AGRICULTURAL PEST MANAGEMENT AT A CROSSROADS: NEW OPPORTUNITIES AND NEW RISKS

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ABSTRACT

Pest management appears to be at a crossroads. The pest control practices of the last 50 years, which mainly relied on (toxic) chemical pesticides and spraying, are slowly changing. On the one hand, they are being replaced by farmer-driven integrated pest management practices, and on the other by new technologies that are based on biotechnology and genetic engineering. Whereas the first is generally safe and sustainable, the long term sustainability and safety of the latter are still widely debated. These new developments are reviewed in this bulletin, based on the perspectives of industry, farmers, and consumers, respectively. The role of governments (and supporting donor agencies) is discussed. The need for proper monitoring is emphasized, and proper pricing of inputs that carry an environmental or public health risk. International development banks are shifting their investment in pest management from support for chemical control programs to sustainable technologies such as integrated pest management, and proper policies and regulations.

INTRODUCTION

By the year 2020 approximately the world is expected to have a population of 7-8 billion people. The proper feeding of these people will be a major challenge, especially for the farmers in Asia, Africa and Latin America who will have to provide food for the higher populations on those continents. This can be achieved through three major programs i.e. (i.) organization of food production and distribution, (ii) increased production, and (iii) a reduction in losses.

In Asia, it will require a sustained increase in yield and better organization, as most arable land is already in production and expansion of the cultivated area cannot be expected. Dramatic increases in yield were obtained during the “Green Revolution” in the early seventies, when high-yielding cereal varieties were introduced into Asia. However, the newer varieties were also more demanding, and their use increased the need for inputs such as water, pesticides, fertilizers and extension. In some cases, these high input requirements lead to non-sustainable production systems, with high risks to farmers and farm workers health. In many case land productivity also came under threat from salination, soil depletion and erosion.

Despite the yield increases of the past thirty years, the losses throughout the production system are still dramatic. Pests are often a major cause of both pre- and post-harvest losses. Real data are scarce, however. Among the best-documented estimates of losses in arable agriculture are those of by Oerke et al. 1995, based on a comprehensive review of literature and industry data (see Table 1). They estimated the average losses in 8 major crops 1988-1990, and claimed that 42 percent of attainable production is lost as a result of pests, varying from 28% in Europe, and 31% in North America to just below 50% in Asia and Africa. Roughly calculated, the total pre-harvest losses worldwide are worth almost to $250 billion, with especially high losses in Asia (see Table 1).

These losses can be divided into absolute losses (due to reduced yields, losses during storage etc), and losses due to a lower cosmetic value (i.e.
blemishes, in otherwise edible produce). The latter type of loss is especially important in markets in North America, Japan and Europe. Overall, the losses due to pests are substantial. It is no surprise that farmers and processors are making use of variety of technologies to control pests. Similar losses occur in animal agriculture. Losses caused by pests, such as tick-borne diseases, mange and intestinal parasites, are difficult to estimate but range from 5 to 20% of production. In some areas losses may be 30 - 40%, with even higher losses during certain years.

Ironically, it appears that the losses due to pests are still increasing, despite the availability and widespread the use of chemical pesticides. The question has been raised whether chemical pest control methods, in the long term, may increase rather than decrease pest problems. Indeed in some cases, such as in rice in Indonesia, the excessive use of pesticides have led to secondary pests that require even more pesticides, leading to the so-called "pesticide treadmill".

### PESTICIDE USE

On a worldwide basis, pesticide use in still increasing, although in recent years the use of insecticides has stabilized or decreased, whereas the use of herbicides has increased. On a country-by-country basis, the use of pesticides varies greatly, depending on the main cropping patterns and the intensity of production.

Typical high consumers are high-income countries with subsidized agricultural systems (France, Netherlands, United Kingdom, United States, Japan) or countries that produce commodities such as cotton, fruit and vegetables. The world pesticide market, grew rapidly in value during the past decade. During the 1980s, the growth was mainly seen in North and South America (see Table 2). In the 1990s, it was Asia and Africa that saw a rapid growth in pesticide use. In India, for example, pesticide use has doubled over the past five years. This growth was influenced by increasing commodity prices and falling oil prices. Future growth will depend on the world economy (the recent downturn in Asia economies has increased prices paid by farmers for imported pesticides), on the economics (including subsidies) of agriculture, on the promotion by industry, and on the ability of farmers to use integrated pest management (IPM).

The volume of pesticides used is falling, as effective control can be given from a lower application rate. The typical application rate for herbicides, for example, dropped from about 3 kg/ha in the 1960s to 100 g/ha in the late 1980s. Insecticide application rates dropped during the same period,
from approximately 2.5 kg/ha to 25g/ha, and fungicides from 1.2 kg/ha to 100 g/ha. However, in some countries, especially those with intensive commodity production systems (cotton, banana, coffee etc.) the application rates are still well over 1 kg/ha (see Table 3). The decline in application rates is mainly because products contain more potent and concentrated active ingredients. This in itself does not make them any safer, but advances have also been made to reduce toxicity and persistence. Persistence has been, and still is, a major issue in pesticide use.

Prolonged biological activity increases the effectiveness of products, but also increases their (unwanted) side-effects in the environment. Products (or their metabolites) banned in the sixties in the mid-western United States, for example, can still be found in soil and water today, and some are still released in water or into the air (Aigner et al. 1998).

Recently, pesticide use has changed further through the development of genetically bio-engineered products (see below). The introduction of these products has been surrounded by controversy. Questions have been raised regarding their long-term safety, the possibility that genes may "jump" to other plants, including weeds, and their effect on bees and other beneficial species. There is also disagreement concerning the need to label genetically engineered products, the dependence these products create, and especially, their effect on small-scale farmers in the developing world (see Mae-wan Ho 1996 for a critical review).

### INDUSTRY PERSPECTIVES

Before World War II, pest control in agriculture was mainly based on sound agronomy. Pesticides were used only occasionally, and were simple chemicals such as copper or sulfur, or derivatives of plants such as tobacco, neem or pyrithium. During World War II, however, the chlorinated hydrocarbons such as DDT were developed for the protection of the military in public health and vermin control. After the war, the chemical industry expanded their use for to agriculture. Insecticides such as DDT and parathion, and the herbicide 2,4-D, became an integral part of agricultural development. The rapid growth in the use of these products was not without setbacks, however. DDT in particular became known as a major environmental hazard, the effects of which are still persisting today. The industry acquired a bad name among consumers and, despite having produced many beneficial products, has not been able to shake this off completely.

### QUALITY CONTROL

One of the difficulties is to ascertain quality production methods and quality products. Production methods vary, and so does the purity of the product. Many pesticides are contaminated with traces of other chemicals. In most cases such contaminants may be harmless, but occasionally the contaminants may be more harmful than the main

<table>
<thead>
<tr>
<th>Country</th>
<th>Insecticide use (mt)</th>
<th>Years sampled (x 1000)</th>
<th>Total ha (x 1000)</th>
<th>Use per ha (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korea</td>
<td>9,339</td>
<td>1990-93</td>
<td>2,160</td>
<td>4.6</td>
</tr>
<tr>
<td>Costa Rica</td>
<td>4,655</td>
<td>1993,1995</td>
<td>2,870</td>
<td>8.8</td>
</tr>
<tr>
<td>Honduras</td>
<td>2,743</td>
<td>1988-91</td>
<td>1,650</td>
<td>1.6</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>394</td>
<td>1986-90</td>
<td>1876</td>
<td>0.21</td>
</tr>
<tr>
<td>El Salvador</td>
<td>2,060</td>
<td>1990,1991</td>
<td>755</td>
<td>2.73</td>
</tr>
<tr>
<td>Pakistan</td>
<td>5,574</td>
<td>1990-95</td>
<td>22,150</td>
<td>0.9</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>60</td>
<td>1988-93</td>
<td>60</td>
<td>1.0</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>1,294</td>
<td>1988-92</td>
<td>1,450</td>
<td>.9</td>
</tr>
<tr>
<td>Thailand</td>
<td>6,010</td>
<td>1986-90</td>
<td>17,370</td>
<td>0.35</td>
</tr>
<tr>
<td>Jordan</td>
<td>315</td>
<td>1988-94</td>
<td>350</td>
<td>.9</td>
</tr>
<tr>
<td>Columbia</td>
<td>3,567</td>
<td>1986-95</td>
<td>6200</td>
<td>0.5</td>
</tr>
<tr>
<td>Malaysia</td>
<td>1,506</td>
<td>1991-95</td>
<td>5,800</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Source: FAOSTAT data 1986-1995. These data exclude China, Taiwan, Mexico, Zaire, Nigeria and Philippines.*
products. A typical case is the contamination of pesticides with toxic dioxins. This is often caused by poor quality control or equipment during manufacturing. Quality control during production is difficult to monitor. The chemical industry has developed “Good Manufacturing Practices” (GMP) and a “Code of Conduct” (and in the US “Responsible Care”) but this cannot be enforced. Moreover, many manufacturers and in less industrialized countries do not adhere to these rules.

Regulators tend to look mainly at the active ingredient, but neglect other ingredients that may be just as toxic (see Sawaeda et al. 1988). These other ingredients either play an essential role in the effect of the pesticide (for example the surfactants in sprays) or are inert.

CHANGES IN THE AGROCHEMICAL INDUSTRY

The agro-chemical industry is changing rapidly. The better companies strive for safer products, improved application methods technical back-up for farmers purchasing their products. In the past, pesticide production was part of the global chemical industry, with a business turnover of US$1,400 billion per year. More recently the industry has been aligning itself with the seed industry and biological sciences. The agro-chemical industry is concentrated in a limited number of countries and companies in North America, Europe and Japan. In recent years there has been a further concentration in the market, and global companies such as Novartis, Merck, Monsanto, Dupont, Hoechst, Bayer, Rhone-Poulenc, Sumitomo and others have stratified their output, often by selling their chemical business and investing in biological sciences. However, this opens a market for low quality producers who manufacture, and sell products that are no longer under patent. These companies and products are often found in countries where quality standards are low or not enforced, or where the local use of such products is prohibited.

Two major factors driving these developments are the tighter controls over the approval of pesticides, and the promise of biotechnology. The tighter controls over chemical use are driving the industry to develop more specific and safer products and find safer application methods (blanket chemical application, by e.g. spraying is too risky). Tighter regulations controlling the approval of pesticides has increased research and development cost for a single new product from about US$ one million in the 1950s to more than US$50 million today. A large part of these costs are related to regulatory requirements i.e., ascertaining the environmental and public health safety of the new products. The regulatory requirements continue to be tightened. This is partly because mishaps still occur, despite all the care taken, and partly because the products are used in more complicated ways. In addition, the larger market shares which the industry seeks become more difficult to achieve as a larger part of the population and the environment are exposed to such (single) products.

BIOTECHNOLOGY

The promise of biotechnology has led to significant investment by the agrochemical industry. The industry has great expectations of biotechnology, especially the use of genetically modified plants (GMO’s) in agriculture, and especially in pest control. This type of biotechnology relates mainly to inserting certain genes in seed that are directly linked to pesticide use. Examples are crops with a Bacillus thuringensis gene (that produces toxins intended to kill specific insects), and the “Roundup-resistant” crops engineered to tolerate certain herbicides. The application of bioengineering technologies is still in its early stages, and further application may lead to fundamental changes in agriculture and food technology. Such fundamental changes are also a major risk, since it is difficult to predict their indirect or long-term effects.

Less controversial developments in biotechnology are those found in developing countries which produce of biopesticides such as microbial pesticides, or mass produce beneficial insects for distribution to farmers. Several Asian countries are world leaders in this development. Simple technologies of this kind include the use of neem products (in India: see Alam 1994) and the use of beneficial insects (Trichogramma, Bracon etc.) in the pest control of cotton in former Soviet central Asia in recent years. The popularity of beneficial insects is increasing in most countries. Most of them are marketed through small scale private companies.

In all the controversy about biotechnology, the need for ecological and epidemiological research is often forgotten. It is easy for farmers, to forget that good agronomy and animal husbandry was the traditional basis of pest control and pest prevention. Crop rotation, proper land preparation, destruction/recycling of crop residues, use of catch/refuge crops, and understanding the lifecycles of pests and predators are still fundamental tools in crop protection. It is here that real progress can be made with judicious,
safe and sustainable interventions.

MARKETING OF PESTICIDES

Three issues stand out with respect to the marketing of chemical pesticides. The first relates to mechanical application, i.e. the need for sprayers etc. Investment in sprayers, and certainly high-quality sprayers, may be a significant production cost. To accommodate these costs, farmers may use inadequate equipment (with poor technical results, and high risk to themselves). Alternatively, they may decide to hire others to do the spraying, or use other methods that do not require equipment. The efforts of the chemical industry in biotechnology, for example, are in part driven by an effort to eliminate the needs for spraying, with its inherent risks. Spraying is basically an inefficient system to apply pesticide on plants. Further research is needed to develop less risky application methods, as for example these used by Chinese cotton farmers to control bollworm (see box 3).

The second issue is the problem of retail marketing. Most pesticides are toxic. It does not seem a good idea for a company to pay incentives to its sales staff (or retailers) for selling more of these high-risk products. Sales staff of many companies, as well as pesticides dealers still “push” their products without providing the buyer with sound information on risk, proper handling and/or safer alternatives. This may lead to unacceptable exposure of farm workers, the sale of obsolete stocks, pest resistance, unnecessary use, exposure of consumers, and elimination of beneficial insects. It is time for the industry to review its sales policies and initiate other reward systems that stimulate its staff and retailers to sell a complete pest control package. This includes safety equipment and information, and advice on how to use the pesticide, how to avoid resistance etc.

A major problem in Asia is that pesticides are often sold through unlicensed dealers and shopkeepers. Some of these may be familiar with agrochemicals, but in many rural shops one may find pesticides sold next to food products such as milk or bread. Although the availability of pesticides in rural areas is important, the benefit of such availability has to be weighed against consumer safety, proper storage, and the need to educate farmers about proper use. The recent development of pesticide resistance in China and India is to a large extent the result of uncontrolled marketing to poorly informed farmers.

The third issue relates also to marketing, in this case in the seed industry. There is a long history of seed companies trying to protect their seed improvement and sell farmers new seed every year. On the other hand, farmers tend to recycle seed, i.e. use seed from the previous harvest for the planting of a new crop. The debate about this conflicting approach, which started even before the introduction of hybrids, has recently accelerated with the patenting of a (GMO) technology protection system; popularly known as the “terminator gene”. This technology inserts genes in plants that produces self-terminating offspring, and ensures that farmers can not replant seed from previous year’s harvest. Since this technology is not in the interest of farmers who use saved seed, especially common in developing countries, it is opposed by various farming groups and NGOs. In October 1998, the CGIAR indicated that it did not endorse “terminator” technology in seed development for its client farmers in developing countries.

The Future

In brief, the result of the research and development in bioengineering has provided new tools, but is also requiring difficult decisions about their use. The decision of farmers is no longer to spray or not to spray, but includes evaluation of the cost/benefits of use more complex technologies such as the use of bio-modified seed, no-till practices, etc. Industry has made heavy investments in biotechnology, and hopes to recuperate these costs. As such, it is heavily promoting these technologies. The recent (Asian and Russian) economic downturn, as well as the drive to reduce farm subsidies in the United States and EU, has worsened the short-term economic outlook of crop production, and thus, the interest of farmers in expensive technologies. This may provide further opportunities for integrated pest management, and for simple consumer-friendly control methods.

FARMER/USER PERSPECTIVES

The dependence since the Second World War on chemical pest control methods is not without risk. Increasingly, farmers and consumers demand either control with no chemicals at all (i.e. organic production), or very limited use of chemicals using only those that are safe farmers, consumers and the environment.

Farmer/User Perspective of Pests

Farmers combat the pests they know about, are concerned about, and are able to do something
A case study: Boll worm control in China

The cotton bollworm, *Heliothis armigera*, is an important pest. This insect has developed resistance to several groups of conventional insecticides, including pyrethroids, organophosphates and carbamates in Australia, Thailand, India, Indonesia and Turkey. In 1989, the cotton bollworm developed resistance to pyrethroids such as deltamethrin and fenvalerate in China. The problem was especially serious in Shandong province. From 1990, various control measures in resistance management were researched and implemented:

1. Agronomic practices were adopted to reduce the need for pesticides. These include using pest resistant or tolerant cultivars, and interplanting of cotton with wheat or maize. Irrigation and cultivation of refuge crops in winter were adopted in order to protect natural enemies.
2. Lamps and poplar twigs were employed in order to trap and kill adults to lessen the number of adults.
3. Pesticides were used through different application methods such as rotational, alternative and mixed use. The use of pyrethroids was stopped in highly resistant areas, and strictly limited in other areas. A single type of pesticide was not used continually.
4. To protect natural enemies and kill insects, pesticides were applied on parts of the cotton stem rather than by spraying.
5. Biological pesticides, such as BT were employed to lessen the use of chemical pesticides. These methods proved to be effective in controlling insect population and insect resistance, protecting the environment and lowering costs.

Source: Bin Xiao Kefu Xue 1997
Farmers’ Perspective of Pesticide Risks

Apart from the economic risk of disease outbreaks in plants and animals, the farmer also has to evaluate the human health risk of dealing with toxic substances such as pesticides. Most farmers, and especially those who are poorly informed, do not appreciate how much risk is involved in using pesticides. Industry and many governments have focused on the need for protective measures (tools, techniques and clothing) used by well-informed farmers in Western countries. However, these are often not suitable for use in tropical countries, or perceived as too costly. Higher taxation for particular risky pesticides is another tool; Antle and Pingali (1994), in rice, and Antle et al. 1998 (in potato) demonstrated the economic benefits of targeted taxation of single pesticides. In some cases informed farmers consider the risk of handling pesticides (and the cost of the administrative obligations) too high, and use specialized custom service operators. These operators have often access to more appropriate equipment and well-trained staff. In some countries, however, there is a risk that such operators attain a monopoly position, resulting in poor services and high costs.

Consumer Perspectives

One of the major changes in agriculture in the last decade is the rapid increase in the importance of consumers. Whereas 20 years ago, most ministries of agriculture would consider farmers as their main clients, today, and especially in Western countries, consumers are equally or even more important. This rise in consumers’ power is the result of a variety of factors. They relate to a variety of food scares. One of the first was the Kyushu rice contamination with PCBs in Japan. This was followed by a number of other highly publicized mishaps, due to either pesticides (e.g. of 2,4-D/2,45-T or “Agent Orange” in Vietnam, the Bhopal case in India, the “Alar” scare in the United States), or to microbial contaminants (E. coli 0157 in Scotland and Japan, Pfiesteria spp. in the water of the eastern United States, mad cow disease in Britain and Europe etc.). They also relate to better awareness, and information exchange among consumers. Consumers are more vocal, and demand that policy makers focus on food safety. Organic farming is still limited, but has been expanding rapidly in Europe and the United States during the last decade.

Overall, the effect of very low levels of pesticides in food has been considered of minor importance. In some cases, however, precautions are recommended, for example where consumers rely heavily on a limited number of products, or in the case of babyfood. However, there is insufficient data, to really assess the risk, especially of newer products. For example, it has been claimed that in certain parts of India, the daily foodborne intake of pesticide residues is approximately 0.51 mg (Alam 1994). This is well above accepted levels, but the impact on public health and reproduction has not yet been fully investigated.

It is only recently that new insights developed into the effect of older pesticide products, especially with respect to hormonal interaction (estrogen mimicking). Fears of long-term health damage have led to renewed calls for the banning of certain products.

The major issues are information and transparency. Consumers, especially in Europe, demand clear labeling of agricultural products, including whether the product is derived from genetically modified organisms (GMO). Part of agro-industry opposes this transparency, arguing that it will increase costs. If this kind of labelling is adopted, GMO and non GMO products will have to be segregated, requiring dual systems. This is a continuation of the age-old debate of perceived industrial cost/benefits versus human health.

GOVERNMENT AND PUBLIC SECTOR PERSPECTIVES

Initially, governments endorsed the use of chemical pesticides. They were perceived to offer an easy, labor-saving tool for the control of pests and weeds. Moreover, in Europe, Japan and the United States, the expanded use of pesticides allowed the expansion of their chemical industries that till 1945 had served military (public health) goals. However, after the publication of Rachel Carson’s “Silent Spring”, attitudes began to change. Very slowly, the role of government shifted from promoting pesticide use to safeguarding society against the risks of pesticides.

In many countries that stage has not yet been reached, and governments, knowingly or unknowingly, support the use of pesticides. Pesticide use tends to be promoted through both direct and indirect measures (see Table 4). The lack of a strong environmental policy prevents governments from reorienting their policies towards more sustainable development strategies.

Increasingly governments realize the need to avoid pesticide “treadmills”, and to minimize risks
to users and consumers. There are a number of instruments available to governments to encourage environmentally sound and economically rational pest management practices (see Table 5). The strengths, weaknesses, and costs of selecting one instrument versus another will be situation specific. Tailoring interventions to local capacity and local character of the agricultural sector is therefore crucial.

**BANNING DANGEROUS PESTICIDES**

Despite international guidelines such as the FAO “Code of conduct” and “Prior Informed Consent” (PIC) there is still a problem of improper trade and use. Many Asian countries have banned some pesticides or restricted their use while at the same time promoting integrated pest management. Indonesia, for example, removed subsidies from pesticides and banned 57 formulations of insecticides, after it realized that over use of insecticides on rice had led to greater pest problems associated with secondary pests. This removal has saved the country over US$100 million in imported pesticides, without significantly affecting rice production (see Table 6). Recently, the United Nations began to negotiate for a worldwide ban of 18 of the most toxic chemicals, known as the “Dirty Dozen”. These include PCB’s, DDT and seven other pesticides, all of which are already banned in more than 90 countries.

**Regulation**

Establishment of a regulatory system for pesticides is the main way in which governments around the world minimize environmental and public health risks, and determine a proper balance between the costs and benefits of agro-chemicals. An efficient regulatory system is a powerful tool to influence pest management practices and increase safety. Its drawbacks are the costs involved, including those of monitoring and enforcement. However, there is some potential for cost recovery through registration fees, user fees and taxes. This selectively raises private costs, thus reducing overall pesticide consumption, and with it the risk of over-use.

A major contemporary issue is the independence of the regulatory system. Recent cases of insufficient oversight (such as mad cow disease in the United Kingdom, and recent failures in the use and marketing of GMO cotton in the southern United States and canola in Canada) raise the question whether government supervision is adequate. The United States, for example, has a complex organization with at least four government bodies (EPA, FDA, NIH, and USDA), each with limited power, and with different and sometimes conflicting constituencies (not only consumers, but also farmers, agro-industry, the environment etc.). None of these agencies is well equipped to assess the safety of new bio-engineered products.

Many regulatory agencies of developing countries are ill-equipped overall. The regulatory agency is often part of the Ministry of Agriculture, and gives higher priority to the interests of farmers and agro-industry than to those of consumers. Moreover, these regulatory agencies are often understaffed and under funded (making low-paid staff vulnerable to bribes), and do not have the particular skills needed to deal with the complex technical and policy issues associated with regulation. A more cost-effective regulatory process, especially for smaller countries, could be established by

- Relying on basic toxicity and safety data, from the strictest developed country
- Restricting pesticides to specific crops, and requiring field data for these crops from areas with a comparable climate, and
- Arranging for reliable overseas laboratories to carry out under contract surveys of pesticide residues in produce.

**Economic Policies and Incentives**

The most commonly recognized economic incentives are based on

- The “polluter pays” principle, including the use of licensing fees, user fees or taxes,
- The support of alternatives, and
- The risk of legal challenge (i.e. “being sued”, mainly in the United States).

The “polluter pays” principle (i.e. adding the environmental and public health costs to the price paid by consumers) can be an effective approach to internalize the social costs of pesticide use. The fees and taxes generated can be used to promote improved (sustainable) pest management.

In order to set the right level of levies and taxes, it may be necessary to calculate the negative impacts of pesticides. Various attempts have been made to determine the costs that relate to public health (risks to farm workers and consumers, and drift risk), and damage to beneficial species, and to the environment. This includes an eco-toxicological risk assessment, which tries to define these risks not
Table 4. Government action (or inaction) that indirectly promotes the use of pesticides

<table>
<thead>
<tr>
<th>Issues</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation authority dominated by producer interests</td>
<td>In many countries the pesticide regulatory agency is part of the Ministry of Agriculture; sometimes in the same department that may be involved in the procurement of pesticides. This conflict of interest can be resolved by creating an independent agency that includes representation of the interests of producers, consumers and environment.</td>
</tr>
<tr>
<td>Weak regulation</td>
<td>In the majority of developing countries’ regulatory systems and regulations are weak (and often based on unenforceable “western” paradigms).</td>
</tr>
<tr>
<td>Weak implementation of regulation</td>
<td>Where legislation is enacted, this proves often to be too cumbersome to implement, either leading to disregard or necessitating further tuning and reform. The staffing of regulatory agencies is often inadequate, the staff under paid, and unable to stand up against self-serving industry interests.</td>
</tr>
<tr>
<td>Misdirected support policies</td>
<td>National governments sometimes also use pesticide regulation to protect their own pesticide industry. In some cases such protection is provided to old, and sometimes dilapidated manufacturing sites and processes, or to unsafe products. This prevents new and safer products from entering the market place. Governments, through public sector supported agricultural research, may indirectly encourage pesticide use by focusing research solely on pesticide development and pesticide application techniques rather than on biological or integrated pest control methods.</td>
</tr>
<tr>
<td>Lack of information on alternatives</td>
<td>The lack of information on alternative, more environmentally benign approaches to pest management, biases extension advice and farmers toward pesticide use</td>
</tr>
</tbody>
</table>

Source: Schillhorn van Veen et al. 1997

only for each chemical, but also for each formulation and each kind of use (Higley and Wintersteen 1992). The same pesticide may have different risks depending on the formulation and application methods. These risks can be quantified through, fairly objective assessments, although the values may vary from country to country (see Table 7 for an example).

Banning or taxing pesticides without proving alternative control methods may in the short term increase the vulnerability of farmers. In such cases, economic incentives can be used to promote environmentally benign pest management practices. Examples include providing initial grants to groups of farmers who begin a collective pest monitoring scheme, mass production of predator arthropods, or other methods used in integrated pest management (IPM).

Research and Extension

There has long been “pro-pesticide” bias in the funding of research, extension and training in many countries. This is the inevitable consequence of distorted economic incentives, and also the economic strength of the pesticide industry, which have been able to promote the use of proprietary packages. Governments can encourage a more socially favorable pesticide use by raising the costs of pesticide use relative to IPM and overall production costs, encouraging farmers to use sustainable pest control methods, and encouraging industry to invest in the supply of environmentally benign technologies.

Perspective of International Donors and Development Banks

In the past, development banks and donors have been actively promoting pesticide use in developing countries. This was based on their belief that the lack of chemical pest control was a major constraint. They saw the role of extension as providing simple “packages” that included seeds and inputs.
This concept is changing. It is now believed that governments should leave the supply of inputs to the private sector, and should instead focus on supporting private agricultural production and marketing, and ensuring the safety of agricultural inputs, as well as the quality and safety of food.

Development banks are now reluctant to support the supply of farm inputs by government agencies. Experience has shown that distribution by these agencies is often inefficient. The products they supply are not always exactly what is needed, and they do not always reach those who need them most. Nowadays, the banks are supporting the distribution of farm inputs by helping establish a sound credit system, reliable extension systems, and removing barriers to private input supply. In order to ensure sustainable use, development banks may require local credit institutions to develop their own (environmental) risk assessment systems that ensure the proper use of agro-chemicals financed through their loans.

A free supply of farm inputs such as agro-chemicals, still the policy of a limited number of donors and governments, may impede the development of independent farmers, (since it is those who supply the inputs who decide what is needed, rather than farmers). This may lead to poor choice of inputs and, with respect to pesticides, may result in outdated or obsolete stocks. Most obsolete stocks, whether in the former Soviet Union or in developing
Table 7. Examples of factors in eco-toxicological risk assessment

<table>
<thead>
<tr>
<th>Product</th>
<th>Formulation or trade name</th>
<th>Surface water</th>
<th>Ground water</th>
<th>Aquatic non-target</th>
<th>Avian non-target</th>
<th>Mammalian non-target</th>
<th>Beneficial insect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qualitative environmental risk assessment</td>
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<tr>
<td>Fonofos</td>
<td>Dyfonate-4</td>
<td>HR</td>
<td>MR</td>
<td>HR</td>
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<tr>
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<td>Dyfonate-II</td>
<td>HR</td>
<td>MR</td>
<td>HR</td>
<td>HR</td>
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<tr>
<td><em>B. thuringensis</em></td>
<td>Pixel</td>
<td>LR</td>
<td>LR</td>
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<td>Quantified environmental risk (in US$ per unit of product sold)</td>
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<tr>
<td>Fonofos</td>
<td>Dyfonate-4EC</td>
<td>1.59</td>
<td>1.17</td>
<td>1.48</td>
<td>1.46</td>
<td>1.42</td>
<td>1.50</td>
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<tr>
<td>Fonofos</td>
<td>Dyfonate II</td>
<td>1.59</td>
<td>1.17</td>
<td>1.48</td>
<td>1.46</td>
<td>0.99</td>
<td>1.50</td>
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<tr>
<td><em>B. thuringensis</em></td>
<td>Pixel</td>
<td>0</td>
<td>0.77</td>
<td>0.86</td>
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HR - high risk; MR = moderate risk; LR = low risk; NR = negligible risk
Source: adapted from Higley & Wintersteen 1992

countries, derive from earlier procurements of pesticides by the government. Although pesticide donations can occasionally be useful in emergency situations, they tend to distort markets and the leftover ("obsolete") stocks are a liability and expensive to remove. Perhaps the donor community should review its policies of free of agro-chemicals, as these “gifts” may create long-term liabilities that far outweigh their estimated short-term benefits.

Development banks are increasingly looking for investments that will support more sustainable pest control methods, such as integrated pest management. Examples from the World Bank are support for the biocontrol of cotton pests in Uzbekistan, and for IPM training based in field schools, in Indonesia. In addition the World Bank has been assisting member countries to develop better pest management policies and regulatory agencies. An important initiative of the World Bank, in cooperation with FAO, UNEP, has been the creation of the Global IPM Facility. This Facility, is located in Rome, and aims to help countries to develop the right policies, and provides funds for research and pilot projects in integrated pest management.

REFERENCES

There is some confusion about the definition of IPM. Some see it as integrated pesticide management. Others see it as pest management without using any pesticides. The World Bank defines IPM as “a mix of farmer-driven, ecologically based pest control practices that seeks to reduce the reliance on synthetic chemical pesticides.”

New York Food and Life Science Bulletin, 139, Ithaca (NY), Cornell University, USA.


**DISCUSSION**

It was pointed out that whereas the World Bank can exert pressure on developing countries through imposing conditions on its loans, there is not the same kind of pressure on developed countries. Dr. Schillhorn agreed, and felt that it is difficult to define who is driving the system. While the World Bank responds to the wishes of its borrowers, the whole issue of world trade is beyond the control of the Bank.

Several participants were interested in transgenics as a component of IPM. Dr. Schillhorn felt that some interesting products are being developed that seem to be compatible with IPM practices, particularly transgenic crops with resistant genes. He pointed out that in developing countries, transgenic crops are being developed by government corporations rather than by multinational companies.

One participant raised the question of using *Bacillus thuringiensis* (B.T.) genes in resistant crops. She commented that while in the past resistance had occurred after repeated applications of B.T. products, that resistance had generally been short-term and reversible. However, if B.T. genes become a permanent part of the genetic make-up of crop plants, resistance is likely to become permanent and irreversible. Dr. Schillhorn agreed that there have been many examples of “magic bullets”, such as DDT, which have then caused problems of their own. He suggested that fundamental changes are taking place in agriculture, and many people are concerned about the long-term and indirect effects of pesticides and bio-engineered products. He also pointed out that many people feel that the question of whether the world can feed its human population is less a matter of increasing production, than of organizing the supply.

One participant pointed out that while the costs of pesticides are going up, the costs of most agricultural products are not. In less industrialized countries, it is becoming difficult for farmers to afford pesticides. Dr. Schillhorn agreed that modern pesticides may not be affordable to many Third World farmers. He pointed out that the World Bank is attempting to change the way in which GDP is calculated, so that the long-term environmental effects of production and consumption, including pollution and energy consumption, are taken into account. In “Green Accounting” of this kind, the environmental costs of chemical pesticides may further increase the price, and IPM looks much more favorable.

* There is some confusion about the definition of IPM. Some see it as integrated pesticide management. Others see it as pest management without using any pesticides. The World Bank defines IPM as “a mix of farmer-driven, ecologically based pest control practices that seeks to reduce the reliance on synthetic chemical pesticides.”
A participant from the Philippines felt that resistance management is the main problem in efficient pesticide use. Dr. Schillorn agreed, and pointed out that successful resistance management needs the cooperation of all farmers. In a free market with private distribution of pesticides, even if only a few farmers do not adhere to a resistance management system, they are enough to produce resistance in a pest species. Current marketing methods are also likely to promote resistance, in that companies promote a particular product and try to make it dominant in the market. If they are successful in doing this, so that all farmers are using a particular pesticide, the pest is likely to develop resistance in only 6-7 generations.