HERBICIDE DEPENDENT AGRICULTURE: HAVE WE GONE TOO FAR?

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'*An unfortunate consequence of the outstanding success of herbicides has meant that much research has been invested in this area with other methods of weed management often being neglected*.' (Lovett and Knights 1996).

Summary By value, herbicides represent about two-thirds of all agricultural chemicals used in Australia, excluding animal health care products. Sales in real terms increased six-fold over the period 1975–1994, reflecting the expanding range of products and, more particularly, the use of herbicides in reduced tillage systems developed for the extensive cropping industries. The benefits that have come with the use of herbicides have been offset, to some extent, by a suite of problems that threaten the sustainability of agricultural systems developed for the Australian environment. The question of whether the level of dependence on herbicides has gone too far hinges on the extent to which reliance on herbicides occurs at the expense of alternatives. There is also evidence from within Australia and overseas that significant opportunities exist for reducing herbicide use.

INTRODUCTION

Herbicides are widely used in all agricultural systems developed for the Australian environment with the exceptions of extensive grazing in the arid zone and commodities produced for the organic market. While herbicides have undoubtedly contributed to growth in production and economic productivity of the rural industries, the extent to which contemporary agriculture depends on inputs of pesticides is being questioned (Pimental and Lehman 1993). Some governments in Europe have legislated to reduce these inputs (Hurst *et al.* 1992). Elsewhere, governments and industries are collaborating to achieve these goals without recourse to legislation.

In this paper the authors seek to catalyse debate on the question of whether herbicide dependence in Australian agricultural systems has gone too far. The need for a strategic approach to maximize integration of weed control measures and to reduce the dependence on chemical weed control will be analysed.

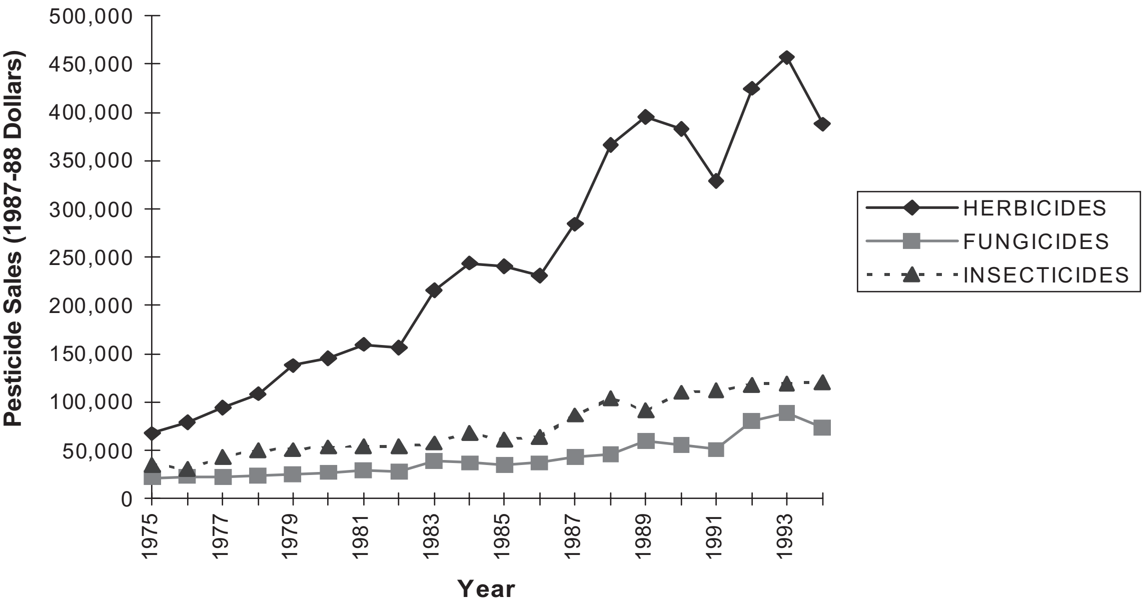

Figure 1. Pesticide sales in Australia 1975–1994, adjusted for 1987/88 dollar values. Figures represent the majority of sales at the factory gate. Source: Australian Commodity Statistics (ABARE 1995).

HERBICIDE USE IN AUSTRALIA

Herbicide represents about two thirds, by value, of all agricultural chemicals used in Australia, excluding animal health care products (Figure 1). Sales of herbicides increased six-fold in real terms over the twenty years 1975–1994. The figure has varied from about 54% in the 1970s to 72% in the late 1980s. This pattern of usage is similar to the situation in the United States, where herbicides represent about 75% of agricultural pesticide use (Benbrook 1996).

It is thought that growth in herbicide sales in Australia initially reflected an expanding range of products in the market place being applied to new situations. More particularly it followed the introduction of diclofop methyl (Hoegrass®) and other products, their adoption in extensive cropping systems and the expansion of cropping into new areas (Poole 1987). Developments in reduced tillage, the adoption of these technologies and intensification of cropping in recent years have resulted in increased use of herbicides. Indeed, it is the availability of herbicides that have made the increase in cropping intensity possible.

The widespread use of herbicides in extensive cropping systems is believed to have reduced erosion and the adverse impacts of cultivation (Hamblin 1987, Kirkegaard 1995).

Herbicides have contributed enormously to economic productivity of rural industries by:

- providing effective weed control over vast areas,
- reducing the energy costs of weed control,
- reducing the volume of commodities subject to dockage and down grading through damage and contamination by weed seed,
- providing producers with flexibility to take advantage of higher prices for grains relative to meat and wool, and
- reducing stock losses from poisoning.

These gains have not been without some cost as evidenced by:

- the emergence of herbicide resistant weeds,
- contamination of surface and ground water by herbicides, extending even to domestic rain water tanks in some areas,
- the negative impacts of residual herbicides on subsequent crop rotations, and
- the sub-clinical impacts of herbicides on biological productivity of crops.

Although herbicides are generally considered to have low toxicities to non-target organisms, there are concerns about, as yet unknown, long term consequences for soil biota. Another major concern to emerge in recent years is that the intensification of cropping made possible by herbicides may be pushing farming systems past sustainable limits, reflected in a very low rate of wheat yield improvement and a decline in soil fertility (Hamblin and Kyneur 1993).

MANAGING THE RISKS

Integrated pest management (IPM) has long been the goal of plant health specialists concerned about the need to counter problems of pesticide resistance. Increasingly the focus is being drawn to the impact of crop protection practices on the sustainability of agricultural systems that are dependent on large inputs of synthetic pesticides. Community concerns about human health and safety and the impact of pesticides on the environment have provided the impetus for change in some countries. The trend began in Sweden in 1985 when the Government set legislative targets for reducing pesticide use (Bernson and Ekstrom 1991), Denmark (Haas 1989) and the Netherlands (Anon. 1991) followed soon after.

While there is growing recognition of the imperative to manage the adverse impacts of pesticides on agricultural sustainability, the establishment of legislative targets has been criticized as being conceptually and technically flawed (Bellinder *et al.* 1994). Critics point out that much of the progress towards reducing pesticide use has come from substituting more biologically active products, especially herbicides, for products that have to be applied at higher rates of active ingredient. Governments and regulatory authorities in other countries have introduced or are in the process of planning strategic approaches to manage risks associated with pesticide use without recourse to legislation (Rowland 1995) (Table 1). Significant reductions in pesticide use have been achieved and perhaps one of the most positive outcomes has been the extent to which farmers, scientists, community interests and governments have come to focus on a common objective.

Table 1. Some international pesticide reduction programs.

Country	Type	Program
Sweden	legislative	75% p'cide reduction target
Denmark	legislative	50% p'cide reduction target
Netherlands	legislative	50% p'cide reduction target
Switzerland	legislation pending	adoption of IPM
USA	voluntary	75% IPM target
Canada	voluntary	Environmental Farm Plans/Pesticide reduction
Germany	voluntary	integrated farming systems
Great Britain	voluntary	integrated farming systems
France	voluntary	integrated farming systems

Drake-Brockman (1995) identifies pesticide use as one of a number of risks that may emerge to constrain trade in agricultural commodities. The trade issue is of particular importance to Australia because of the large contribution that the rural sector makes to export earnings and the potential for growth from trade liberalization (Kennedy *et al.* 1995). Realizing the potential, however, will depend on the extent to which countries can exploit non-tariff trade barriers under Uruguay Round Agreements relating to health and quarantine – the Sanitary and Phyto-Sanitary Measures and Technical Barriers to Trade. There is concern, too, that some governments are looking to use trade to pressure exporting countries to improve environmental performance in the production of internationally traded commodities. Such approaches contravene the aims of the World Trade Organization (WTO), although the mooted Green Round of trade negotiations could see the emergence of legitimate trade barriers in the future. Meanwhile, there is a trend to eco-labelling driven by consumer preferences for products that are produced in an environmentally sustainable manner. As a marketing strategy, eco-labelling promotes product differentiation on the basis of environmental quality, with the potential to incorporate life cycle analyses based on processes and production methods (PPMs), not merely the physical characteristics of the final product. It is not yet clear whether the WTO will uphold import restrictions based upon PPMs but there is a possibility that eco-labelling may limit market share, particularly for countries like Australia where producers may have limited access to labelling and certification schemes (Drake-Brockman 1995).

Although there are many initiatives in Australia directed at improving pest control, some encompassing a reduction in the amount of pesticides used, the work is fragmented and lacks an overall framework for engaging debate on the issue. However, the Standing Committee on Agriculture and Resource Management recently endorsed a proposal to progress the development of a National Strategy for Agricultural and Veterinary Chemicals. Pesticide use and concepts of use reduction, risk minimization, efficiency of use and issues of industry dependence on pesticides will be some key elements for consideration in the strategy.

For completeness the strategy will need to include a broad analysis of the concept of integrated pest management and the development of integrated farming systems for sustainable agriculture that other countries are beginning to explore. Integrated arable farming systems being evaluated across Europe are now showing benefits, including lower pesticide inputs and enhanced wildlife habitat (Holland 1994). Success has revolved around the integration of various crop protection measures, including resistant cultivars, careful timing of sowing and spraying, the use of forecasting and economic thresholds, optimization of dose rates and application techniques. The European Initiative for Integrated Farming set up a network of organizations across six countries, Germany, France, Luxembourg, Great Britain, Sweden and Spain (Rowland 1995), using commercial farms to demonstrate the potential of integrated crop management practices that combine economic viability with environmental responsibility. Integrated arable farming systems, developed in the Netherlands are now being adopted by over 500 farms and achieving good yields with 50–65% reductions in pesticide use (Wijnands 1993). The United States is actively developing integrated pest management systems for key regional combinations of crops and pests.

FUTURE DIRECTIONS

In his keynote address to this conference, ‘Where in the World is Weed Science Going?’, Professor Lovett answers the question with a clear and unequivocal response—integrated weed management. A recent survey of integrated pest management research in Australia encompassing research into insect pests, weeds, plant pathogens and animal parasites (Bureau of Resource Sciences (BRS) unpublished data) indicate that, for Integrated Weed Management (IWM) to be the way of the future, weed science will need to undergo a major directional change.

The BRS survey invited responses on IPM activities undertaken in those research centres identified in the 1989 Directory of Research Centres (Anon. 1989). There were 230 responses that included 20 references to work on weeds. Excluding one response that referred to work on the use of adjuvants for enhancing herbicidal activity and two references to projects on the development of biological control agents, the survey results contain only 17 references to integrated weed management projects. While acknowledging that the survey may not have captured the full range of IWM activities, there is a striking inverse relationship between the value of sales of herbicides and insecticides and the level of research activity into integrated pest management technologies.

This observation may come as no surprise to weed scientists, but it invites the question as to why the resources allocated to IWM should be so low compared to the resources allocated to work on insect pests. In part the answer may lie in the dearth of weed scientists. Williams (personal communication) advises that a recent survey of research in the grain cropping industry identified only 28 practising weed specialists. Given the dependence of our rural industries on herbicides and the negative impacts that are now widely recognised, there would appear to be a compelling need to reassess issues of resource allocation by funding organizations and research providers alike, and for weed scientists to explore the opportunities to expand research into IWM.

Several initiatives in Europe and North America provide a useful starting point for engaging debate on the issue. The US experience could be particularly relevant. It began in 1993 when the Clinton Administration announced a commitment to reduce pesticide use in response to a report prepared by the National Academy of Sciences into pesticides in the diets of children. After extensive deliberation, the government adopted a national goal of having 75% of US arable land under IPM management by 2000, under a tri-partite agreement between the US Department of Agriculture, the Food and Drug Administration and the US Environment Protection Agency. A survey of IPM practices adopted by US farmers served as a starting point to estimate the area of crop under IPM at three levels, 'low', 'medium' and 'high'.

The World Wildlife Fund commissioned an analysis of the results of the USDA study (Benbrook 1996) and has since presented its own perspective on this analysis to the Third National IPM Symposium held in Washington in February this year (Hoppin 1996). Hoppin argues a case for reducing reliance on pesticides, the adoption of multiple weed management strategies in IWM and monitoring progress against environmental parameters rather than numerical targets for reduced pesticide use. Notwithstanding Hoppin's assessment, there is a large body of evidence that reductions in pesticide use are possible and herbicide use is no exception. Refinements in pesticide application technology, an improved understanding of thresholds and susceptibility of the weed to herbicides at different stages of growth have all yielded progress. A striking example is provided by Emmerman (1991), reporting on work in Sweden showing herbicide application at half the recommended rates have resulted in improved crop yields.

Transgenic herbicide-resistant crops may offer new opportunities for weed control and used in a strategic manner, may contribute to the sustainability of agricultural systems in Australia (McLean and Evans 1995). Proponents of the technology believe that, by withholding the application of treatments until a weed problem manifests itself, growers can reduce the number of herbicide applications, thus reducing the overall level of use. On the other hand, widespread use of herbicide-resistant crops will entrench dependence of farmers on herbicides at the risk of ignoring alternative control strategies, as pointed out by Lovett and Knights (1996). To avoid the risk of repeating past mistakes, agricultural scientists will need to give attention to integrating all available alternatives into sustainable weed management strategies. There is also scope for weed scientists to work more closely with farmers, agronomists and other crop protection specialists to develop a comprehensive systems approach to pest control in Australian farming.

REFERENCES

ABARE (1995). Australian Commodity Statistics. (Australian Bureau of Agricultural and Resource Economics, AGPS, Canberra).

Anon. (1989). Centres for Rural Research in Australia: Directory. (Bureau of Rural Resources, Australian Government Publishing Service, Canberra).

Anon. (1991). Meerjarenplan Gewasbescherming (Multi-Year Crop Protection Plan). Regeringbeslissing. The Hague, SDU, 298 pp.

Bellinder, R.R., Gummesson, G. and Karlsson, C. (1994). Percentage-driven Government mandates for pesticide reduction: the Swedish model. *Weed Technology* 8, 350-9.

Benbrook, C.M. (1996). Adoption of Integrated Pest Management systems by corn and soybean farmers in 1994: Application of a new methodology to measure adoption of IPM and pesticide use and reliance. Workshop on Measurement of Pesticide Use in IPM, Annual Meeting of the Weed Science Society of America, 7 February 1996, Norfolk, Virginia.

Bernson, V. and Ekstrom, G. (1991). Swedish policy to reduce pesticide use. *Pesticides Outlook* 2, 33-6.

Drake-Brockman, J. (1995). 'Trade and environment—the international agenda and its implications for Australian agriculture', 96 pp. (Council for International Business Affairs, Melbourne).

Emmerman, A. (1991). Program to reduce the risks of pesticides in Sweden. *Pesticides News* 14, 12-13.

Haas, H. (1989). Danish experience in initiating and implementing a policy to reduce herbicide use. *Plant Protection Quarterly* 4, 38-44.

Hamblin, A. (1987). The effect of tillage on soil physical conditions. *In* 'Tillage: New Directions in Australian Agriculture', eds. P.S. Cornish and J.E. Pratley, pp. 128-70. (Inkata Press, Melbourne).

Hamblin, A. and Kyneur, G. (1993). 'Trends in wheat yields and soil fertility in Australia', 141 pp. (Bureau of Resource Sciences, Australian Government Publishing Service, Canberra).

Holland, J.M. (1994). Progress towards integrated arable farming research in Western Europe. *Pesticide Outlook* December 1994, pp. 17-23.

Hoppin, P. (1996). Reducing pesticide reliance and risk through adoption of IPM: An environmental perspective. Third National IPM Symposium/ Workshop, 27 February 1996, Washington D.C.

Hurst, P., Beaumont, P., Jorgenson, C.E. and Winther, S. (1992). 'Pesticide Reduction Programs in Sweden, the Netherlands and Denmark', 48 pp. (World Wide Fund for Nature International, Gland, Switzerland).

Kennedy, D., Mai, Y.H. and Vanzetti, D. (1995). Australia's agricultural exports: implications of APEC trade policy reform. Queensland Rural Outlook Conference, ABARE, 9–10 November 1995, 22 pp.

Kirkegaard, J.A. (1995). A review of trends in wheat yield responses to conservation cropping in Australia. *Australian Journal of Experimental Agriculture* 35, 835-48.

Lovett, J.V. and Knights, S.E. (1996). Where in the world is weed science going? Eleventh Australian Weeds Conference, 30 September–3 October, Melbourne, pp. 3-15.

McLean, G.D. and Evans, G. (1995). The Potential for Transgenic Herbicide Resistant Crops. Asia Pacific Agri-industry Community Conference, Australian Institute of Agricultural Science and the New Zealand Institute of Agricultural Science, Brisbane, 8–10 August 1995.

Pimental, D. and Lehman, H. (eds.) (1993). 'The Pesticide Question: Environment, Economics and Ethics', 441 pp. (Chapman and Hall, New York).

Poole, M. (1987). Tillage practices for crop production in winter rainfall areas. *In* 'Tillage: New Directions in Australian Agriculture', eds. P.S. Cornish and J.E. Pratley, pp. 24-47. (Inkata Press, Melbourne).

Rowland, P.C. (1995). 'Recent changes in international crop protection practices: the growing trend to reduce pesticide use and pesticide risk', 48 pp. (Bureau of Resource Sciences, Canberra, ACT).

Wijnands, F.G. (1993). Development and introduction of integrated arable farming in the Netherlands. NJF Seminar: Integrated Farming Systems in Agriculture, 1–3 December 1993, Hamar, Norway, pp. 24-41.