Pesticids Chemistry and Bioscience: The Food-Environment Challenge

Pesticide Chemistry and Bioscience

The Food–Environment Challenge

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Preface

During the last 30 years, the IUPAC sponsored Congresses of Pesticide Chemistry have provided an enthusiastically supported four-yearly forum for the presentation of the latest developments in this increasingly complex subject. The 1998 Congress is the last of the series in the present century. The scope of the Congress has increased greatly over the years, particularly to satisfy increasing environmental concerns. This development is summarised in the theme of the 1998 Congress: The Food–Environment Challenge, which reflects the problems that await solution in the next millennium.

The papers in this volume are derived from the plenary and symposia lectures presented at the Congress and are sectionalised into the eight main topics of the Congress, arranged in the traditional order, ranging from Chemical Synthesis, through Mode of Action and Resistance related topics, to Regulation and Risk Assessment. They demonstrate the remarkable changes that are taking place in approaches to crop protection, in response to the above challenge.

In addition to these papers, the Congress included more than 1100 poster presentations, with associated poster discussion sessions. Most significant is the now routine application of the techniques of molecular biology/biotechnology in all areas relevant to 'Pesticide Chemistry'. Together with concurrent advances such as combinatorial chemistry, these techniques are bringing a revolution in our understanding of the life processes involved and in our ability to develop complex, environmentally acceptable strategies for weed, pest and disease control.

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Contents

Natural Products

Mode of Action and Resistance

Metabolism

Environmental Fate

Residues in Food and the Environment

Regulation and Risk Assessment

Plenary Lectures

How Can Technology Feed the World Safely and Sustainably?

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1 INTRODUCTION AND BACKGROUND

I was delighted to be asked by the Chairman of the Executive Committee, John Finney, to provide one of the opening addresses for this meeting to be entitled, "How can technology feed the world safely and sustainably?" One of the great advantages of working in an industrial context is that one is influenced by other members of multidisciplinary teams who have complementary skills. I have been taught by our patent attorneys that the key approach to answering any question is to ensure that you fully understand it. Accordingly, I have dissected the question which I have been posed into individual words and will discuss the underlying meaning of each to provide some background to the full meaning of the question as a whole.

1.1 How

This begs the question of the impact of various technologies on the world's food supply. With regard to sufficiency, the World Bank estimates that ca. 90% of the required increase in food production will come from yield increases on existing acreage.

Technology will need to make vital contributions to:

- protecting yield - by control of weeds and pests
- increasing yield - through agronomic effects and by provision of cultivars which optimise production of the useful parts of plants and
- improving yield - by enhancing the composition of plant products eg. oils, proteins, nutrients relating to specific food needs

At a more detailed level, advances in technology will assist the whole process of provision of crop management products from invention through to market.

1.2 Can

The two key questions here are whether it will be technically feasible to feed the burgeoning world population in coming decades, and whether political choices will encourage or hinder the adoption of such technologies.

A combination of technologies has provided a 2% annual global increase in yields over past decades. It is tempting to simply assume by extrapolation that this rate of increase can be sustained over coming years, or even accelerated, but this can only occur through sustained innovation. Figure 1 illustrates that comparatively little of the total land area of the world is currently under the plough and the area made available for crop production increased very slowly in the period 1985-1995. During the same period however population increased by 16%. The food production index showed an increase of 22.1%, reflecting an increasing agricultural intensity to meet the consumer requirement for better food variety and quality[1].

The World 1985-1995

Total land area = 13.0 billion ha

	1985	1990	1995	% Change 1985-1995
Arable and permanent crops (billion ha)	1.44	1.46	1.48	2.8
Population (billion)	4.89	5.28	5.68	16.1
Food production index	90.7	100.8	110.8	22.1

Source : FAO Yearbook, Vol 50, 1996

Figure 1 *Land in agricultural production*

Figure 2 illustrates the gain in the yields of various crops in different geographic locations from the 1950's to the 1990's. It can be seen that gains have been substantive across a broad range of crops and countries[2]. The success of modern farming methods has confounded the gloomy predictions of world starvation which were so common in the 1950's and 60's.

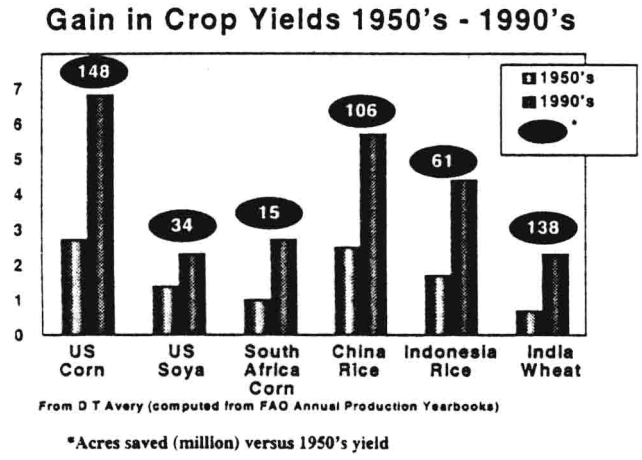

Figure 2 *Gain in Crop Yields 1950's - 1990's*

The continuance of this positive trend will have several dependencies. The successful progress of the last half century has been largely based upon science and technology applied to agriculture. It is therefore of concern that, in real terms, the funding of agricultural research is declining. Taking the US as an example, federal and state government spending on agricultural research has declined by approximately 30% in the last 25 years, and that in the private sector by 14%. In the early 1990's, the combined public and private spend in the US was approximately $5 billion, dwarfed by farming subsidies of $100 billion per annum. Furthermore, the spend on agricultural research appears minuscule alongside the three trillion dollar food industry which is supported by agriculture. It is likely that the current upsurge in the funding of research in biotechnology will reverse this trend, at least temporarily, but there must be concern that the more traditional, yet fundamental areas of agriculture and associated environmental issues will be neglected. Indeed, governments of developed countries with very adequate food supplies are presently questioning the current levels to which agricultural research (and the industry) are supported.

Even if we assume that advances in technology will enable us to meet food demands, there must be a question as to whether political forces will permit this to happen. In Figure 3, I quote the concerns of Norman E. Borlaug, recognised as one of the fathers of the Green Revolution for which he was awarded the Nobel Peace Prize. I believe that this quotation succinctly summarises the current situation[3].

"Twenty seven years ago, in my acceptance speech for the Nobel Peace Prize, I said that the Green Revolution had won a temporary success in man's war against hunger. I now say that the world has the technology - either available or well-advanced in the research pipeline - to feed a population of 10 billion people. The more pertinent question today is whether farmers and ranchers will be permitted to use this new technology. Extremists in the environmental movement from the rich nations seem to be doing everything they can to stop scientific progress in its tracks."

Norman E. Borlaug, Plant Tissue Culture and Biotechnology, 1997, 3, 126

Figure 3

The perception of science and scientists by the public in very many developed countries is negative, especially in the context of pesticides in the environment and dabbling with Nature by the genetic modification of plants and hence food. Clearly, as scientists we have not sold our message. The benefits provided by technology are taken for granted but the risks are considered unacceptable, however minute they may be. Some pressure groups have now raised their suspicions around chemical pesticides and genetically modified crops to the level of an ideology and outright opposition is voiced. Moratoria are proposed, irrespective of the outcome of science-based risk assessment, and constructive dialogue seems impossible. In many countries, the political response is already leading to damaging legislation with no heed being paid to providing solutions to root causes of problems. It is now imperative for the crop management industries to address the issue of public perception more proactively and with greater skill than in the past.

1.3 Technology

The last five years have seen greater changes in technology than in the previous fifty. For half a century, organic chemistry has provided a reliable mainstay for crop protection, but its prominence is being challenged by exciting developments based upon biotechnology. For the first time, growers have a real choice of technology. Furthermore, the creativity of the scientists and technologists who support the industry continues unabated, and at present there is a positive prognosis for delivery of sufficient appropriate technology to feed the world for decades to come.

Recent advances in technology will provide the major focus for this paper, and will be addressed in Section 2 below.

1.4 Feed

Conventionally, crop protection chemistry has been considered as part of the chemical industry. More recently, we have all come to understand that we form a key part of the food provision industry. This has demanded that we understand the complex interrelationships with the other parts of the food provision chain and that we come to terms with new influences beyond the farm gate. Accordingly, dialogue with processors, food companies and retailers is intense. The strategies of several of the agrochemical majors is to participate by vertical integration into the food provision chain, whereas others such as Zeneca choose to rely upon partnerships. Whichever, we are climbing a steep learning curve with regard to the key customer values which motivate the aspirations of the downstream food companies. This has required an immense amount of adaptation and has required assimilation of a battery of new skills and concepts. Furthermore, consumer attitudes to food are highly variable by geography, and often run counter to trends in globalisation.

One notable feature of the food companies is that they are huge - Figure 4 illustrates the 1995 sales figures for the top five companies, taken from annual reports to shareholders. As such, they dwarf the sales of the individual crop protection/management companies. Given their position opposite the consumer, and their proximity to the regulatory affairs debate, it is not difficult to imagine why partnerships with the food companies are highly valued. It is noteworthy that several of these companies have an enormous global reach - Nestle's food sales for example are greater than food sale purchases in countries such as Mexico, Spain, Holland, Belgium and Australia.

The technological revolution which is presently impinging upon the crop protection industry has significant relevance to the food companies downstream in that cutting-edge long term science has the potential to impact the basis of competitiveness in the industry.

Top 5

Company	$ Sales Food (Billion)
Nestle	42.3
Phillip Morris (Food only)	35.9
Unilever (Food only)	24.2
PepsiCo (USA)	17.9
Danone	14.4

Figure 4 *Sales revenues of the top five food companies (1995)*

1.5 World

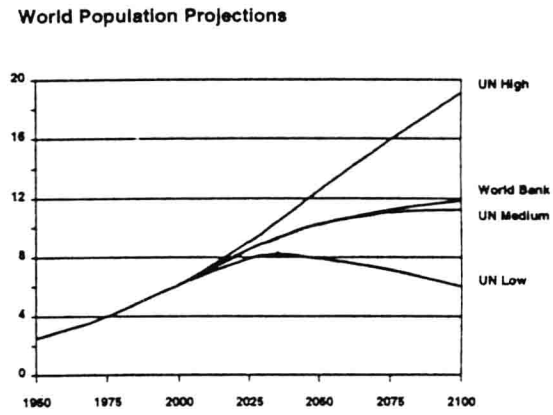

Figure 5 *World population*

Figure 5 illustrates estimates of world population growth provided by several agencies[4]. Up until 2040, there is general agreement on a rise in population to approximately 10 billion. We must regard population growth as inevitable, given that the females have already been born who will bear the population increase shown in the first part of the graph. As mentioned above, quality and variety requirements will ensure that demand for food will outstrip population growth. This suggests that we need to provide for roughly a tripling of food requirements by the middle part of the next century. This scenario provides the boundary conditions for two basic choices - either the same amount of land has to be three times more productive, or we put three times as much of the world's surface into agricultural production. Inevitably, the outcome will be a hybrid of these factors, but the balance between them is open to question. A detailed discourse on this topic is provided by Dennis Avery's thought-provoking book (1995).[5] In Figure 6, I have extracted some data from this volume in relation to world population growth. A commonly held myth is that providing more food to under-developed countries will lead to a population explosion. The data provided in Avery's treatise indicate that producing more food appears to lead to lower birth rates. In a range of very different countries, increased food provision via yield enhancement bears a correlation to a reduction in births per female. We must of course recognise that related factors, both social and educational, also play their part.