proviso is needed. Data on the performance of the integrated systems come generally from research projects and from farmers pioneering the alternative approach. The intensity and quality of the management involved may fall away as an integrated approach is more widely adopted, with a consequent greater yield penalty.

Table 5

	Apples	Potatoes*	Wheat*	Wine
Standard	100	100	100	100
Integrated	140	100	93	100
Organic	190	200	133	56

* rotation level

The economic performance of the integrated systems were fairly close to the standard; the better performance of integrated apples reflects the price premium that apples from Trentino obtain. More significant is the worse performance of the Schleswig-Holstein integrated wheat rotation. First, the data are probably more reliable; second, the interpretation of "integrated" is strict; third, this case study is the most important by far in the context of EU agriculture as a whole.[4]

The organic systems appear at present to be very much more profitable (except with wine) than the standard and integrated systems; owing largely not to reduced input costs but to higher end product prices. As the farmgate price indices below demonstrate, the prices for standard and integrated products were found to be generally similar (except for apples, a special case), whereas the premia for organic products were high, apart from wine.[5]

Table 6

	Apples	Potatoes*	Wheat*	Wine
Standard	100	100	100	100
Integrated	113	100	100	100
Organic	200	204	298	107

* rotation level

What would happen to the prices of organic products if production expanded greatly is considered to be an 'unknown' at present, by the authors. The available evidence from consumer studies suggests that, broadly speaking, only 20-25 percent of consumers are willing to pay any premium at all for organic produce. The study estimated the gross margins for the organic systems on two different assumption (a) that the organic premium remained at 20 percent over standard, and (b) that it fell to zero. If the present high prices for organic products decline, profitability would fall below that for standard and integrated production,[6] and gross margin indices for organic production at different levels of premium are set out below.

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4 The results presented are drawn from the relatively few farms following an integrated approach however.

5 The small premium for organic wine produced in Bordeaux (which varies considerably from one product to the next) is part of a price structure which reflects perceptions of quality and long-established reputation, and where the production system used influences very few buyers.

6 The economic cost of a large-scale switch to organic is quite probably underestimated as it does not allow for the likely fall in livestock product prices that would follow as a result of the increased production of these under most organic rotations (assuming that organic stockless rotations prove unsustainable). In addition, the economics of organics at present benefit from set-

Table 7

	Apples	Potatoes*	Wheat*	Wine
Present level	190	200	133	56
20% premium	80	(loss)	40	63
Zero premium	40	(loss)	(loss)	31

* rotation level

The overall economic benefits provided by PPPs (in conjunction with fertilisers) at national level for each case study crop were estimated by calculating the differences in output under organic and standard systems, and valuing these differences at the case study farmgate prices for standard production, summarised below:

Table 8

	Apples (Italy)	Potatoes (Netherlands)	Wheat (Germany)	Wine (France)
Output gain ('000 tonnes)	589	1,474	9,204	15,015
Value (ECU million)	62.4	154	1,243	1,747

It is accepted, however, that theoretical estimates of this sort must have a large measure of uncertainty.

5.4.2 Explanation

While economic comparisons between organic and standard systems have been made, there have been few if any which have also considered the economics of integrated crop production. The situation is complicated by a tendency towards convergence between systems, as is indicated by the Trentino case study described in the full sub-Report, here the "integrated" system has largely become the "standard".

> *Comparing the farm-level economic performance of alternative production systems* - Comparisons of the economic performance of different systems have relied on comparisons of yields achieved, costs, and enterprise gross margins. The findings of some relevant studies are reviewed in the full sub-Report, albeit that the evidence of such studies is considered incomplete. Two limitations of an approach based on systems comparisons if these are used as a basis for policy-making are identified - (a) there may be significant off-farm costs with the standard and integrated systems (*i.e*. for pesticide monitoring and water clean-up) which are real though not at present carried by farmers,

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aside, which allows the set-aside area to be used for part of the fertility-building phase of the organic rotation. Given the likely disappearance of set-aside if there was any large scale switch to organic (because of the production shortfall that would result), it is felt that this would have a further negative effect on the economics of organic systems.

and (b) the fact that historic data alone may be an inadequate guide to future performance or technical and economic changes.

Yields in standard, integrated and organic systems - Comparisons of yields under the three systems point to a ranking of standard, closely followed by integrated followed quite a way behind by organic across all products. Unfortunately, there are few comparative data covering integrated systems, and the data relate primarily to standard-organic comparisons.

Costs and margins - Evidence on costs and margins relates primarily to organic and standard systems. The available evidence suggests, however, that lower yields also provide lower variable costs in organic and integrated systems. Fixed costs for labour and machinery may also be higher. Lower variable costs alone, however, have been found to be insufficient to offset the effects of lower yields on enterprise gross margins for organic systems. The Landell Mills (1992) study covering seven European countries found that in general higher prices for organic products compensate for lower yields.

Rewards to management and investment are identified as negative. In the case of wholly organic farms, financial performance was generally worse as general cropping farms achieved an output per hectare only about half that of standard farms. A recent study (Leake, 1996) over a seven year period found that the average net margins for each system (stocked organic, stockless organic, integrated, standard with integrated rotation, and standard with standard rotation) were more or less comparable. Existing data suggest that, in the absence of premia, organic production would need to be subsidised in some way to overcome its financial weaknesses.

Prices and markets - Other than the (occasional) use of special labels, marketing of integrated products appears to follow similar procedures as standard products. Organic products however, tend to be marketed in rather different ways (according to product type), although the trend is towards more mainstream channels and methods, such as the recent development in "quality assurance" schemes operated by larger retailers. In general, premium prices are not offered to producers for sticking to these improved standards. Rather, they tend to be a condition of getting the business.

Volumes of organic food traded are typically small, and economies of scale are limited. Quantity and quality of products are variable. Supermarket penetration is therefore considered necessary for the more widespread availability of organic products. Price premia for organic products have been significant - up to 150 percent for organic milling wheat in the UK, and up to 300 percent in Germany, for example. For livestock products in Northern Europe, the organic premium is significantly less at 10-25 percent. Research reported in a Landell Mills (1992) study found that in Denmark and Germany 20 percent of consumers were willing to pay a premium of 15-20 percent, but no more than 5 percent willing to pay a premium of 35-40 percent.
In spite of the limited demand for organic products domestic production is still far too little to meet market requirements, and imports account for a

significant market share. The UK, for example, imports 70 percent of its fresh organic produce.

The outlook for organic and integrated production - Recent years have seen an apparent expansion in the extent of organic and integrated farming systems, although they remain small in absolute terms. Further expansion is expected, and it appears that the open-ended prophecy that organic production will ultimately capture 5-10 percent of retail markets for agricultural products is still current. The extent of any price change will depend upon the elasticity of demand for organic and integrated products. Unfortunately, these basic parameters are unknown. For the generality of standard consumers price is a major issue and presumably elasticity of demand for organic and integrated products will be higher than for standard products.

In general, complete conversion to organic production is expected to lead to a 40-50 percent reduction in cereals output with an accompanying shift away from wheat and barley and towards rye and oats; large increase in output of forage crops, especially grain legumes; a reduction in oilseeds production; a reduction in sugar beet production; an expansion in production of potatoes and field vegetables; reduction in numbers of grazing livestock; a substantial reduction in pig and poultry production.

5.5 ENVIRONMENTAL ISSUES

The sub-Report does not detail the arguments and evidence on the negative environmental effects of PPPs against which net benefits may be calculated, as this has been done exhaustively in many recent publications (e.g. Beaumont, 1993). In brief, these negatives are considered to include pesticide residues in food, pesticides in ground and surface water, accidental poisoning of those exposed to pesticides, (both the users and the general public), and damage to fauna and flora of every type. These problems divide between those arising where the stringent regulations on pesticides are broken, and those which occur despite observance of the regulations. The following observations are made:

Biodiversity - Agriculture, since its beginning, has contributed to a loss of biodiversity. A return to farming systems which exclude use of PPPs would involve an enormous increase in the crop area to produce the same quantity of food with a consequent loss of wildlife habitats.

Soil Erosion - Soil erosion is generally due to bad farming practices. PPPs can contribute to this by making possible no-tillage systems and by reducing the soil damage done by frequent cultivations to control weeds mechanically.

The high level of farmgate prices brought about by the CAP is thought to have encouraged intensification and persuaded farmers throughout the EU to bring marginal land into cultivation. Lower prices might therefore achieve a movement in the opposite direction. Conclusions about the net benefits (or losses) in environmental terms of PPPs must balance the pluses and the minuses, and can mostly only be put in qualitative terms. Attempts to put monetary values on these are considered inherently flawed.

5.6 SOCIAL ISSUES

The social consequences of a return to a farming system which did not use chemical PPPs would be some increase in farm employment. The loss of output which would follow from a wholesale switch to organic would have negative employment consequences. The lack of raw material would reduce the extent of food processing, and would reduce (generally better paid) employment in the ancillary industries such as pesticide manufacture. It is accepted that present day organic food consumers do not necessarily spend much more on food, because their pattern of consumption changes. Whether this is socially a good thing or not introduces value judgments beyond the scope of this study.

5.7 ALTERNATIVE SYSTEMS

Overview

Rising concern at the consequences of modern, mainstream intensive systems of agriculture (and horticulture) have resulted in two main alternative approaches. These are broadly categorised as "organic" and "integrated". The sub-Report dedicates some considerable space to the background and definitions of the two systems. Only very broad definitions are distilled in this Synthesis Report.

The organic approach -At its simplest, organic farming is crop production without using synthetic chemicals and pesticides and livestock production without using pharmaceuticals and intensive methods, although to define the ideas of the organic movement merely in such limited and negative terms would be neither accurate nor fair. The explicit aim is to develop a sustainable system of farming which gives priority to ecology.

The integrated approach - This incorporates the integrated pest management (IPM) approach - defined by the FAO as "the use of all suitable techniques in a compatible manner to reduce pest populations and maintain them at levels below those causing economic injury" - but goes further by involving all aspects of farm operations and management.

5.8 DISCUSSION OF SUB-REPORT FINDINGS

5.8.1 Limitations of the study

The method used in preparation of the sub-Report was to compare the performance of the three systems - "standard" (the current conventional and mainstream system used by the majority of farmers), "integrated" (a system which puts greater emphasis on ecological/environmental considerations, and generally involves a substantial reduction in PPP use), and "organic" (which in general avoids the use of chemical PPPs, and follows stringent rules which have legal force for farmers who wish to market their products as organic). The authors of the sub-Report conclude that the differences between the performance of farms using an organic system on one hand, and integrated and standard systems on the other, appropriately extrapolated to regional and national level, properly reflects the benefits provided by PPPs.

In order to assess the benefits of PPPs an examination was undertaken of the performance and problems of a system which does not use them, *i.e.*: theorising about the implications of a complete switch to organic in order to provide a baseline from which the benefits of PPP-using systems can be assessed. Many commentators find this exercise unrealistic, but nobody has been able to suggest an alternative and better way of making the estimates needed.[7]

While it would have been possible to have arbitrarily allocated a percentage of the benefits accruing from use of fertilisers and the rest to PPPs, this is considered to have little scientific justification. Therefore the authors have allocated the whole benefit to PPPs (as in many instances it would have been lost without their use) while making it plain that this includes the benefits of fertiliser use. In other words what has been demonstrated are the benefits of agrochemical use, rather than solely PPPs use.

The second important limitation of the analysis is considered to relate to farmgate prices of organic products. In each of the case studies the organic market share is minuscule - under one percent for all crops (except wheat in Schleswig-Holstein - around 3%). Despite recent increases in production organic products serve a small niche market, at very high prices. There is only limited evidence of what would happen to organic product prices if and when production expands substantially (distinguishing between changes in the overall price level and the premium for organic (and in some cases for integrated products) over those from standard systems). Indications suggest that the present organic premium will rapidly diminish, and that only a minority of consumers are prepared to pay one at all. The provisional assumption made is that in a theoretical situation where organic production reached 20 percent of the total supply, the organic premium would be no more than 20 percent.

In practice, if organic farming was to become the mainstream system, the impact on food supply and demand is expected to be so dramatic that one can only guess at what would happen to prices overall. But it is also not unreasonable for the advocates of organic production to argue that, with suitable organisation and promotion, demand for organic products may grow in line with expanding output, thus maintaining present prices. That certainly might happen as the market expands from its present level to say, 15 or 20 percent of the total. But the authors' conclusion, on the basis of the limited consumer research done so far, is that it will not; in the author's view the organic premium will decline sharply as production increases.

As most organic systems are based on a combination of crop and livestock enterprise, in considering any large expansion of organic production one comes up against two major barriers: (a) at farm level, the practicalities of introducing livestock enterprises where they do not exist at present are immense, and there are also, under current CAP rules, quota limits to an expansion of dairy production; (b) a large increase in milk and meat production would have a drastic effect on product prices, as both are already in "structural surplus" (*i.e*. the farmgate prices assured under the CAP mean that production is substantially in excess of demand at these prices). Though organically-

[7] It is accepted that this exaggerates the benefits of PPPs in one important respect in that it ignores the contribution of fertilisers. However, crop yields will generally only be at their economic optimum when both fertilisers and PPPs are used appropriately.

produced meat and milk might substitute for non-organic, the overall dilemma would remain.

This issue has led to a considerable effort by the organic sector to develop "sustainable stockless rotations". But it is felt unclear where the market for a massive increase in supplies of grain legumes arises, and it is considered that an attempt to substitute relatively high-cost domestically produced pulses for cheaper imported oilseeds would cause immense problems at WTO level, quite apart from the effect on EU food prices. As for green manures, these are either catch crops or grown on the set-aside area. The latter is an artificial situation, and if organic production expanded to 20 percent of the EU total, virtually the whole present set aside area would be needed for crop production. In effect, a sustainable stockless arable organic rotation needs 25 - 30 percent of the farm area to be diverted to fertility building.

In comparing organic and non-organic systems these matters ideally ought to be taken into account. The difficulty is that the effects on product supply, on product prices and on land use of a major switch to a system without agrochemicals can only be estimated within rather wide ranges.

The other serious limitation of the sub-Report is felt to be the difficulty of attempting to extrapolate the findings of four limited studies to provide regional and national estimates of PPP benefits. The authors have given broad brush estimates in numerical terms of these benefits, as that is one purpose of this exercise. It would be easy to retreat behind the barricades of scientific caution and to claim (with some justification) that the data are too weak to permit any general conclusions to be drawn. It was preferred, however, to put forward some inevitably rough-and-ready calculations, while making clear the assumptions on which they are based.

5.8.2. Economic benefits for the selected crops/regions

The overall findings of the four case studies are summarised in Table 9 below (expressing the area grown of each crop, the yields, the crop gross margin, the rotation gross margin (for the two annual crops), farmgate prices and reduction in PPP use as percentages of "standard". The figures are, inevitably, averages and the range within each category is wide. The main qualifications that need to be made about each score can be found by reading the case studies.

Table 9 : Summary of the economic performance indices from the four case studies[8]

	Apples	Potatoes	Wheat	Wine
CROP AREA :				
· Total	100	100	100	100
· Standard	6	82	96	94
· Integrated	83	15	2	5
· Organic	1	3	2	1
YIELDS :				
· Standard	100	100	100	100
· Integrated	112	100	90	100
· Organic	70	59	48	73
GROSS MARGINS :				
A. Crop				
· Standard	100	100	100	100
· Integrated	140	124	93	100
· Organic [1]	190	110	133	56
· Organic [2]	80	60	100	63
· Organic [3]	40	40	70	31
B. Rotation				
· Standard	n/a	100	100	n/a
· Integrated	n/a	100	93	n/a
· Organic [1]	n/a	200	133	n/a
· Organic [2]	n/a	(loss)	40	n/a
· Organic [3]	n/a	(loss)	(loss)	n/a
FARMGATE PRICES :				
· Standard	100	100	100	100
· Integrated	113	100	100	100
· Organic	200	204	298	107

Three main conclusions are drawn from the above data. Firstly, overall there appears to be very limited or zero economic benefits in using PPPs beyond the level needed for integrated production. In reality, however, this is a tautology. The rules for integrated production are flexible, and in practice tend to mean an effort to reduce the use of PPPs (alongside other environmentally-desirable modifications to the farming system) while avoiding any loss of profit. In other words, it is felt feasible to reduce PPP use (typically by the 25-40 percent), but to a varying extent from crop-to-crop depending on circumstances, while maintaining profitability. However, if the integrated protocols are strictly defined and include a (say 50 percent plus) reduction in overall pesticide use, then there will often be an economic cost; the German case study on wheat production - the one with the widest implications - suggest that gross margins would be reduced by around 10 percent if integrated products obtain the same prices as standard.

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[8] The organic gross margins are estimated at three levels : [1]The case study price premium (generally 1995 prices); [2]Organic products at a 20 percent price premium to standard; [3]Organic prices the same as standard.

In practical terms, even if integrated production was as profitable as standard, many farmers would be reluctant to changeover comprehensively. There would be no economic benefit, there would often be some risk and the integrated system is likely to be significantly more management-intensive. So while some elements of an integrated approach, including agrochemical input reductions may well be adopted, a full-blown commitment to IFS is unlikely to appeal to a majority of farmers unless incentive is provided.

The second main conclusion is that, at the present time, assuming there have been no big changes over the past two years, organic production is on balance more profitable than standard or integrated. This is despite the much lower yields achieved by organic producers. The key to this is felt to be the extremely high farmgate prices currently obtained by organic producers. The subsidies for organic production are secondary.

The one exception to this is organic wine (which is also the exception in that organic wine production involves the permitted use of chemical PPPs, albeit old-fashioned ones). There is a smaller premium for organic wine and the price is insufficient to compensate for reduced yields. The important proviso needs to be made, however, that the price structure in Bordeaux is untypical, and organic wine producers may get a larger premium elsewhere.

5.8.3 Economic benefits at national level

Any attempt to extrapolate the case study results in order to estimate the economic benefits of PPPs at national level is fraught with hazards, because the relative performance of the different systems in other regions may well be different. What follows assumes these differences are zero, and therefore can best be regarded only as providing rough estimates.

Table 10 below estimates the benefits at national level in each country for the crop covered in the country case study. This calculation simply calculates what the production loss would be in total resulting from a 100 percent switch to an organic system. This loss is then valued at current market prices in order to give an estimate of the value of PPPs (in reality the benefits of using a standard system) with the crop in question in the case study country. Some economists argue that market prices should be used in this calculation as many EU prices are artificially inflated under the CAP system. If this approach was followed, the benefits would be reduced substantially but by variable amounts - least for potatoes, most for wheat.

Table 10 : Estimated benefits at national level of PPP use: *Standard to Organic Switch*

	Apples	Potatoes[9]	Wheat	Wine [10]
Current production (mn tonnes)	1.96	2.76	17.51	55.60
Estimated production (mn tonnes)	1.37	1.63	8.41	40.60
Production gain from PPPs (mn tonnes)	0.59	1.13	9.11	15.00
Total output ('000 tonnes)	1,964	3,595	17,700	55,610
Organic index	70	59	48	73
Gain from PPP ('000 tonnes)	589	1,474	9,204	15,015
Value per tonne (local currency)	210,000[11]	222	257[12]	761[13]
Value gain (local currency)	123.7[14]	327[15]	2,366[16]	11.4[17]
Value gain	48.75[18]	121	197[19]	1.36[20]
Value gain ECU	62.4[21]	154[22]	1,243[23]	1,747

What is felt to be evident are the enormous economic benefits which the use of agrochemicals, including PPPs, provide as the key components of the standard system.

The authors of the sub-Report also gross-up the benefits across the rotation to give an (inevitably crude) estimate of the benefits of PPP use on all arable crops in the country concerned. In this calculation it has been assumed that if an organic system

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9 In D/t

10 In '000 hl

11 Lira/tonne

12 DM/tonne

13 FF/hl

14 Bn lira

15 Fl mn

16 M DM

17 Bn

18 T=2538

19 M £

20 £ Bn

21 Mn

22 Mn

23 M

entirely replaced the standard system, then the organic price would fall to 20 percent above the standard price. The actual benefits of the standard system are probably seriously underestimated in this calculation, however, as it does not allow for the reduced area of the arable crops that would result from a switch to 100 percent organic, and the very low prices that would be obtained for livestock products if their supply was substantially increased above present levels. This further assumes that the supply shortages (of cereals) and surpluses (of livestock products) could not be covered by trade.

Table 11 : Estimated benefits at national level of PPP use on all arable crops

	Netherlands[24]	Germany[25]
1. Rotation margin : standard (ECU/ha)	259	805
2. Rotation margin : organic (ECU/ha)	0[26]	322[27]
3. Difference in margin (ECU/ha)	259	483
4. National arable area ('000 ha)	1,965	11,834
5. Value of difference (ECU/ha)	0.51	5.72
6. Total monetary difference (calculated by multiplying 3 x 4) in millions of ECU (rounded down)	508	5,715

Clearly, different assumptions will give different results, but the authors submit that its assumptions are not unreasonable, and do demonstrate how enormous would be the economic cost of a ban on PPPs.

5.8.4 Environmental benefits of PPPs

In each case study described in full in the sub-Report, the conclusion is reached that the main environmental benefit of PPP use arises from the much greater area of farmland that would be required to produce the same amount of the crop in question if a PPP-based system is substituted by an organic one. In other words, this is the area of farmland that is saved by the use of PPPs under a standard system.

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24 Netherlands data are net margins

25 Germany data are gross margins

26 This assumes the organic price premium is 20% over standard prices

27 At this level of prices organic production would make a loss, so the GM is shown as zer

The assumption in this context is that the quantity of each product currently reaching the market is needed to meet consumer demand. Therefore, if yields fall then the crop area will need to be increased. If an organic system is adopted in the case study country, the assumption made is that it will be adopted in other countries, so shortfalls in production in the case study country cannot be made good by extra imports. The argument has been made that within the EU there is considerable overproduction, and hence such land-saving is not a significant benefit. The counter-argument is that this is a consequence of CAP-influenced price levels. If prices were allowed to fall to world free market levels, "structural" overproduction would disappear. One consequence would almost certainly be some reduction in PPP use, though estimates of this are beyond the scope of this study. Thus with reduced farmgate prices there would be both some extensification of production due to reduced use of inputs combined with some reduction in the area cultivated as marginal producers ceased production.

However, the effect with the crops covered in the case study would not be uniform. Effectively, there is no EU price support for ware potato production, so CAP reform would have little impact on this crop. Over production in some years is the consequence of the largely unavoidable weather-induced fluctuations in yields from one season to the next. In contrast, wheat CAP-based support measures have a large impact on prices. With both apples and wine the situation is more complex, as reforms introduced to the fruit and vegetable regime will reduce market distortions, and will make product quality and marketing effectiveness of even greater importance than in the past. In this respect the Trentino producers are well-placed. For wine, the Bordeaux region depends hardly at all on the CAP mechanisms and the effect of CAP reform would presumably be to remove the present market distortions that still encourage over-production of low quality wine. The area of vineyards in Bordeaux, and the use of PPPs within the region, is unlikely to be effected by CAP reform unless it strengthens the direct incentives to adopt IPM methods. Table 12 below estimates the extra areas that would be needed at national level to make good the output reduction that would follow from a switch to organic.

Table 12 : Extra farm area needed for organic production

	Apples	Potatoes	Wheat	Wine
Present production area ('000 ha)	67.0	80.1	2,530.0	926.0
Organic yield (% of standard)	70.0	59.0	48.0	73.0
Extra area needed to maintain output ('000 ha)	28.7	55.7	2,741.0	343.0

While it is conceivable that the extra land needed to maintain apple and wine production could be found, this is felt to be impossible for potatoes in the Netherlands (for rotational reasons) and for wheat in Germany, as that much extra land suitable for the crop does not exist. These figures are considered in the authors' main point that a substantial increase in organic production will put immense pressures on current land availability and use.

From an environmental point of view, the demand for extra land to meet food supply needs under a reconversion to organic can only mean that land at present left as woods, wetlands, heaths and other uncultivated areas would need to be brought into cultivation.

Benefits to soil, flora, and fauna from organically farmed land are acknowledged by the sub-Report authors. For example, German research (Isselstein J. *et al.*, 1991) has highlighted the favourable impact of organic methods on soil microorganisms as well as on the populations of invertebrates, beetles and other genera. To the extent that weeds are poorly controlled, an increase in insect population occurs, and this in turn is beneficial for the populations of insect-feeding birds (and of the species which predate these).

The authors of the sub-Report suggest, however, that it is less clear what the comparative level of these gains would be on cultivated organic farmland and the biodiversity gains of areas used exclusively for conservation. The authors of the sub-Report found no research documentation that would allow this comparison directly to be made but what is felt to be clear is that such research needs to be done over a sufficient number of years to allow the full impact of system changes to become evident.

While the relative benefits of the two model scenarios as ways of sustaining and, where possible, strengthening biodiversity under different scenarios for the use of existing farmland can be disputed, the case is different once one considers a larger scale conversion to organic. It is felt that, should complete or near complete conversion take place, the need for extra land to maintain food supplies would require the bringing to cultivation of land not currently used for farming and this loss of existing uncultivated wildlife habitats would be beyond dispute, and an effect on biodiversity comparable to what was experienced in Europe in the periods of farming expansion in the 16-19th centuries, before pesticides were invented is suggested.

The sub-Report also identifies benefits from use of PPPs in the following areas:

Food quality - This has two main aspects (Johnen & Urech 1997) - (i) avoidance of fungal and bacterial contamination and damage (with many cash crops from organic systems a substantial proportion of the harvest cannot be marketed because of contamination and damage); (ii) storeability. For example, apples or potatoes with various rots and insect damage cannot be kept in store. In general, organic wheat losses in store are estimated at 15 - 20 percent higher than for non-organic. Around 2 - 3 percent of foodstuffs have detectable residues, and these may have long term negative health effects, a matter which the authors accept cannot be totally disproven. It is difficult to quantify the benefits of efforts to satisfy consumers, but the costs of monitoring are clearly a negative to be put against the benefits of PPP use.

However, the authors point out that provided PPPs are used correctly, any detectable residues should be well below the legal limits which in turn are designed to provide a wide margin of safety. It can and is argued that only in healthy, disease and pest-free crops, can their genetic potential be fully expressed, for example in relation to the protein content and other aspects of nutritional quality of the crop.

There are many naturally occurring toxins that can contaminate foodstuffs. There are about 400 known toxins of fungal origin alone (Obst *et al*., 1990; Anon., 1994). Crop protection products help considerably in preventing such contamination of food by these mycotoxins which are products of fungal metabolism. These toxins can be directly acutely toxic, but also exert chronic or long-term effects including causing cancer. Mycotoxins can develop both during the actual growing period of the crops as well as in storage. Processing does not destroy or remove these toxins, thus crop protection measures must be directed towards prevention.

The negatives of PPP use are discussed in other sub-Reports in the current study programme. What this study seeks to show, however, is that an integrated approach has relatively minor economic costs, and can further reduce PPP use by big amounts, both in terms of the quantity of active ingredient use per ha and of the environmental impact of the products used. Technical developments - safer PPPs, innovative biological alternatives, and better application methods, are thought to offer further gains in safety in future.

Social benefits of PPPs - It is accepted that any assessment of social benefits is value-laden, and the question is posed, for example, whether, maintenance of small farms is a good thing, regardless of other considerations. The social benefits are considered to be primarily the consequences of the economic and environmental benefits discussed above. Four are identified in particular, namely, in relation to:

- food prices - declined in real terms in recent years and absorb a declining proportion of EU consumers' incomes, despite price-raising effect of the CAP. Currently organic food prices are much higher (20-150 percent higher in general) than those for standard and integrated products;

- food security and quality - PPPs play an important role in ensuring reliable crops each year, as yields generally fluctuate less under a standard or integrated system than under an organic system (but note the contrary data on this from the German case study);

- land use for non-farming purposes - for housing, industry, roads, recreation, wildlife conservation and landscape protection is contingent on it not being required for food production (see above);

- rural employment and incomes - reconversion to organic farming would mean some increase in farm labour requirements, though the authors accept that it is difficult to quantify the impact.

5.8.5 GENERAL CONSIDERATIONS

The use of PPPs in modern agriculture has its costs and benefits. This study has attempted to evaluate, and where possible quantify the key benefits. In economic terms the sub-Report authors feel that they are enormous, but they are also real in environmental and social terms. The authors draw the conclusion that an integrated approach would further reduce what limited hazards the correct current use of PPPs under standard systems still pose, as economic costs are felt to be small, particularly if CAP reform reduced the economic threshold for PPP use.

The overall picture which is concluded from the sub-Report is that farmers' expenditure on PPPs provides very large economic benefits, as well as significant and real environmental and social benefits which need to be balanced against any costs or losses which they may cause.