SESSION 6B

WEED CONTROL IN THE DEVELOPED WORLD WITHOUT CHEMICALS: AGRICULTURAL AND OTHER IMPLICATIONS

CHAIRMAN DR A. BUCKENHAM

SESSION ORGANISER PROFESSOR D. ATKINSON

INVITED PAPERS 6B-1 to 6B-4

IMPLICATIONS FOR WILDLIFE, LANDSCAPE AND THE ENVIRONMENT OF FARMING WITHOUT PESTICIDES

N.M. Fisher; D.H.K. Davies

SAC Crop Sytems Dept., Bush Estate, Penicuik, Midlothian EH26 0QE

D. Atkinson

SAC, 581 King Street, Aberdeen AB9 1UD

ABSTRACT

An estimate is made of the likely effects for UK arable farming of discontinuing the use of pesticides. Unit production costs of ceareals would rise by an estimated 19% and production of cereals from current arable land areas would fall from 132% to an estimated 82% of self-sufficiency. Similar rises in costs and deficiencies in production would apply for other arable crops. It is argued that this would increase the pressure on unfarmed land of high conservation and amenity value and lead to the ploughing of grassland. The effect on nitrate leaching is likely to be detrimental in the short term but uncertain in the long term. Consumption of fossil energy would be increased by substituting cultivation for herbicides and an expanded arable area would increase the release of carbon dioxide and the greenhouse effect. Benefits of the no-pesticide option include the conservation of those species which are adapted to low-intensity arable farming, an improved public perception (possibly ill-informed) of the safety of home-grown produce and a less rapid decline in farm employment.

ASSUMPTIONS ABOUT THE EFFECTS OF STOPPING PESTICIDE USE IN BRITISH FARMING

We begin this paper by examining the likely effects for the UK farm if the use of pesticides were discontinued. We are not advocating this as a policy but rather we wish to draw attention to some of the implications of it, particularly as it affects land use. Neither are we looking at an organic farming scenario, partly because others have done this but also because we feel that the distinction between fertilisers and pesticides is a real one which needs a public airing. We do not therefore assume any restriction on fertiliser use, only a slight decline in use as a result of optimum rates being assumed lower in crops with more disease and lower yields. Because of their major impact on land use issues, we have restricted this treatment to the major arable crops.

Yields

The likely reductions in yield associated with no pesticides can be inferred with fair confidence from the many field trials which take place to evaluate pesticides. For the cereals, the variety trials run by NIAB and SAC, with and without fungicides provide a very useful and representative estimate of the national response to fungicide. For the other crops, field trials may tend to overestimate the national picture because the trials often use more susceptible varieties and are located in areas where the pest or disease in question is most likely to occur. We have tried to avoid such bias, but at the end of the day, the figures we have put into Table 1 are only educated guesses.

A digression on erratic crop failures

Our yield figures do not allow for the erratic event when some new strain of disease causes sudden losses or some unusual weather pattern suddenly raises the importance of a latent crop disorder. We have tried but failed to demonstrate that the stability of UK yields for wheat, barley and potatoes has improved since pesticide use became widespread. It does not appear to have greatly changed over the relevant years with a Cv for UK mean annual yields about the trend line of 9.8% for wheat (1946-87), 7.7% for barley (1946-87) and 10.1% for potatoes (1960-87). What is true, however, is that the consequence for the consumer of an erratic event is much more serious if the supply and demand situation before the event was delicately balanced rather than in consistent surplus. If the infrastructure for the manufacture and distribution of pesticides were allowed to wither away, then the ability to respond to an avoidable erratic event is eliminated. Widespread, erratic crop failures, even in temperate farming, are too common to be ignored.

A concession within the no-pesticide option might be for government to finance a mechanism for holding emergency stocks of pesticides to be used, not routinely but at the threat of widespread crop failure from preventable disorders. Emergency pesticide stocks might include fungicides for use in years with weather conditions particularly conducive to potato blight or for use if the yellow-rust resistance of a widely grown wheat cultivar were to break down.

Changes in the farming system

Much more difficult to quantify than the yields, are the changes in the crop production systems which we feel are inevitable in any return to weed control without chemicals. We envisage two major shifts, both reversing the observed trend since herbicides came onto the scene in the 1950s. First is a move away from continuous arable involving the land most difficult to work where blackgrass and couch in particular would simply not allow continuous arable production. Our estimate is that 5% of existing arable land would not be economically cropped at all and that a further 15% would be lost to arable at any one time in order to allow grass breaks back into the rotations, not to restore fertility but to contain pernicious weed problems such as blackgrass, wild oats and couch. We acknowledge major farm management problems in refencing and restocking these lands but any solution of these is outside the scope of this paper.

TABLE 1. Current production and unit costs and the projection if routine pesticide use were discontinued within the United Kingdom. Total land use for arable farming assumed unchanged.

C = current position, P = projection

Crop	Current or Projected	UK area Mha	UK yield t/ha	UK prodn Mt	Share of fixed costs £/ha	Variable cost £/ha	Unit cost £/tonne
W wheat	C	2.00	6.6	13.2	400	205	92
	P	1.00	5.0	5.0	420	146	113
S wheat	C	0.02	5.6	0.1	350	150	89
	P	0.62	4.8	3.0	370	110	100
W barley	C	1.00	6.3	6.3	400	184	93
	P	0.50	4.8	2.4	420	132	115
S barley	C	0.85	4.3	3.7	350	146	115
	P	1.02	3.9	4.0	370	114	124
W oats	C	0.05	5.7	0.3	400	164	99
	P	0.03	4.8	0.1	420	130	115
S oats	C	0.05	4.7	0.2	350	118	100
	P	0.06	4.2	0.3	370	104	113
All cereals	C	3.97	6.0	23.8			96
	P	3.23	4.6	14.8			114
W OS rape	C	0.30	3.6	1.08	400	301	195
	P	0.15	3.3	0.50	420	198	187
S OS rape	C	0.05	2.4	0.12	350	154	210
	P	0.13	2.2	0.29	370	146	235
All rape	C	0.35	3.4	1.20			196
	P	0.28	2.8	0.79			205
Potatoes	C	0.18	35	6.3	600	1262	53
	P	0.18	28	5.0	650	1217	67
Sugar beet	C	0.20	41	8.2	500	235	18
	P	0.20	36	7.2	540	246	22

We further believe that, in order to give time for control of weeds by cultivation, there would be a large shift back into spring cropping for cereals and oilseeds. This shift would be further enhanced by the smaller yield advantages for winter cropping if fungicides were not used and by the lesser risk to the spring crops from vector-borne virus. Our projections do not allow for any spatial extension of arable farming: the changes imply reduced areas for the combinable crops to accomodate the grass breaks but unchanged areas of potatoes and sugar beet which are controlled by quota.

In order not to double account, we have assumed for Table 1 that most of the weed problems which do reduce yields (as opposed to injure farming pride) would be contained by the combination of wider rotations and mechanical cultivation and have little effect on yields. We have allowed for a small reduction in yield by root pruning during cultivation.

Production costs

The current costs shown in table 1 are based on the Farm Management Handbooks (Nix, 1990; SAC, 1990) but with our own estimates of "share of fixed costs". We envisage an increase in "share of fixed costs" to meet the added labour and machinery costs of mechanical as opposed to chemical weed control and a reduction in variable costs according to the cost of pesticides, plus a small amount for likely reductions in fertiliser use.

IMPLICATIONS OF THE NO-PESTICIDE OPTION

Unit production costs

It is clear from these projections that no individual farmer or individual farming nation within a free-trade area such as the EC could possibly go it alone and incur the nearly 20% increase in the unit cost of production which our figures imply. The only thing that might alter this is a price premium for produce grown without pesticides. Even though no such premium exists at present, it is worth noting that our figures do not suggest the premium needed is anything like as big as that operating for fully organic produce. McGregor et al (1991) cite various consumer surveys suggesting that "a large number of consumers are willing to pay premiums of between 5 and 20%". In context, this is for fully organic produce but it does imply that many consumers are not prepared to pay the bigger premiums of more than 50% which are typical of organic production. Low income families spend a larger than average proportion of their budget on food and for them, a 20% increase in food prices is very serious.

Supply and demand

It is clear from Table 2 that our projected changes would turn the large UK cereal surplus into a considerable shortfall and create shortfalls in all the other major arable crops. Either:

more land would need to be brought into arable rotations,
or dietary habits would change (less pig and poultry products)
or imports would increase.

Certainly set-aside would become irrelevant. We see the increased pressure on the land resource as a major cost of the no-pesticide option as discussed below.

TABLE 2. The effect of a no-pesticide option on supply of the major arable commodities assuming no expansion of arable farming areas, other assumptions as for Table 1.

	UK utilisation million tonnes	Production as % of use Mean 1984-87	Projected
Wheat	11.0	121	73
Barley	6.5	154	98
All cereals	18.0	132	82
Oilseed rape *	1.2	100	66
Potatoes	6.4	98	78
Sugar beet *	8.2	100	88

* Utilisation for UK processing only. Large quantities of oilseed products and sugar are imported.

COSTS OF THE NO-PESTICIDE OPTION

Land use issues

(Sir Daniel) Hall (1913) described an East Lothian farm which he visited in 1910 as follows:

> "The fields are large and divided by stone walls; hedges mean both waste of land and perpetual source of weeds. In these fields we found the crop growing as well right up to the wall as in the middle of the field, and one had to look about in order to find a weed at all. The whole of the land was under the plough, being much too costly to be left in grass; and the leading crop was potatoes, which are taken every third year over the whole area."

His words serve to remind us first of all that pre-chemical weed control could work, that the beauty or otherwise of hedges and small fields is very much in the eye of the beholder but most of all that intensification is a function, not primarily of technology, but of the balance of product price and input cost. Nor would the public have found wall-to-wall potatoes quite so interesting as did the great enthusiast of "high farming". If they used the land at all it was probably only to cross it because it lay "between the coast and the railway".

Hall also wrote of land in the Vale of Belvoir which is today again largely arable but might at the time have provided a more attractive environment for recreation and amenity:

> "Much of the grassland in the district was of high antiquity, as can be seen by the way it is thrown up in high ridge and furrow, the long curves the furrows made at the ends of the fields telling of the old ox-teams that took so much room to turn. Doubtless some of this land went back to grass in the early years of the 19th century."

The area under cereals for GB in 1910, was 2.7 million hectares, having fallen from 3.5 million in 1870 at the end of the "golden age". Even as a result of the plough-up campaign in World War II, it did not exceed 3.4 million hectares but has now risen to 3.9 million hectares which is probably an all-time high and almost certainly includes an unprecedented proportion of class 3 or even worse land. On the other hand, the area of crops and (enclosed) grass which stood at about 13 million hectares in 1910 has fallen steadily to about 11.3 million hectares (GB) at the present day. This results from urban sprawl, the building of motorways and so on. Much of the 4 million hectares of "permanent" grass displays evidence, like the pastures of the vale of Belvoir, of having been ploughed at some time in history and another 2 million hectares or so of temporary grass is certainly ploughable.

There is not very much lowland "natural" habitat left but there is still a large reservoir of ploughable grass available into which arable cropping could expand, at least in the mixed farming and spring cropping type of systems which we have envisaged. It is likely to be the best lowland grass which will first give way to the plough, possibly also stimulating an intensification of grassland further up the hill. The productive potential of fertilised grass shows little decline over land capability classes 1 to 4 (Xie, 1990) so there is ample scope for increased land pressure in the best land leading to the intensification of the uplands. We suspect that the loss of wildlife habitat, recreational facilities and scenic quality of the pastoral areas involved in such a transition represents a more serious threat than the continuation of intensive farming in the 5 million hectares of predominantly arable Britain.

Nitrate leaching issues

Both of our assumed changes are likely to increase nitrate leaching, at least in the short term. The ploughing of grassland, particularly old grassland, which we envisage as necessary to make up the arable area is considered to be a serious contributor to pollution of groundwater. In the longer run, rotational grass does not carry the same potential for leaching after ploughing.

Although it is difficult to establish a relationship in the short term; over a period of several years, lysimeter studies do suggest a strong association between nitrate leaching losses and fertiliser inputs at rates around those widely used in modern cereal production. For instance, in Sweden, the mean annual loss is about 40 additional kilograms of nitrogen for every 100 kg applied over the range from 100 to 200 kg/ha/annum

(Bergstrom and Jarvis, 1991). Most of the changes we envisage, spring cropping and grass breaks should lead to smaller annual nitrogen fertiliser inputs for the arable crops.

There is, however, little doubt that more serious leaching can occur in the months of September to February from a spring-cropping regime than if a winter cereal is sown early enough to take up the mineral nitrogen. The long term effect is not so clear, because the typical spring crop actually has a more favourable balance than the typical winter crop (Table 3). Since soil organic nitrogen contents under arable cropping do tend almost invariably to decline, it is by no means certain that in the longer term, winter cropping with unrestricted N fertiliser is conducive to reduced leaching losses.

TABLE 3. Balance of nitrogen inputs and offtake in spring and winter barley.

		Spring barley	Winter barley
Annual input:			
typical fertiliser use	kg N/ha	100	180
rainfall + fixation		30?	30?
total inputs	kg N /ha	130	210
Annual offtake:			
typical yield	tonnes grain/ha	4.3	6.3
N removed (grain + straw)	kg/ha	75	109
N not accounted for kg/ha		55	101

Energy use

Estimates of energy inputs from fossil fuel for mechanical weeding all suggest that these greatly exceed the requirement for the manufacture, distribution and application of herbicides. For growing wheat, Leach (1976) puts the total energy input for "sprays" at less than one tenth of that for tractor fuels and machinery. Green et al. (1987) put the total application and manufacturing energy for a single herbicide application at about half of that of a single mechanical cultivation and argue that "at least two mechanical weeding operations are required to achieve the effect of one chemical treatment".

Carbon dioxide emission and the greenhouse effect

Arable land, almost invariably associated with declining soil organic matters, is a major source of carbon dioxide, whereas grass and other perennial crops tend to be a sink for as long as the land remains unploughed. Adger et al. (1991) put the annual loss of soil carbon in GB arable farming at 1027 kilotonnes, based on land use in 1980. This is more than balanced by peat accumulation in upland semi-natural vegetation at 1761 kilotonnes per annum but is nevertheless a significant factor in the overall carbon balance of GB land use. Improved grass is reckoned to accumulate carbon in the soil at 377 kilotonnes per annum. Any change which might encourage the ploughing of permanent grass is therefore likely to exacerbate the greenhouse effect.

BENEFITS OF THE NO-PESTICIDE OPTION

The Game Conservancy work demonstrates rather conclusively that "sterile prairie" farming greatly reduces game and wildlife numbers (Potts, 1980 and Rands, 1985 on partridges; Rands and Sotherton, 1986 on butterflies). This operates through direct effects of insecticides on non-target invertebrates but more importantly by eliminating those weeds that are the important food plants for invertebrates. The latter reduces food sources for seed eating birds and for the invertebrates which are in turn the food of mammals and birds. Undoubtedly this option would favour those species which have been selected through many centuries of low-intensity arable farming. However the benefit does tend to decrease with distance from suitable nesting sites, that is from field boundaries (Fuller 1984). We suspect that about 70% of the benefits could be achieved if perhaps 20% of the arable area could be pesticide-free: with conservation headlands widely adopted and deintensified farming on even wider strips adjoining unfarmed land. Wildlife corridors, not necessarily with fence or hedge could be laid down to link areas of unfarmed land.

The public perception of pesticide risk would be eased by a no-pesticide policy and the objections of the agrochemical industry should not be allowed to hide the fact that this is a potential benefit for the farmer. Good marketing in a no-pesticide production system could increase the attractiveness of home-produced food, even if the reality is that the public are misinformed and much greater health risks are presented by substances added after the produce leaves the farm, microbial contaminants or a swing back to red meat if cereal prices rise. It is unfortunately doubtful whether any measure short of a total pesticide ban would have much effect on public perception of the risk.

A return to mechanical rather than chemical weed control and to mixed farming would certainly retard and perhaps even reverse the trend to reduced employment in arable farming. It would also benefit the tractor and machinery industries and the plant breeding industry.

CONCLUSIONS

To discontinue the routine use of pesticides in British farming (and by extrapolation in comparable arable farming systems elsewhere in northern Europe) would increase the production costs of all arable commodities but not by as much as is sometimes suggested and possibly not sufficiently to deter public opinion from a no-pesticide policy.

Much more serious are the likely effects on the balance of supply and demand where a no-pesticide option would reduce the standard of the UK diet, increase the proportion of imported food or result in even more land being used for mixed or arable rotations. Most probably a mix of all three would ensue.

Our calculations clearly demonstrate that the increased pressure on land not currently farmed or on grassland and the failure to release land from farming for amenity, recreational or conservation use represents a much more serious environmental threat than does the continuation of intensive farming with pesticides on the land least suitable for the alternative uses.

There would probably be a short-term increase in nitrate leaching if more grass was ploughed and more spring crops grown. The longer term effect is not clear and could be beneficial. Emissions of carbon dixide would be increased with larger arable areas and substituting mechanical for chemical methods would approximately quadruple the fossil fuel energy requirement for weed control.

We accept that a case can be made for preserving the habitat of low-intensity arable farmland but suggest that it is best achieved by the extension of schemes to promote conservation headlands and other low intensity farming practices on areas close to unfarmed land. More widespread elimination of pesticides would rapidly encounter a diminishing return, even for the narrowly-defined habitat of low-intensity arable.

REFERENCES

Bergstrom, L.; Jarvis, N. J. (19) Prediction of nitrate leaching from arable land under different fertiliser inputs using the SOIL-SOILN models. *Soil Use and Management*, **7**, 79-85.

Fuller, R. J. (1984) The distribution and feeding behaviour of songbirds in cereal farmland at Manydown Farm, Hampshire in 1984. *Report to the Game Conservancy* from the *British Trust for Ornithology.*

Green, M.B.; Hartley, G.S.; West, T.F. (1987) *Chemicals for crop improvement and pest management*, Oxford, Pergamon Press.

Hall, A. D. (1913) *A pilgrimage of British Farming*, London, John Murray.

Leach, G. (1976) Industrial energy in human food chains. In: *Food production and consumption*, A. N. Duckham, J. G. W. Jones, E. H. Roberts (Eds.), Amsterdam, North-Holland Publishing Company, pp. 371-382.

McGregor, M.; Blackholly, H.; Chadwick, L.; Lilwall, N.(1991) Consumer attitudes to, and awareness of, organic produce in the United Kingdom. *Edinburgh School of Agriculture, Annual Report of the Organic Farming Centre for 1990*, pp. 113-126.

Nix, J. S. (1990) *Farm Management Pocketbook.* University of London, Wye College.

Potts, G. R. (1980) The effects of modern agriculture, nest predation and game management on the population ecology of partridges (Perdix perdix and Alectoris rufa). *Advances in Ecological Research*, *11*, 1-82.

Rands, M. W. R. (1985) Pesticide use on cereals and the survival of grey partridge chicks: a field experiment. *Journal of Applied Ecology*, **22**, 49-54.

Rands, M. W. R. and Sotherton, N. W. (1986) Pesticide use on cereal crops and changes in the abundance of butterflies on arable farmland. *Biological Conservation*, **36**, 71-82.

SAC (1990) *Farm Management Handbook 1990/91*, Edinburgh, The Scottish Agricultural College.

Xie, J. (1990) The relationship between land characteristics and grass dry matter yield and grass production maps, *M. Phil. Thesis, University of Aberdeen.*

UK FARMING: THE ECONOMIC BACKGROUND

S Rickard*

Chief Economist, National Farmers' Union

ABSTRACT

After 40 years of growth the agricultural industry now faces policies designed to cut back and control production. Just how this will be achieved is still a matter of speculation. One thing however, is clear, overall farming will use less chemicals in the future.

INTRODUCTION

There can be little doubt that arable farming is now greatly dependent on chemicals. Table I shows that for cereal and general cropping farms expenditure on plant protection has increased substantially in real terms during the 1980's.

TABLE I: AVERAGE PLANT PROTECTION EXPENDITURE (1988 POUNDS)

Farm Type	Cereals (1)	General Cropping (2)	Dairying (3)	Lowland Livestock (4)
1979				
i) Expenditure (£)	4,868	5,712	2,240	406
ii) % variable costs	10.9	8.5	3.3	1.8
1988				
i) Expenditure (£)	9,122	10,726	1,091	862
ii) % variable costs	18.1	12.4	1.7	3.0

Source: Farm Business Survey, MAFF.

From the perspective of the farm level chemicals and fertilisers together with genetics and improved husbandry form a troika pulling the industry to ever higher levels of production. This is reflected in steadily rising yields and falling real unit costs of production.

This state of affairs appears to be an unqualified success. British farmers are now more productive than they have ever been, the spectre of food shortages is a distant memory in Western Europe and the real cost of food has fallen steadily. Today the average UK household spends less than 12 per cent of its income on food compared to 25 per cent at the end of the 1960's.

But from another perspective that of a macro view of the industry, the situation does not look like a success at all. From the early 1980's the authorities have been attempting to control production. In this they have been unsuccessful and the consequences of increasing output is a deepening agricultural recession. Some pertinent statistics are set out in table II.

---

* The views expressed in the paper are the author's and should not be interpreted as necessarily representing current or proposed NFU thinking on policy.

TABLE II: KEY AGGREGATE INDICES (1978-82=100)

	1986	1987	1988	1989	1990
Volume Pesticides	154	152	177	192	178
Cereal Yields	125	113	111	121	126
Arable Production	124	128	128	132	130
Real Farming Income	76	76	53	64	49

Source: MAFF

So what is going on here? Why is an industry that is becoming ever more productive slipping steadily into its worst recession since the inter-war period? The answer is quite simply that, generally, production not only exceeds the levels that governments believe are appropriate but also it continues to grow faster than demand. This situation has never been, and can never be, the basis for a prosperous industry.

I have no doubt at all that the explosive growth of output during the 1970's and 1980's is the cause of farming's current malaise. Farming was a more prosperous industry at the start of the 1980's than at the end. The increasing surpluses have resulted in a substantial increase in budget expenditure and even more severe measures to control production. Table III shows the pattern for cereals. But potentially most damaging is the role EC surpluses played in persuading the US to insist that for the first time agriculture be part of a GATT round. If a GATT settlement results in reduced border protection for EC agriculture the result would be a much steeper deterioration for farming profitability.

TABLE III: EC CEREALS SECTOR*

	1978	1982	1986	1990	1991(f)
Production (mn tonnes)	135	147	155	160	169
Consumption (mn tonnes)	140	139	137	132	130
Surplus (mn tonnes)	-5	8	18	28	39
Budget Costs (£/bn)	0.5	1.1	2.0	4.0	4.5

*EC(12) excluding E. Germany

f = forecast

Source: EC Commission

The futility of pursuing farming practices that result in ever higher levels of output is one factor - though not the most important - in the growing interest in organic agricultural production.

<u>Organic production</u>

So is the solution to deny EC farmers access to chemicals? Without chemicals crop yields would fall markedly. It is impossible to be precise but the removal of all chemicals from farming - including inorganic fertilisers - could reduce overall output by as much as a half and EC surpluses would be a thing of the past. But what would happen in this situation?

The EC would now have moved to a position of less than self-sufficiency in food. The shortfall in supply would need to be made up by greatly increased imports. The price at which these imports entered the Community would largely determine the prices for domestically produced products: that is there would be no such thing as an organic premium. As considerably higher prices would be needed to compensate incomes for the loss of output the EC would have to persuade other parties to the GATT to allow it to significantly increase current levels of protection. As I judge this level of protection would not be forthcoming the result would be an even deeper recession and eventually a much smaller industry.

So an imposed - in contrast to a developing - organic solution would not improve the economics of farming. It would also result in the crazy situation where the bulk of food imports would be produced by the very techniques denied to EC farmers.

POLICY OBJECTIVES

For the foreseeable future the vast majority of EC farmers are going to continue to be dependant on chemicals. But given the background sketched above it is appropriate to ask for what purpose, and is there a need for change?

In order to answer this question we must go back to fundamentals. In fact we must start with a question. What is, or what should be the purpose of agricultural policy today? All those engaged in agriculture, particularly policy-makers, farmers and their suppliers, must have a clear answer to this question. It is a sobering thought that despite the great difficulties now facing the industry I have never found this question posed let alone seriously debated by anyone in authority.

There are at least three answers:

- A balanced supply of food at reasonable cost.
- A social policy for farming communities.
- An integrated farming and countryside industry.

Of course the politicians will answer that all three are relevant. But this is not good enough. Each objective requires very different, even contradictory policies so if we are not to end up with a complex set of competing and contradictory policies we do need to decide which objective, at this point in time, is dominant.

A balanced food supply

I suspect that the prevailing view in the UK is that agricultural policy is primarily about providing a balanced supply of good quality food at reasonable prices and that both the social and environmental concerns are secondary. By balanced I mean not only bringing supply down nearer consumption for the Community's agricultural products but also a situation where the output is growing at the same rate as demand.

Now the logic of this approach is that farmers should adopt every proven, or to be more correct acceptable technological advance, including pesticides, that results in lower unit costs of production. In the case of crops, fixed costs account for some 66 per cent of total costs so this approach must imply a preference for technology that increases yields. This is demonstrated in table IV which shows the impact on production costs of a less intensive and more intensive response to price cuts.

TABLE IV: PRICES, COSTS AND YIELDS (WHEAT)

	Starting Position*	Greater Intensity	Lower Intensity
Yield (t/ha)	7.0	7.5	6.5
Price (£/tonne)	108.0	90.0	90.0
Revenue (£/ha)	756.0	675.0	585.0
Variable Costs	205.0	215.0	190.0
Gross Margin (£/ha)	551.0	450.0	395.0
Fixed Costs (£/ha)	400.0	400.0	400.0
Total Cost per tonne (£)	86.4	83.3	90.7

* NFU estimates.

But in a situation of surplus production this policy fails at the macro level. Fails in the sense that it must involve proportionately larger cuts in market prices. The purpose of these cuts is partly to encourage consumption - though in practice the impact of lower farm-gate prices on consumption is very small - partly to pass on some of the benefits of improving technology to consumers but mainly to drive out of farming higher cost resources; initially, people, but eventually land. In short it is a policy of the survival of the fittest.

This approach receives more support in the UK than in other member states because of the widespread belief that UK farmers would tend to be the survivors at the expense of their smaller EC counterparts. In fact there is not much hard evidence to support this view; indeed, the economic condition of UK farming has deteriorated more sharply than any other EC farm industry.

But if we were ever to succeed in persuading our EC partners that a 'market forces' or 'survival of the fittest' policy is 'best' we would also have to accept the inevitable logic of the removal of all barriers to trade. If the prime objective is a stable supply of good quality food at low prices then why should we not now meet more of our needs from the world market that is over supplied?

This issue is normally dodged by assertions that as farm support is reduced around the world ie, in Europe and the US, world prices would rise. In fact there can never be a sustained rise in world prices unless demand rises or world supply is reduced which in effect means EC farmers producing less. Ultimately a survival of the fittest policy means a very deep recession and by the turn of the century a much smaller UK farming industry and substantial areas of unfarmed land. I am certain such an outcome is not in the interests of anyone involved in supplying inputs to British farming.

THE MACSHARRY REFORMS

Mr MacSharry's or more correctly the EC Commission's reforms clearly put the emphasis on the social aspects of agricultural support. The purpose of his reforms is to keep the maximum number of farms viable. That is the smaller, generally higher cost farms that are particularly vulnerable to steady cuts in farm gate prices. In order to offer these farms a better chance of survival the reforms involve not only greatly increase public expenditure on farming as CAP support is switched from the market to direct payments but also heavy penalties on larger farms if the do not reduce production and so make room for the output from these smaller farms.

Under the Commission's proposals farmers, both large and small, would still have the incentive, or more correctly would have no choice but to continue to seek output enhancing techniques as this is the proven route to least cost production (see table IV). But increasing output from the land remaining in production would lead directly to ever increasing areas of set-aside on larger cropping farms and cut backs in the number of breeding animals receiving premiums. Thus rising yields and stocking rates mean higher incomes for smaller farms and even lower incomes for larger farms.

If Mr MacSharry wins the day the continued drive towards more intensive methods of production would create not a more efficient industry but a more unequal one. This state of affairs creates uncertainty for UK farms and thereby makes it far more difficult for them to plan and invest in the future.

One outcome of the proposed solution would be a slow down in the rate at which smaller full-time farm businesses are leaving the industry. From the view point of suppliers of chemicals this may appear to be not altogether bad. But UK data shows that smaller farms spend less on crop protection and fertilisers per hectare so I doubt if overall sales of chemicals and fertilisers can do other than reduce as the number of larger farms is reduced and the area of idle land rises under a MacSharry solution.

WIDESPREAD EXTENSIFICATION

So what of the third suggested objective for policy: an integrated farming and countryside industry. If surveys of public opinion and media articles are any guide this would probably be a very popular solution. I believe that such a policy would have to be founded on the widespread adoption of less intensive production techniques. The widespread adoption of such a policy would reduce overall production and thereby remove the need to cut farm-gate prices. As can be seen from the example in table V, in this situation lower intensity farming achieves lower output with much less damage to farm incomes than price pressure.

TABLE V: LOWER INTENSITY FARMING

		LOWER INTENSITY	
	Starting Position*	With Price Cuts	4% Price Rise
Yield (t/ha)	7.0	6.5	6.5
Price (£/tonne)	108.0	90.0	112.0
Revenue (£/ha)	756.0	585.0	728.0
Variable Costs (£/ha)	205.0	190.0	190.0
Fixed Costs (£/ha)	400.0	400.0	400.0
Income (£/ha)	151.0	-5.0	138.0

* Based on NFU estimates.

The great difficulty with this approach is that it would rule out price cuts and therefore require continued border protection for EC farmers. This would appear to be an obstacle to a GATT settlement.

Nevertheless, if the GATT negotiations run into difficulties then a solution based on lower exports from the EC and continued protection might prove an acceptable compromise. I suspect that suppliers of chemicals to farmers might view the idea of less intensive farming - which means less inputs - with horror. Yet it may still be a better option than the two alternatives outlined above. It is a middle road between the impracticality of widespread organic farming and the growing disenchantment with ever higher levels of intensity.

THE NEED FOR CHANGE

I have tried to demonstrate that things cannot go on as they are. The agricultural industry faces a crisis and a solution demands radical action. In the future either the area of agricultural land is going to be substantially reduced or farmers generally are going to farm it less intensively. One way or another this suggests the UK agricultural market for chemicals is going to decline in the future and I have come to this conclusion without considering the likely growth of integrated pest management programmes and current research into lower input farming techniques. Against this background might there not be merit in both farming and its suppliers attempting to find a framework which could help stabilise production at lower levels and encourages the integration of food production with the growing demand for more countryside?

A clear policy objective to cut production by the widespread adoption of less intensive methods does offer a number of advantages to both farmers and their suppliers. For example such a policy would:

- not discriminate against larger farms and thereby the UK farming industry;
- create a more certain future for the industry; and
- force farmers to consider more carefully the quality of their production.

The importance of quality

This last point merits further consideration. There is certainly some evidence which suggests to me that there is a trade off between quality and quantity at the farm level. Over-supply reduces the premium for quality and so exacerbates the problem by encouraging farmers to seek quantity in preference to quality; for example, producing feed instead of milling wheat.

Now looking back at the contribution of chemicals to reducing disease and blemishes a growing emphasis on quality might appear to benefit the suppliers of chemicals. Unfortunately it's not that simple.

It all depends on how consumers view quality. If surveys and media articles are any guide then it would appear that there is a growing perception by consumers that 'over-use' of chemicals produces an inferior product. Perceptions of over-use will vary from individual to individual but there are two good reasons for believing the trend away from chemicals will continue.

Firstly, we are now generally well fed and therefore much freer to exercise our prejudices as regards food production. Secondly, we are better informed. Consumer and environmental groups provide a steady stream of information on chemicals used in food production and as the Alar campaign demonstrated they can be very effective.

CONCLUDING THOUGHTS

Agriculture is probably the most talked about industry currently. Over recent years many 'solutions' have been proposed but very few actually guarantee lower output and also stand up to the constraints of controlling budgetary expenditure.

The Commission's proposed solution involves a considerable increase in budget expenditure and a substantial shift towards greater dependence on the taxpayer for farm incomes. I have great difficulty in reconciling the concept of a prosperous industry with one largely dependent upon the public purse.

If one believes that a prosperous industry is one for whose output there is growing demand then it seems to me that agriculture has got to start to place far more emphasis on its production of the countryside. Demand for this attribute is growing, and society seems prepared to pay something towards its provision.

To my mind we must find a way to incorporate agricultural and countryside policies. A clear move in this direction would I believe be in the best interests of farmers. Not only would it improve the industry's prospects but also it would reduce much of the recent criticism of farming. A more environmentally friendly farming industry might improve the image of the whole food chain including the suppliers of inputs to farming.

A Comparative perspective on the economic performance of organic and conventional farming systems in Great Britain.

MICHAEL MURPHY

Agricultural Economics Unit, Department of Land Economy,

University of Cambridge

Preamble

Interest in organically grown food is growing world wide, though the concept of farming organically is certainly not new. As late as the 1950s many farming systems in the UK and beyond were organic in the sense that the use of non-organic fertilisers and spray chemicals was not widely adopted. The time honoured rotational farming which was at the forefront of the agricultural revolutions in the 18th and 19th centuries was based on an ordered pattern of mixed farming. Arable crops were rotated with break crops and forage fed grazing livestock. Yet even in Disraeli's day it was said that there was no better way of assessing the economy than by measuring the sales of sulphuric acid used principally to manufacture phosphate fertiliser and sulphate of ammonia. The Bessemer process opened the gateway for inorganic farming by providing the technology to manufacture a relatively cheap source of nitrogen. When farming was ubiquitously characterised by hand labour and physical toil from dawn to dusk on mostly family farms, inorganic fertilisers brought new horizons to crop yields. Sturdy fast growing crops outmanoeuvred what many farmers saw as obstacles to better farming overshadowed by vermin, weeds and disease. Only a tiny minority with farming interests could foresee that if the agrochemical revolution were to continue unabated from the late 1930s, that there could ever be a build up of chemical residues in the natural environment which could be a cause for concern. Later as governments took a closer interest in the organisation and availability of food supplies, the extent to which guaranteed prices, for the most part set at levels well above world prices, would eventually boost production of indigenous type food raw materials to levels well beyond effective demand was only remotely considered. If prices were set too high they create surpluses too low starvation. Now consumers are increasingly setting the agenda and it was entirely predictable that if farm production continued to increase at a much faster pace then consumption, now at best stagnating in response to dietary trends, that the present crisis in agricultural would eventually emerge. There is now plainly excess capacity in conventional farming though this is not universally agreed upon. It is wholly understandable that some of those who have worked hard and risked much to build up businesses, and more importantly created employment in modern farming systems and associated agri-businesses (supply industries, food processing and exporting) will resist this claim. Politicians and civil servants too often find themselves besieged between two vigorous, if proportionately unequal yet important, groups of voters. Consumers and producers often cry favouritism to those who might appear to be seeking to protect the infant industry now taking on the guise of a hydra. Food politics have tinder box qualities of their own and farmers have rarely received a good press except in times of war.

There are many who charge that contemporary agricultural policy is adrift in the high seas of indecision. Mischief makers distract and exaggerate further often with nothing else better to do. Down on the farm, though they might not freely admit it, most sensible farmers realise that the present course needs correction. If production of indigenous food raw material increases still further against a background of a declining more sedentary, diet conscious population in the industrialised countries, prices will inexorably decline to those levels which would be so low that the business of farming becomes economic nonsense. What is to be done? Farmers hope that politicians and consumers will not be too harsh on them so that they can stay in business albeit at lower levels of prosperity compared with the past decade.

It is not surprising then that new systems of farming should now become the focus of attention. Plainly the motives differ, some may even stem from a long awaited opportunity to put farmers in their place. Centuries old grudges against land owners and family farm businesses, seen as a closed shop where inheritance is the mainstay of the system, come out of the woodwork. With the leisure industry on the increase, more and more people, particularly as they reach more mature years, have an urge to walk in the countryside but feel prohibited from doing so by laws of trespass on land which they feel should be withdrawn from present use and possibly only kept in production by public funding. But this isn't a one sided argument. Farmers and environmentalist also have views and feel their rights and voices are not being heard.

In this context, one new area of possible interest to agricultural policy makers is that of organic farming. If chemical farming leads to over production, and is now also giving rise to some concern about the possible impact of chemical residues in water, in the environment in general and in food products, organic farming may be one way of arresting this trend. Those who grew up on farms 40-50 years ago and who may have begun their farming careers at that time would say that this was a system which had now been superseded by conventional farming as we now know it, and *surely* why turn the clock back to those days. Those who, and not without some passion, regard organic farming as a supreme way of producing food, albeit making higher demands on good husbandry skills, soil, fertility, management and control of disease and weeds more through rotations and integrated crop cultivation, are not likely to take kindly to these reactions. Understandably there will be many cynical and possible ill-studied rebukes on either side of the farming divide and possibly now is the time to provide some hopefully less biased information on the performance of organic farms in Great Britain and to see how they compare with conventional farming systems especially in the area that most matters in the longer term; whether 'organic farming' is a viable alternative source of sustaining an income from farming.

What is organic farming?

The common perspective on organic farming differs in many parts of the world. Consequently there is often confusion, even ridicule, on the purpose of this method of farming. The international federation of organic agricultural movements (IFOAM 1989) define organic farming as:

to produce food of high nutritional quality in sufficient quantity;

to work with natural systems rather than seeking to dominate them;

to encourage and enhance biological cycles within the farming system, involving micro-organisms, soil flora and fauna, plants and animals.(abbreviated version)[1] These are objectives with which few agricultural policy makers and or farmers would generally disagree, and to an extent share many of the aims and conditions of agricultural policy in the US, EC and many other countries.

---

[1] Lampkin N. 1990 Organic Farming, Farming Press Books, Ipswich

In the UK the Soil Association and the Organic Farmers and Growers Ltd. lay down husbandry standards and an inspectorate monitors land in conversion through transition to organic farming. The Bio-Dynamic Agricultural Association operates very demanding systems using Bio-Dynamic preparations first advocated by Rudolph Steiner.[2]

Economic Performance on Organic Farms in Great Britain

One of the ubiquitous problems overshadowing organic farming is that there is a paucity of empirical comprehensive information available on the economics of organic farming. To remedy this the UK Ministry of Agriculture, Fisheries and Food commissioned a study on organic farming based on farm performance in the farming year 1989/90.

One of the interesting findings of this investigation was that it confirmed that the area of land devoted to organic farming is still quite small was estimated at about 14,000 hectares in 1989. The number of registered farms involved in commercial production of organically farmed enterprises was estimated at less than 600. Since that time many farmers have retired from organic farming for a multitude of reasons, and others have taken their place. There are also presumably many others who are not registered with the recognised organic associations. However the total area of land now farmed organically or in transition is not thought to have expanded greatly and is now in the region of 20,000 hectares. The bulk of this area is farmed in England, with Scotland and Wales contributing between a fifth to a quarter of the total area in Great Britain.

Production Types

Horticulture and mixed livestock farms are the dominant production types but farms engaged in organic dairying account for a about 10 per cent of the total. The number of specialised cereal producers engaged in the production of organic cereals is estimated at between five and eight per cent. The total tonnage of organic cereals produced in 1989/90 was estimated to be in the region of 12 to 15 thousand tonnes.

Land Use Pattern on Organic Farms

Farms engaged in the production of organic products in Great Britain can be broadly divided into two main categories. There are those engaged wholly in organic production, and those

---

[2] Steiner R. Agriculture, Bio-Dynamic Association.

engaged in both organic and conventionally farmed enterprises. The question now arises how did the methods of farming, land use and income levels differ between these two categories of farms and perhaps even more importantly to what extent did the economies of these systems differ for conventional farms.

Farm Size, Rotations and Yields per hectare

It may surprise some to learn that the wholly organic farms, were small and on average just less than 30 hectares. A typical rotation (1989/90) on these small farms was that over 70 per cent of the area was allocated to both grass and or forage crops. The remainder was allocated to arable crops of which organic cereals contributed over a half. On smaller wholly organic farms the area of grass was closer to 50 per cent of the farm area, and those less than 10 hectares tended to specialise in horticultural crops. In general wholly organic farms generated about 50 per cent of the farm output from arable crops from 30 per cent of the total area; the remaining 50 per cent from organic livestock mostly dependent on grass and or forage (70 per cent) sustained by home grown and to a lesser extent on purchased concentrates. Farm yard manure (often composted) supplemented by purchases from other farms was widely used and the costs incurred were clearly reflected in the levels of contracting and marketing charges Table 2. The stocking rates on these wholly organic farms were about 40 per cent lower when compared with the conventional farms, which may be a reflection of the lower energy output per hectare from forage crops and or grass.

Organic Farming in England 1989/90 Output Levels, Gross Margin and Income

The level of output from crops and livestock enterprise on all farms in the English organic sample, farms engaged in varying degrees of organic production was estimated at £892 per hectare for the sample of farms as a whole. However to put this level of performance into perspective, it was £112 a hectare lower on the smaller but wholly organic farms, or £780 a hectare, but was £135 a hectare more on the larger mixed output farms. Miscellaneous on farm agricultural revenue helped to make up some of the shortfall on the wholly organic farms but total output at £862 per hectare was still less than ten per cent lower compared with the mixed output farms. Despite higher contracting charges (muck spreading etc) variable costs were at £242 a hectare about £100 per hectare lower compared with mixed farms. The net effect was that the farm gross margin was remarkable similar for both categories, which resulted in a net farm income of £32 a hectare or less than £1,000 per farm. Occupiers' income was even lower at £459 per farm, the high level interest charges on these farms in 1989/90, £80 a hectare placed a heavy burden on these small farms particularly on owner occupier farms (Table 1). However these wholly organic farmers were also engaged in activities such as farm house catering and tourism. These activities generated much needed revenues of £25 a hectare boosting the total on farm income to £57 a hectare just under £1,400 per farm. Unfortunately if the value of farmers' and spouses' own labour is estimated at £8,000 per farm, then the shortfall is just in excess of £6,500. Plainly the small wholly organic producer despite revenues for farm shops and tourism is faced with a tough decision in the longer term especially if this shortfall has to be repeatedly financed out of depreciation or savings, and it is unlikely that there is an inviting future for this type of farming in terms of earning a livelihood. .pa

Comparisons of the economic performance of organic and conventional farming by type.

To improve the focus of these comparisons the sample of farms investigated in England were divided into production types. These categories are widely used in farm business studies, EC/FADN and FBS results are usually reported in this form, which provide a recognised and convenient statistical data base for comparison purposes. The FBS results[3] for England 1989/90 were used to compare the performance of the English organic farms studied here with that of those in comparable groups (and regions) farming conventionally. The data for organic farms were collected in a similar manner so that the results mapped easily into the FBS results.

Mainly Cereal Farms

The comparison of organic and conventional cereal farming produced some striking features. The yield of winter wheat the major cereal crop on these farms was 3.82 tonnes per hectare for organic wheat enterprises, but for conventionally grown wheat on the same farms almost 50 per cent more at 5.65 tonnes a hectare. The England and Wales average for that year was 6.7 tonnes a hectare almost three tonnes a hectare more compared with organic wheat yields as recorded in that year (1989/90). The farm gate price received for organic wheat in this survey was at £228 a tonne twice that received for conventionally grown wheat £111 a tonne very close to the HGCA estimated

---

[3] Farm Incomes. 1991 edition MAFF HMSO London.

at £112.28 per tonne for 1989/90. Hence despite the lower yield, output per hectare was over a third higher for organic wheat. Moreover since expenditure on variable costs at £159 per hectare for organically grown winter wheat was almost 30 per cent less than for conventionally grown wheat then, the gross margin was over 75 per cent higher at £711 a hectare compared with £405 for conventionally grown wheat on the same mixed organic farms.

Table 3 Gross margins per hectare Mainly Cereal Farms

	Org	Conv[1]	Conv[2]
Winter wheat	711	405	510
Spring wheat	623	-	350
Spring barley	450	148	355
Winter barley	295	432	412
Oats	348	361	392

1 Conventional farms organic sample.
2 Conventional budget using farm planning data J. Nix 1989/90.

Since the gross margins for organic barley and oat crops were not so dissimilar from those for conventionally grown crops then winter wheat (Table 3) enterprises played the key distinguishing role in the economy of organic mainly cereal farms. The net effect was that the output per hectare on these farms at £734 a hectare was higher compared with mainly cereal farms in the FBS (Table 2) £658 a hectare. Farm retailing and processing also played a part in boosting the value of output on organic cereal farms but not by as much as commonly supposed. Total variable costs were higher on organic farms as also were contracting and marketing charges. This reduced some of the advantage enjoyed by the organic farms from the high prices received for organic wheat. The farm gross margin at £469 a hectare was almost identical to that for conventional farms (470 hectares), Table 2.

Fixed Costs

Though the organic farms incurred higher expenditure on labour and to a lesser extent on machinery this was off set by lower expenditure on land, buildings and miscellaneous overheads. The net effect was interesting, fixed costs on both types of farms, the FBS and organic samples, were practically identical. Consequently the net farm income differed by a mere £2 per hectare; at

£66 for conventional farms and £68 for organic farms. Indeed the imputed costs for farmers and spouses own labour was only slightly greater on the organic farms but this resulted in a lower level of management and investment income per organic farm of £1,415,(118 ha), compared with £2,225 for conventional farms, (131 ha).

Land Use and Composition of Output

The main difference between the two systems of farming was that organic farmers produced more output from forage fed livestock. The organic farms had just over 70 per cent of the farm area in arable cash crops which produced 63 per cent of the farm output. The remaining 37 per cent was contributed by livestock mostly sheep though the stocking rates were lower in comparison to conventional farms. In total organic products contributed 19 per cent of the total value of output, O which organic cereals contributed 11 per cent.

In contrast the conventional FBS farms had just over 85 per cent of the farm area in conventional cash crops, which contributed 87 per cent of the farm output. Only 13 per cent of the output was contributed by livestock enterprises. Thus the major difference between the two systems was that for every hectare of crops and grass on organic mainly cereal farms the output from crops was £463 compared with £576 on the FBS sample farms. In terms of arable cropping the organic farms were less specialised in cereal production compared with the conventional farms. In contrast the organic farms produced 37 per cent of the farm output from forage fed livestock. Not surprisingly the systems of organic farming adopted made heavy demands on farmers and spouses' own labour and this resulted in a lower level of management and investment income on these farms compared with conventional farms.

The financial results for both indicate that organic and conventional farmers engaged mainly in cereal production the difference in their levels of income were small and statistically insignificant. However the physical characteristics differed considerably. The organic farms were more labour intensive and the physical output from every hectare in production in organic crops was lower, (about 40-50 per cent) compared with that of conventional farms. Indeed physical productivity in general was low on these farms. Organic farms had to devote a third more of the farm area to crops and grass. Machinery costs were similar between the groups but the organic sample farms spent more on contracting services. It should be also emphasised that the value of output per hectare of cereals was £679 on conventional farms compared with £627 on organic farms despite the premium prices paid for organic cereals. However the organic farms generated more output per hectare both from cash crops such as vegetables, roots and livestock (mainly sheep). The net result was that the output was £76 more per hectare of land farmed. If they had modelled their farming systems similar to that of the average farm in the FBS they would have earned a higher level of management and investment income but this must be weighted against other factors such as the possible benefits of mixed farming in the longer run if lower input farming systems are to be encouraged.

Comparisons on other major production types

The contribution which organic enterprises made to farm output ranged from 18 per cent or mixed cropping farms to 38 per cent of horticultural farms. In many instances this was enhanced by on farm retailing and food processing. However there were only two production types where these revenues were substantial, on mixed livestock and especially on horticultural farms. Yet there was only one production type, mixed farms, where the organic farms excelled over conventional farms. However for those farms in this group who ventured to produce wholly organic produce 44 per cent of the sample, the results were rather disappointing. Output per hectare declined to £516 a hectare over 30 per cent lower compared with mixed organic farms who produced £761 a hectare, (Table 2). Though the yields of most organic crops were similar to the levels achieved on farms engaged partly in organic farming (mixed output), the performance of livestock enterprises, mostly sheep and grazing beef cattle was discouraging, despite the boost to valued added through farm processing and food retailing. They generated negative levels of net farm income -£4.50 a hectare and even lower levels of management and investment income because of the heavy demands made on unpaid farmers and spouses labour.

The results of this study strongly suggest that for those who were engaged in wholly organic farming, especially on small farms less than 50 hectares, the rewards are not very attractive and income levels were low and often negative. The most appropriate area for the integration of organic farming into existing farming systems would appear to be on the larger farm preferably engaged in livestock production and where some of the land can be switched to organic production through well planned transition farming. However for those who do there is a risk that output and income levels will decline. There is much work to be done on new husbandry techniques for organic and extensive (lower inputs) farming systems, the economic viability of which are fragile unless steered by competent and skilled farmers who painstakingly undertake these demanding systems of organic farming. There are opportunities for the supply industry which should not go unheeded.

Table 1

England

Survey Results on Organic Farming

Harvest Year 1989

	All Farms surveyed	Specialist Organic Farms (100% organic)	Conventional and organic farms (less than 100% org.)
No of Farms	185	93	92
Crops and grass	81.6	27.1	136.8
Woods & buildings	5.2	2.5	7.9
Total Farm area	86.8	29.6	144.7
	£ per hectare		
Output			
Farm output	892.0	780.3	915.1
Of which:			
(Value added on processing	9.5	18.4	7.6)
(Farm retailing	23.3	60.0	15.7)
Total misc income	44.4	81.3	36.8
Total output	936.4	861.6	951.9
Variable costs	323.9	242.0	340.9
Gross margin[1]	612.5	619.6	611.0
Fixed Costs			
Hired Labour	172.3	187.6	169.1
Machinery			
Depreciation	65.6	83.9	61.8
Fuel/elec	35.9	39.2	35.3
Repairs	42.0	40.9	42.2
Vehicle tax & Ins	6.5	11.1	5.5
Unallocated contract	11.6	6.1	12.8
Total machinery costs	161.6	181.2	157.6
Rent/rental value	106.7	107.2	106.5
Overheads	91.4	111.2	87.4
Total fixed costs	532.0	587.2	520.6
Income Measures			
Net farm income	80.5	32.4	90.4
Occupier's Income	95.6	15.5	112.2
Farmers' own labour	101.7	305.7	59.5
Management and investment income	-21.2	-273.3	30.9
Interest Payments			
Short term	28.8	30.5	28.4
Long term	26.4	49.0	21.7
Other farm income	7.5	24.5	4.0
TOTAL INCOME	88.0	56.9	94.4

TABLE 2

A comparison of costs and returns per ha. between farms engaged in organic produc

England

Farm Type	Mainly cereals		Mixed cropping		Mainly dairying		Mixed farming		Horticulture	
	A	B	A	B	A	B	A	B	A	B
Number of Farms	256	22	507	16	485	20	177	66	41	59
Area (ha)										
Crops & grass	125.7	113.8	144.6	133.8	68.6	183.6	71.2	92.9	29.7	10.3
Woods, buildings	5.2	4.1	5.4	12.6	5.3	11.2	5.7	5.8	1.2	1.0
Total area	130.9	117.9	150.0	146.4	73.9	194.8	76.9	98.7	30.9	11.3
					£ per hectare					
Output										
Farm output*	658	734	971	847	1554	940	587	761	4592	2548
Of which:										
(Val add on processing	0	1	0	1	0	3	0	8	0	131)
(Farm retailing	-	5	1	0	17	22	10	17	128	243)
Total misc income	51	38	43	45	36	22	51	50	175	155
Total output	709	772	1014	892	1590	962	638	811	4767	2803
Variable costs	239	303	350	281	695	308	257	264	843	1160
Gross margin[1]	470	469	664	611	895	654	381	547	3924	1643
Fixed Costs										
Hired labour	83	96	135	147	174	207	76	160	1556	481
Machinery	141	143	165	163	181	167	95	140	641	415
Rent/rental value	132	109	145	119	164	101	124	102	308	134
Overheads	48	56	73	90	58	114	46	77	941	240
Total fixed costs	404	405	518	519	577	588	341	479	3446	1270
Interest Payments										
Short term	-	35	-	17	-	30	-	24	-	79
Long term	-	34	-	24		22	-	18		116
Income Measures										
Net farm income	66	64	146	92	318	65	40	68	478	373
Occupiers income	62	105	131	176	278	88	30	57	299	252
Farmers' own labour**	49	52	47	42	125	41	108	85	270	981
Management and investment income	17	12	99	50	193	24	-68	-17	208	-608
Other on farm income	**1**	**4**	**0**	**1**	**2**	**2**	**2**	**6**	**5**	**90**
TOTAL INCOME	**67**	**68**	**146**	**93**	**320**	**67**	**42**	**74**	**483**	**463**

A = Farm Income Report 1991 edition MAFF London HMSO   B = Organic survey

* Net of breeding l'stock appreciation; these estimates of output and income may differ from those for production types shown elsewhere

** Imputed cost of farmers' and spouses' own labour

WEED CONTROL IN THE DEVELOPED WORLD WITHOUT CHEMICALS: IMPLICATIONS FOR AGRICULTURE, AGRICULTURE-RELATED INDUSTRIES AND CONSUMERS

MELVYN F. ASKEW

AGRICULTURAL DEVELOPMENT AND ADVISORY SERVICE, WOODTHORNE, WOLVERHAMPTON, WV6 8TQ, UK.

ABSTRACT

The food supply of Western Europe and North America is plentiful and wide in variety. Standards of food are high in fresh and processed foods and herbicides are an integral part of economic production. Herbicides are also used widely for safety and other reasons in non-food situations. Evidence suggests that herbicide use may be reduced in some crops as prices fall. There is no potential for abandoning herbicides without radical changes in food supply and quality and increases in hazards to staff or facilities elsewhere.

INTRODUCTION

Western Europe and North America are fundamentally economically well-developed regions where food supply is not usually limited and where diversity of choice is large. Apart from fresh food consumption both regions have considerable processed food industries providing a wide range of ready-to-eat or partially prepared foodstuffs.

Standards for food both in the raw state and in the prepared state are very high and usually set by contract specifications. Additionally, enshrined in the statutes of many countries in these regions are food safety standards which control or proscribe, the level of occurrence of non-food species in food. Similar standards are found in the European Community legislation involved in market support.

There have also been changes in many peoples' diet. This is especially so in recent years where there has been a trend to replace animal fats with vegetable oils; considerable changes in preferences and choice of food have occurred as disposable income has increased.

Agriculture has been able to respond to such demands of increased production and improved quality by a combination of improved cultivars which have been taken up by growers and crops produced from them using improved technology, much of it based upon crop protection with agrochemicals.

This is shown quite clearly by yield and production data and by agrochemical use data (FAO, 1989; BAA, 1991).

It is against this background that any changes caused by herbicide-free crop production would occur.

WHY USE HERBICIDES?

The use of herbicides is not a new process. In 1931 a UK delegation visited France to view the use of sulphuric acid as a selective herbicide in cereals; in 1932 two horse-drawn sprayers treated between 80 and 120 ha of UK cereals with sulphuric acid and by 1935, 155 sprayers treated approximately 12 000 ha of cereals with sulphuric acid in UK (Anon).

The use of herbicides can have one or more of several benefits depending upon the circumstances in which they are used:

i) Weed removal pre-planting of a crop.

ii) Selective removal of some weed species prior to sowing of/or from a cultivated crop stand to:

- a) Increase yield - directly
  - by aiding establishment or harvest
- b) Increase quality
- c) Reduce cost or need for mechanical weed control and skilled operators associated with it.
- d) "Pride in the job" and the social "stigma" of having weedy fields.

iii) Desiccation or killing of some or all weeds and/or a crop at or near to harvest as an aid to:

- a) Weed control in a rotation.
- b) Total weed control in a crop to aid harvesting.

iv) Total and persistent weed control in industry and amenity.

The above are now discussed individually.

i) Weed removal pre-planting of the crop.

In essence this is total weed control but without leaving phyto-active residues. Such processes could involve, for example, the use of paraquat to kill weeds or volunteer cereals pre-sowing or pre-planting of many crops or the use of products containing glyphosate to control couch grass (Elymus repens) again prior to a range of crops.

Non-persistent weed control in the absence of crops has advantages of not requiring selectivity; reduction of moisture loss caused by weeds and mechanical weed destruction; reduction of potential competition or contamination of the sown/planted crop produce with established weeds; in most cases, easier and more rapid drilling of the crop. Moisture conservation is of particular importance in much of Europe.

Table 1: UK agrochemical sales by year (£ million)

UK Sales (£m)

Area of Use	1984	1986	1988	1990
Herbicides				
Agriculture, horticulture	166.5	175.8	202.1	181.2
Industry, forestry	4.7	5.9	6.8	9.1
Garden, household	7.0	8.6	10.3	9.1
Total	178.2	190.3	219.2	199.4
Insecticides				
Agriculture, horticulture	30.9	25.2	28.7	38.6
Industry, forestry	1.1	0.8	0.8	1.2
Garden, household	4.6	5.7	7.7	7.0
Total	36.6	31.7	37.2	46.8
Fungicides				
Agriculture, horticulture	90.2	94.5	108.7	128.0
Industry, forestry	0.6	0.8	1.0	1.5
Garden, household	1.1	1.2	0.8	1.1
Total	91.9	96.5	110.5	130.6
Molluscicides				
Agriculture, horticulture	-	-	8.9	1.0
Seed Treatments				
Agriculture, horticulture	14.7	13.8	11.3	12.7
Growth Regulators				
Agriculture, horticulture	6.7	8.8	9.9	11.7
Herbicides/Fertiliser Mixtures				
Garden	2.3	2.3	2.9	3.8
Other Pesticides	10.9	9.4	9.2	7.5
Total	341.3	352.8	409.1	413.5

Source: BAA, 1991

The removal or prohibition of non-persistent pre-sowing/planting herbicides would necessitate an increase in cultivations allied to a delay in planting or sowing of many crops. It would cause major problems in quality cereal production, when straw burning was no longer an option to destroy shed corn yet where production of quality wheat or barley was planned. Losses in price between £20 or £25 per tonne at current British prices respectively could occur. Alternatively, were it practicable, extra cleaning/sieving costs of at least £2 per tonne would be incurred.

Additionally were pre-sowing/pre-emergence weed control to cease extra pressure would be put upon selective weed control; this would conflict with the current conception that agrochemicals are "best" applied as far from consumer use of the crop as possible.

ii) Selective removal of weed or volunteer species prior to sowing of or from a cultivated crop stand

iia) Published data shows that in 1990 in the United Kingdom sales of active ingredients in agriculture and horticulture were 23,750,000 kg (of which 11,927,000 kg were herbicides) and in industry and forestry 702,000 kg (of which 576,000 kg were herbicides) (BAA, 1991).

In financial terms these amounted to a total of £413,500,000; of which £199,400,000 was herbicide. Table 1 shows a breakdown of data and market trends.

An analysis of agrochemical use in Great Britain in the 1990 harvest year is shown at Table 2.

Table 2: Agrochemical use by crop, 1990, Great Britain

	Cereals	Potatoes	S. beet	Oilseed rape
Area grown 1989/90 '000 ha	3,795	154	196	414
* Herbicides - total	7,418	225	932	728
- Couch/stubble	318			
- Wild-oat/blackgrass	3,212			
- dicot. weeds	3,888			
* Fungicides - total	10,083	618	-	600
* Insecticides - total	3,023	146	302	543

* - single hectare-sprays   More than one treatment can occur

Source: BAA, 1991

Table 2 shows that in Great Britain more hectare treatments with fungicides occur than with herbicides. This is quite different from the overall world situation where approximately half of the product used is herbicide; 1/5 fungicide and 1/3 insecticide. Table 2 also highlights the fact that the entire cereal area equivalent is treated specifically against dicotyledonous weeds and that the equivalent of 84% of the area is treated against blackgrass and/or wild oats. It has to be decided whether or not this is worthwhile? Could it be dispensed with?

Evans (1969) found that in experiments on broad-leaved weed control in winter and spring cereals over 269 sites in 3 years, weed control varied, 26% of sites being very good, 40% good, 21% fair and 13% poor.

Yield responses to herbicides used in the same experiments, but quoted by crop species were:

Spring barley	-0.3 to + 0.3 cwt/ac	(-0.04 to + 0.04 t/ha)
Spring wheat	-1.2 to 0.0 cwt/ac	(-0.15 to 0.0 t/ha)
Winter wheat	+0.1 to +1.9 cwt/ac	(+0.01 to 0.23 t/ha)

Yield responses were better where good weed control was achieved; a range of common broad-leaved weeds were present in the crops. However, with cost of product and its application it would appear that broad-leaved weed control in cereals was at that time marginally economic at best.

Since 1969 new products have been introduced; newer, higher yielding varieties, some perhaps more sensitive to stress, have been bred and weed spectra have changed. The more difficult dicotyledonous weeds to control, for example, cleavers (Galium aparine) and the graminaceous weeds, including volunteer cereals, have increased in incidence. Wilson (1981) reported wild-oats (Avena fatua) to be a continuing problem in cereals but that straw burning had beneficial effects in reducing seed population of the weed in the soil; Moss (1981) reported black-grass (Alopecurus myosuroides) to be favoured by tine-cultivation or direct drilling; Budd (1981) reported increasing incidence of sterile brome (Bromus sterilis) in harvested cereal samples.

In a review of ADAS experiments Baldwin (1981) concluded that black-grass-induced yield reductions in wheat varied according to amount of nitrogenous fertiliser applied and severity of weed infestation whilst fertilizer nitrogen did not have any effect in the absence of black-grass, effects were massive at 323 blackgrass per m^2 (grain yields were 3.24 t/ha @ 50 kg/ha N; 4.32 t/ha @ 100 kg/ha N; control 6.00 t/ha). With wild-oats Smith and Towerton (1981) found yield increased from zero to 225% in wheat according to weed incidence and control product. Similarly large responses to control of sterile brome (up to 40%) were reported by Orson (1981) but in this instance chemical weed control was less effective than with the 2 preceeding species.

A review of autumn and spring application of broad-leaved weed control (Orson, 1982) showed a considerable range of yield responses in winter wheat (-0.12 to +0.45 t/ha) but a smaller range in winter barley (-0.03 to +0.34 t/ha).

It does seem likely therefore that some reduction in herbicide use for control of dicotyledonous weeds could be possible. Total abolition of herbicides for weeds would reduce yield and food production.

The situation in European oilseed rape production, the most important arable sector crop after cereals, and yield benefits from weed control, splits into dicotyledonous weeds, where yield responses per se are small, and monocotyledonous weed control (especially that of volunteer cereals) where yield benefit vary according to density of weed population and the time of their removal. Ward and Askew (1984) reported small and generally non-significant responses to broad-leaved weed removal; similar results were reported by Ward and Turner (1985); Jewell (1989) demonstrated similar results but showed that good yield responses from controlling aggressive species like cleavers. Removal of volunteer cereals showed seed and oil yield benefits from weed control in 2 of 8 experiments (Lutman, 1984). These findings were supported by Ward and Turner (1985); Ogilvy (1989) and Bowerman (1989).

In potatoes yield responses from weed control were small and variable (Askew and Flint, 1985; Orson, 1986; Jewell and Short, 1986) but shown to be more positive and significant by Nelson and Thorenson (1981).

It seems reasonable therefore to conclude that yield benefits alone do not in many circumstances justify current level of herbicide use in some mainstream arable crops; herbicide use could be reduced. Conversely, where aggressive weed species are controlled by herbicides, the prohibition of herbicides would materially affect total production and food supply. Certainly palliative measures could be taken (for example, spring sowings rather than autumn sowings) albeit that these would reduce yield. Subjective assessment suggests reductions of 1-2 t/ha in barley; 2-3 t/ha in wheat; 1 t/ha in rapeseed. On a European basis these reductions would amount, at maximum, to 20% barley production; 30% wheat and 35% rapeseed. Estimates are based upon E.C. 12 crop area data for 1990 (E.C. 1991). There would, of course, be increased costs in terms of cultivations to eradicate or reduce weed number during the winter fallow period. Additionally non-pecuniary disadvantages would occur with such a change; there would be increased nitrogen leaching from soils during winter; a reduction in available winter food for wildlife (it is thought that winter oilseed rape is a major reason and feed source for the high woodpigeon (Columba palumbus); populations in Great Britain and possibly north east France); there would be an increased and possibly untenable, workload in spring which would at least delay sowings and thereby incur yield penalties or crop failures which in turn would limit food supply.

The establishment and development of good yield potential in some crop species like sugar beet is often difficult on light soils in the "sand" soil classification and on high organic matter soils since such soils are liable to drying out and are then prone to wind erosion. Estimates suggest that up to 20% of sugar beet in Britain was grown on such soils in 1991; French data suggests a further 2% at risk in French sugar beet production (Choppin de Janvry - Personal Communication).

Prediction of incidence of "blowing" is not possible: the only option therefore is to undertake preventative action as routine. In wind erosion incidents seed and soil are frequently blown from the field; any young plants die from desiccation or mechanical abrasion. The drilling of cereals between the rows of crops at risk gives protection from "blowing"; these cereals are later removed with a selective herbicide. Redrilling of crops after blowing is an option but this increases costs and since it usually occurs later than optimum sowing date does not produce maximum root or sugar yield in the case of sugar beet. Subjective estimates suggest average yield reductions of 4 t/ha of clean beet, equivalent to approximately 0.64 t/ha of sugar where redrilling occurs. Presuming only 10% of the British sugar beet area drilled on wind erosion prone soils to be "blown" the yield reduction would be over 3000 tonnes clean beet or 500+ tonnes sugar.

Other crops grown on wind erosion prone soils and at risk to loss from it include carrots, onions and a range of other horticultural crops including small transplants. With some of these there is the possibility of using floating plastic mulch to protect the crop and enhance its earliness and through that, market value. However as a broad generality floating plastic mulches would not be practicable or economic options, nor indeed would they be generally environmentally acceptable.

iib) Selective removal of weeds to enhance quality

Herbicides alone or in conjunction with other weed control techniques are used to remove weeds, including volunteer crop species, from a range of crops, especially those destined for human consumption although the value of the herbicide contribution to quality varies considerably.

It has been shown that many of the most popular potato cultivars grown in Britain have the propensity to produce so-called berries and these in turn to carry large quantities of viable true potato seed (TPS) (PMB, 1991a; Lawson, 1983). The population dynamics of volunteer potatoes arising from such TPS show that they will persist at significant levels through most normal rotations (Askew, 1991). In doing so they perpetuate the production of further "potato berries" which can occur in other crop species used for canning or freezing. In peas for processing the occurrence of such berries would cause the crop to be rejected. Output losses alone in this instance could amount to £700 per ha (Gent, Personal Communication). This is in effect virtually a total crop loss for the producer and is accompanied by unquantifiable losses for the processor in terms of idle factory capacity and a reduction in added value as well as a negative effect on the balance of payments for the country as imports are sucked in to fill the vacuum caused by a shortfall in home production. Whilst volunteer potatoes have been used as an example, seed capsules of linseed, seed heads of thistle, seed/fruits of bryony and other weeds would be equally unacceptable.

In potatoes themselves volunteers produce tubers and these in turn contaminate samples for processing or ware use. The severity varies and if the volunteer tubers are visually identifiable they could be removed, at a cost, manually. However should a white or yellow-skinned cultivar occur as a contaminant in processing cultivars, most of which are whitish or yellow skinned then quality of produce could be adversely affected.

The same would occur if the wrong coloured skin variety occurred in a pre-pack sample. In 1990 approximately 700,000 tonnes of potatoes were pre-packed in the United Kingdom and approximately 26% (c. 1.4 million tonnes) of the total crop produced in the United Kingdom processed in one form or another. (PMB, 1991b). Volunteers can also contaminate potato seed tuber certification stocks in many countries.

Contamination of small-seeded crops also causes yield, quality and financial loss although it is not always feasible to reduce contamination using herbicides. The option of using manual labour to reduce such weeds and therefore contamination is not feasible on the basis of cost in developed countries. Examples of contamination of small-seeded crops include low glucosinolate types of volunteer rapeseeds occurring in culinary mustard and thereby reducing quality; high erucic acid-containing cruciferous weeds or volunteers occurring in conventional rapeseed reducing quality and, if high enough in numbers, causing the total crop to be valueless; wheat occurring in barley or vice versa reduces value; weed beet in sugar beet reducing value and yield.

Many trading standards both internally, in the European Community and worldwide stipulate maximum levels of contamination with non-crop species and many specify analytical quality standards too, whilst in some countries specific standards are laid for specific weeds (for example Canola in Canada - wild mustard; sugar beet in several countries - weed beet).

iic) Reduction of need for skilled labour and/or cost in weed control.

Applying herbicides using a tractor drawn or mounted sprayer of a commonly used size, for example, 15m, takes approximately 0.6 man hours per hectare (Nix, 1987). Precise figures depend on shape and size of the field to be sprayed, proximity of water supply and sprayer tank capacity. In row crops, mechanical cultivations could provide an option for weed control using a steerage hoe. Mechanical hoeing would take approximately 2 man hours per hectare per cultivation or up to 4 man hours per hectare with a 2 man team using steerage hoeing. Weeding within the row would still necessitate the hoeing gang, as used to occur in sugar beet production prior to the introduction of herbicides, monogerm beet and drilling-to-a-stand. Currently some row crop vegetables are still hand-weeded. Work rate is approximately 20 man hours per hectare at a current UK cost of £75 per hectare (Briggs - Personal Communication).

Subject to the availability of staff and the time lag which would occur whilst they were trained to identify weed and crop species, mechanical and hand-weeding could, in principle, be used as the sole weed control in row crops. Cost would be high and generally in excess of current herbicide costs; timeliness of weed control is unlikely to be optimal, since work rates would be lower; employment would need to be found for staff at intervals between weed control periods. It should be remembered that many crops would need to be weeded several times at intervals of two or more weeks apart. The supply of such labour would need to be set against a declining agricultural population in developed countries and a perceived but understandable reluctance for anyone to work long hours, frequently in adverse conditions on an extremely monotonous task .

iid) "Pride in the job" as a reason for weed control

It is widely thought that job satisfaction and "pride in the job" are major factors in maintaining good performance from staff at all levels of responsibility (McGregor, 1985). Agriculture appears to be no different from other industries, as exemplified by ploughing matches; best farm competitions; potato storekeeper and spray operator of the year competitions; best animal beef/sheep/pig at agricultural events throughout the world. On this premis it is therefore understandable that there appears to be a desire on most farmers' parts to minimise or indeed eradicate weeds.

The social stigma of "the missed strip" when applying herbicides still pertains. Nonetheless the public impression of a large infestation of field poppy (Papaver rhoeas) is very favourable, despite the fact that this plant may be an agricultural cost.

It is impossible to evaluate "pride in the job" or to balance it against economic weed control. Moreover even though the public impression of field poppy may be acceptable their impression of stinging nettle (Urtica dioica) or thistle (Cirsium spp) could be quite different.

iii) Desiccation/total weed control pre-harvest

A number of important arable crops are frequently desiccated or alternatively, and where possible, mechanically pretreated as an aid to harvesting and/or quality assurance. These include winter oilseed rape, linseed, maincrop potatoes. Occasionally dried peas or field beans are dessiccated in weedy conditions or with the need to kill off indeterminate growth. Ease of harvesting, reduced damage to crop and improved storage potential are not quantifiable but nonetheless important.

With the advent of the technique of using glyphosate pre-harvest of cereals as a weed control measure it became possible to achieve some control of volunteer potatoes, a major problem in some parts of Europe and one for which there is no single effective control measure, Arctic winter conditions and deep, penetrating frosts excepted. In essence this is rotational weed control where the weed may or may not have significant adverse effects upon the host crop, but would certainly have adverse effects on other crops in the rotation where its control might not be a possibility.

iv) Total and persistent weed control

Whilst Agriculture and Horticulture are major users of weed control technology there are a large number of other areas where weed control is essential. Statistics quoted earlier show in 1990 576,000 kilos of herbicides were used in industry and in forestry in UK for various types of weed control (BAA, 1991). Worldwide 14.8% of agrochemicals are used outwith mainstream agriculture or horticulture (County Natwest 1991); of that approximately half could be herbicides. These uses include railways (in 1990 UK had approximately 40,000 kilometres of track); industrial sites where weeds including scrub, create fire or safety hazards; waterways and associated land where weeds cause impedence of water flow, reduce navigable water and cause safety and to a lesser extent fire risks; around public buildings and car parks, especially where mineral chippings or gravel are used as a final screed. Obviously requirements vary substantially and hand labour is still used to a degree. It does not seem feasible to suggest alternatives to herbicides in many instances where hand labour is not used at present, especially where this would entail placing operators or facilities at greater or more frequent risk than they are at present because of physical conditions. Where herbicides are used to control pests or diseases affecting humans or their habitation, by killing host plants or destroying harbourage, benefits are obvious but intangible.

THE FUTURE OF AGRICULTURAL PRICING

Since the opening of the Uruguay round of the General Agreement on Tariffs and Trade (GATT) there has been a degree of acceptance amongst trading states in developed countries that the various types and degrees of agricultural aid, and where it occurs, horticultural aid payments have distorted markets and that a freer trading system should be created.

Within the European Community steps had already been taken to contain arable production within its planned aid budgets through co-responsibility payments in cereals or maximum guaranteed quantity arrangements and penalties for oilseeds and pulses. On July 31, 1991 further changes were proposed by European Commission. These are intended to fulfill GATT requirements on competition whilst maintaining cost of crop production aid within planned common agricultural policy budgetary limits. Final decisions will be announced on or after 31 October 1991; for sunflower, oilseed rape and soya bean they are likely to involve flat rate area payments up to a maximum area in EC 12 accompanied by substantial cuts in price per tonne of each individual crop. For example the oilseed rape price will fall by approximately 50% to approximately £130 per tonne. The European Commission plan to stabilise it within 8% of that price before taking any further action should price rise or fall. Similar but independent systems will be announced for sunflower and soya.

Inevitably changes in unit price will cause a reviewing in producers' minds of inputs and their unit cost. Using oilseed rape as an example, yield in the major producing countries in Europe has usually been between 2.9 and 3.5 tonnes per hectare and return has been made and aided on a per tonne basis. Under the new proposals the unit price will fall substantially and return be aided with the area payments described above, subject to various rules of fairness and honesty. Hence the producer will receive the same aid as others in his locality whether he produces 1.5 tonnes per hectare rapeseed or 3.5 tonnes per hectare rapeseed. The rapeseed itself has become less valuable and in doing so the marginal cost of producing each unit weight of rapeseed will need to fall too.

These price structure changes as they occur throughout arable crop production of the European Community, and where they have already occurred as in Canada and USA not only demand reduced input costs, but after a point reduce inputs in absolute terms too.

COST: BENEFIT AND AGRICULTURAL CHEMICALS

It has already been suggested earlier that inputs of herbicides to some crops in some situations could be rationalised, based on purely economic grounds. Continuing the example above, if rapeseed yields 3t/ha seed at £130 per tonne and yield benefits from broad-leaved weed control were only 0.1 or 0.2 t/ha seed then herbicide costs including application costs, should in pure economic terms be less than £13 or £26 per ha.

In terms of yield alone the same would hold true for fungicide and insecticide use on rapeseed and indeed the entire scenario would be repeated for each individual crop species.

On the presumption, perhaps, spurious, that more expensive inputs are more effective inputs, then less effective materials would be used for yield benefit alone. This in turn could lead to a change in weed species and numbers, other criteria remaining unchanged. Pest and disease incidence and severity might increase. At that point cost:benefits would need to be reviewed and more effective (and expensive?) materials used if they were still manufactured.

In essence entirely new thresholds for weed, pest and disease incidence and corrective measures would be needed.

Yield benefit is only one aspect of agrochemical use; quality and reliability of yield are others which are at least as important in many crop species and market outlets.

Reductions in agrochemical use might not necessarily reduce yield as such since mechanical or other cleaning or purifying processes could be introduced or improved in drying, storage or processing. However all carry a cost and unless that cost were within the range that the industry could afford would need to be passed on to the consumer in added-value products at least. It would be ironic if the consumer had to pay more for lower quality produce!

FUTURE CROPPING PATTERNS

Should herbicides be proscribed then, as indicated earlier, there could be a move to later drilling of winter cereals in order to control early-germinating graminaceous weeds allied with a transfer of some drilling to spring in order to ease workload. Alternatively there could be a massive shift to spring cereals in order to allow autumn or winter weed control by mechanical means. Such a change would have "knock-on" effects on use of other agrochemical, for example, autumn use of pyrethroids against aphids as a means of controlling barley yellow dwarfing virus whilst wheat bulbfly damage and materials for its control would be in less demand. Similarly autumn and spring fungicide programmes would be substantially rationalised.

The same situation could be envisaged with winter oilseed rape where volunteer cereal control would need to be undertaken mechanically, thereby causing delays in establishment in what is already a narrow time window for drilling. An increase in spring rapeseed area would accrue;

this would generally have a reduced need for herbicides and fungicides but an increased need for insecticides, all subject to acceptable cost: benefit values.

However proscription of herbicides would not be the only factor that might cause a drift towards spring crops, at least in the European Community. If the proposals on area aid described above were accepted then growers in several member states may find spring rapeseed production, with reduced input costs for the same area payment as that for winter rapeseed an increasingly attractive proposition. Constraints upon this change may occur for other reasons, for example, a statutory requirement to have 65% arable land under a crop in the autumn as a means of controlling nitrogen leaching in soil as in Denmark. Alternatively use of volunteer cereals or special sowings of low-cost catch crops as nitrogen leaching preventatives which were ploughed down the following February could develop. The ramifications of such changes are wide ranging.

The horticultural situation is likely to be quite different from that in agriculture since reductions in agrochemical use, especially fungicides or insecticides would lead to reduced produce quality. That would either cause a drastic reappraisal of what consumers considered acceptable, or, if other countries still used such products, an ingress of their produce to fulfill market requirements. Alternatively some produce would become immensely expensive being developed in the short term from plants selected perhaps by novel means for pest and disease resistance and grown with high labour inputs, whilst other species or types could cease to be cultivated totally. Inevitably, the consumer could then face a smaller choice of produce.

THE AGROCHEMICAL INDUSTRY OF THE FUTURE

The use of agrochemicals clearly depends upon their ready availability and reasonable cost. In turn these factors are governed by research and development costs, not least of which are the justifiable demands for more and better data to ensure human and environmental safety. Mass markets for product generate sales and profit which in turn allow reinvestment. Whilst simplistic, these statements are undeniably true and the dearth of new products for small area crops in horticulture and even in agricultural crops like field beans and linseed highlight the problems of low use, low sales and therefore limited profitability of product. It should be noted that virtually half of agrochemical sales are herbicides.

If reductions in agrochemical use generally, or herbicide use specifically, were enforced directly or caused through other reasons, profitability and reinvestment would be reduced. This would be especially so if price forces caused a move to cheap commodity chemicals. It is estimated that the cost of discovering, developing and marketing a new agrochemical is £25-40 million.

Such financial constraint would be outwith any financial constraint imposed by the world economy as a whole and, in UK at least, recent recessions have reduced herbicide use in agriculture and horticulture by 5.3%, equivalent to approximately £10 million per annum.

CONCLUSIONS

Whilst agrochemical use, allied to other developments in agriculture, horticulture and industry has helped produce many diverse benefits, not least in terms of choice, supply and quality of food it seems probable that some economies in some areas of use are justified. Also changes caused by GATT and CAP reform will reduce farm gate price of some mainstream products so that reductions in production costs or changes in cropping will be necessary. These are unlikely to benefit the agrochemical industry; it is too early to say whether or not they will benefit agriculture or horticulture or other users of agrochemicals.

REFERENCES

Anon. (undated) A practical guide to sulphuric acid spraying in agriculture. Publ. National Sulphuric Acid Association Ltd.

Askew, M.F. (1991) The bio-dynamics of volunteer potato populations. Proceedings of British Crop Protection Conference - Weeds - 1991. In Press.

Askew, M.F.; Flint, C.E. (1985) Trials with metribuzin applied as a low dose programme. Proceedings of British Crop Protection Conference - Weeds - 1985, 819-826.

Baldwin, J.H. (1981) A review of trials by ADAS on Alopecurus myosuroides. Proceedings of AAB Conference on grass weeds in UK, 197-206.

Bowerman, P. (1989) Weed control in winter oilseed rape - a review of ADAS trials 1985-1987. Aspects of Applied Biology, 23, 219-226.

Budd, E.G. (1981) Survey, dormancy and life cycle of Bromus sterilis (Barren brome) in cereals, with particular reference to spring barley. Proceedings of AAB Conference Grass Weeds in Cereals in UK, 23-30.

County Natwest Wood/Mac (1991) in Agrow, No. 136,23.

E.C. (1991) Unpublished European Commission data.

Evans, S.A. (1969) Spraying of cereals for control of weeds. Experimental Husbandry, No. 18, 102-109

F.A.O. (1989) Annual yearbook, Production. Publ. Food and Agriculture Organisation of United Nations, Rome.

Jewell, S.N. (1989) Herbicide programmes for broad-leaved weed control on organic soils. Aspects of Applied Biology, 23, 251-256.

Jewell, S.N.; Short, J.L. (1986) An assessment of herbicides for potatoes on organic soils. Aspects of Applied Biology, 13, 245-252.

Lawson, H.M. (1983) True potato seeds as arable weeds. Potato Research, 26, 237-246.

Lutman, P.J.W. (1984) The effects of weed competition and growth and yield of oilseed rape. Aspects of Applied Biology, 6, 209-220.

McGregor, D. (1986) The human side of enterprise. Publ. McGraw Hill.

Moss, S.R. (1981) The response of Alopecurus myosuroides during a four year period to different cultivation and straw disposal systems. Proceedings of AAB Conference on grass weeds in cereals in UK, 15-22

Nelson, D.C. Thorenson, M.C. (1981) Competition between potatoes (Solanum tuberosem) and seeds. Weed Science, 29, 672-677.

Nix, J. (1986) Farm Management Pocket Book. Publ. Wye College, Ashford, Kent.

Ogilvy, S.E. (1989) The effect of severity and duration of volunteer barley competition on yield of winter oilseed rape - a review of ADAS trials 1986-1987. Aspects of Applied Biology, 23, 237-244.

Orson, J.H. (1981) The control of Bromus sterilis in cereals with herbicides. ADAS results 1979 and 1980. Proceedings of AAB Conference Grass weeds in cereals in U.K., 291-298.

Orson, J.H. (1982) Annual broad-leaved weed control in winter wheat and winter barley, autumn and spring treatments compared. Aspects of Applied Biology, 1, 43-52

Orson, J.H. (1986) Chemical control of weeds in maincrop potatoes. ADAS Ag. Service and Terrington EHF results, 1983-1986. Aspects of Applied Biology, 13, 253-262.

P.M.B. (I991a) Bulletin of Statistics on Potato Production in Great Britain. Publ. Potato Marketing Board, Oxford.

P.M.B. (I991b) Potato Processing in Great Britain, 1990. Publ. Potato Marketing Board, Oxford.

Smith, J., Towerton, J. (1981) The sequential use of herbicides for the control of Avena spp. in winter cereals. Proceedings of AAB Conference Grass weeds in cereals in the U.K., 283-289.

Ward, J.T., Askew, M.F. (1984) The control of annnual grass and broad-leaved weeds in winter oilseed rape. Aspects of Applied Biology, 6, 239-250.

Ward J.T., Turner, E.W. (1985) Annual grass and broad-leaved weed control in winter oilseed rape. British Crop Protection Conference - Weeds - 1985, 223-230.

Wilson, B.J. (1981) A review of the population dynamics of Avena fatua in cereals with special reference to work at W.R.O. Proceedings of AAB Conference Grass weeds in cereals in the U.K., 5-14.