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Review

Understanding benefits and risks of pesticide use

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Pesticides are widely used in most areas of crop production to minimize infestations by pests and thus protect crops from potential yield losses and reduction of product quality. Thus, they play an essential role in ensuring high profits to farmers, providing reliable supplies of agricultural produce at prices which are affordable to consumers, and also improving the quality of produce in terms of cosmetic appeal which is also important to buyers. Benefits from pesticide use can accrue to a number of different recipients, not only to farmers or consumers, but also to the society. At the same time, there is evidence of both direct and indirect dangers involved in the use of these chemical substances both for humans and the environment. Although discussions among scientists and the public have repeatedly focused on the real, predicted, and perceived risks that pesticides pose to people and the environment, in reality nobody will ever know with complete certainty that a pesticide is safe or not. Thus, a major issue which always arises is whether we are willing to accept the risks of pesticide use in pursuit of the benefits. It is necessary to reduce unreasonable fears, heighten awareness, foster support, and steer good public policy on pesticides and their use. The most promising opportunity for maximizing benefits and minimizing risks is to invest time, money, and effort into developing a diverse toolbox of pest control strategies that include safe products and practices that integrate chemical approaches into an overall and ecologically based framework which will optimize sustainable production, environmental quality, and human health.

Key words: Pesticides, crop protection, pest control, human health, risk communication.

INTRODUCTION

Pesticides include naturally occurring and man-made substances which are used to control destructive pests such as insects, plant disease organisms, and weeds, including many other living organisms such as nematodes, arthropods other than insects, and vertebrates that endangers our food supply, health, or comfort. In particular, the term pesticide refers to chemical substances that are biologically active and interfere with normal biological processes of living organisms deemed to be pests, whether these are insects, mould or fungi, weeds or noxious plants. Pesticides are widely used in most areas of crop production to minimize infestations by pests and thus protect crops from potential yield losses and reduction of product quality.

Pesticides are by no means a new invention. In fact, intentional pesticide use goes back thousand years when Sumerians, Greeks, and Romans killed pests using various compounds such as sulphur, mercury, arsenic, copper or plant extracts. However, results were frequently poor because of the primitive chemistry and the insufficient application methods. A rapid emergence in pesticide use began mainly after World War II with the introduction of DDT (dichlorodiphenyltrichloroethane), BHC (benzene hexachloride), aldrin, dieldrin, endrin, and 2,4-D (2,4-dichlorophenoxyacetic acid). These new chemicals were effective, easy to use, inexpensive, and thus enormously popular. However, under constant chemical pressure, some pests became genetically resistant to pesticides, non-target organisms were harmed, and pesticide residues often appeared in unexpected places. With the publication of Carson's book 'Silent Spring' in 1962, public confidence in pesticide use was shaken. The book claimed detrimental effects of pesticides on the environment, particularly on birds.

Moreover, Carson accused the chemical industry of spreading disinformation and public officials of accepting industry claims uncritically. Although the quality of that report had been severely criticized, the risks of pesti-cides were pointed out in that book more than ever be-fore. The result has been a redirection of research toward more pest-specific pesticides and cropping methods that reduce reliance on pesticides.

In the late 1960s, a movement towards more environ-mentally friendly crop protection methods emerged and researchers began developing a different approach to pest control called integrated pest management (IPM). IPM is a pest control strategy that uses an array of com-plementary methods to keep pests at economically insignificant levels with natural predators and parasites, resistant varieties, cultural practices, biological controls, various physical techniques, and pesticides as a last resort. IPM assumes that low levels of pests are tolerable and thus eradication is not necessarily a goal or even desirable in some cases because the elimination of a pest may also result in the loss of the beneficial pre-dators or parasites that need the pest in order to survive. IPM is rarely a substitute for using pesticides; rather, it is more often used to improve the effectiveness or reduce the overall pesticide use. However, even with IPM, pesticides are often the only effective way to deal with emergency pest outbreaks. Moreover, in some situations any level of a pest is intolerable. For example, most people would consider even one rat in their house intolerable and most shoppers would not buy fruit or vegetables with blemishes from insects or plant diseases. As a result, farmers cannot afford to produce foods with even minor signs of pest damage, so they are forced to use pesticides.

Progress in chemical crop protection has been extra-ordinary over the last 60 years, not only in the invention of new active ingredients, but also in the assessment of the behaviour of these chemicals in the environment, the residues in crop plants, and of their potential toxicity to humans and the environment (Muller, 2002). Tremen-dous scientific progress in chemistry, biology, and molecular biology has revolutionized the way of search-ing for new agrochemicals. Requirements, in terms of safety to humans and the environment, have also changed. The development of new agrochemicals with novel modes of action, improved safety profiles, and adapted to the changing requirement of the food and feed production chain are more than ever the challenge. Today, chemical crop protection is a well-established technology to support sustainable production of food, feed, and fibre and it seems that it will probably continue to play an important role in agribusiness in spite of the emergence of novel biotechnological solutions. World pesticide expenditures totalled more than $32.5 billion in 2001 (Fishel, 2007), whereas in the USA, approximately 500 million kg of more than 600 different types of pesti-cides are applied annually at a cost of $10 billion (Pimentel and Greiner, 1997).

Understanding pesticide benefits

There are many kinds of benefits that may be attributed to pesticides but often these benefits go unnoticed by the public. The most obvious and easiest benefits to calcu-late are economic benefits for the farmers derived from the protection of commodity yield and quality and the reduction of other costly inputs such as labor and fuel. Estimates of global losses from pests for eight crops in some regions showed that pest-induced losses were more than 50% of attainable crop output (Oerke et al., 1994). Insects caused destruction of 15% of crops, disease pathogens and weeds 13% each, and post-harvest pest infestations another 10%. Without pesticides, food production would drop and food prices would soar. With lower production and higher prices, farmers would be less competitive in global markets for major commodities. Preventing or reducing agricultural losses to pests with the use of pesticides improves yields and thus ensures reliable supplies of agricultural produce at prices which are affordable to consumers and improves the quality of the produce in terms of cosmetic appeal which is also important to buyers.

Pesticides are also widely used in a variety of other settings, some of which most of the general public are not aware of. In the same way that pests in agriculture and public health cause undesirable effects such as losses, spoilage and damage, those organisms when unchecked, have a negative impact on human activities, infrastructure, and the materials of everyday life. Pesti-cides play a major and often unseen role in preventing this negative impact. Thus, benefits from pesticides can accrue to a number of different recipients, not only to farmers or consumers, but also to the society. For exam-ple, trees and bush growing beneath power lines would cause power outages, if left unchecked. Herbicide use eliminates the problem and provides unobstructed access for maintenance and repairs. Road crews use herbicides to control vegetation along high-ways for safety reasons; clear roadsides, thereby increasing visibility for drivers and allow water to escape more efficiently during a downpour or flooding. Herbicides are used also to manage invasive weeds in parks, wetlands, and natural areas.

Other kinds of benefits include the maintenance of aesthetic quality, the protection of human health from disease-carrying organisms, the suppression of nuisance-causing pests, and the protection of other organisms including endangered species from pests. Pesticides are used around our homes and businesses in ways we often take for granted. For example, plastics, paints, and caulks may contain fungicides to prevent moulds. Toilet bowl cleaners and disinfectants often contain pesticides.

Raw commodities and packaged grocery products are protected from insect contamination by the controlled use of insecticides in processing, manufacturing, and packaging facilities. Pesticides are used in grocery stores to manage insects and rodents attracted to food and food waste. Davis et al. (1992) reported that nearly all families (97.8%) used pesticides at least one time per year and two thirds used pesticides more than five times per year. The most common setting for family pesticide use was in the home, where 80% of families used pesticides at least once per year. This was followed by herbicide use to control yard weeds (57% of families) and insecticide use to control fleas and ticks on pets (50% of families). A substantial number of families also used pesticides in the garden or orchard (33%). It is evident that proper use of pesticides improves quality of life, protects our property, and promotes a better environment.

These non-monetary benefits from the use of pesticides are difficult to calculate. Policy makers have long wrestled with how to put dollar-based values on such things as aesthetic quality, survival of certain endangerred species, and peace of mind. In practice, such non-market benefits are rarely considered by policy makers to be as important as benefits that can be measured in the marketplace, and hence they are generally ignored. The calculation of benefits for each pesticide usually starts with the development of a profile of pesticide use. However, data are often difficult to obtain, and in some cases, especially for minor crops and non-agricultural uses, do not exist. Lack of a pesticide use data base is a major impediment for determining accurate estimates of the impact of changes in pesticide availability. The development of realistic economic analyses is hindered by the lack of market data and economic models for minor crops and non-agricultural pesticides. Even the economic benefits of greater crop yields are unclear for many commodities for which huge surpluses exist. Additionally, the overall benefits of a pesticide are difficult to evaluate when they are distributed unevenly among various impacted groups such as pesticide users, non-users (e.g. organic growers), other market participants (e.g. shippers and retailers), residents of those areas where the pesticides will be applied, consumers of products treated with pesticides, formulators, marketers, and applicators. Obviously, the risks and benefits to these diverse groups will vary considerably, but all should be considered.

Understanding pesticide risks

No field of human endeavour is entirely free of risk. All aspects of our daily life are surrounded by some degree of risk. Even to do nothing can incur a risk. In every case, we have to consider all risks of any activity in the light of all its benefits. This applies equally to the safe and

effective pesticide use. For decades, discussions among scientists and the public have focused on the real, predicted, and perceived risks that pesticides pose to people and the environment. It is evident that wide-spread use of pesticides in modern agriculture has been an accepted part of the industry for many years. At the same time, there is evidence of both direct and indirect dangers involved in the use of these chemicals (Metcalf, 1987; Woodruff et al., 1994; Koh and Jeyaratnam, 1996; Van der Werf, 1996; Pimentel, 2005). This is probably because widespread use of pesticides produces immediate benefits mainly to a small section of the society, the agricultural industry, while the long term risks are shared by society as a whole. Despite continuing disagreements over the degree of risk posed by pesticides, it appears that people have become increasingly concerned about pesticide and other agrichemical use over the past years (Dunlap and Beus, 1992). This increase in concern corresponds to the emergence of a more general concern about environmental quality, the emer-gence of a growing health consciousness among the public, and often the distrust of authorities' regulations aimed at protecting both the environment and human health. As a result of these interacting trends, there seems to have been an increase in the degree to which modern life is viewed as 'risky'.

As pointed out earlier, pesticides are beneficial, yet they pose risk. But, what are the dangers from any particular pesticide? How many and which organisms are at risk? Are we willing to accept the potential risks in pursuit of the benefits? These questions have to be addressed and, ultimately, authorities must decide what constitutes acceptable risk. The issue is not only whether pesticides are dangerous, but also to whom or what they are dangerous, and to what degree. Unfortunately, there are uncertainties in evaluating the safety of any sub-stance, including pesticides. Scientific data, policy guide-lines, and professional judgment must be incorporated in estimating whether a pesticide can be used beneficially within the limits of acceptable risk. A product is assumed safe from a scientific point of view if the associated risks are minimal. However, the following four points must prevail to substantiate that assumption: conditions must not change to the extent that the assumptions and methods used in the supportive risk assessment may be rendered invalid, the user must follow product label directions explicitly, the product must perform as anticipated once it is released into the environment, and use of the product must not create adverse effects previously undetected in lab and field test data used for risk assessment. In reality, we will never know with complete certainty that a pesticide is or is not safe: the line between safe and dangerous is never as defined in real life as it is in science. Pesticides are developed to work with reasonable certainty and minimal risk. But they exist in a world of 'what ifs' that loom outside the realm of verifiable scientific information; and often it is the 'what ifs' that alert policy makers to data gaps. Based on evalua-tion of the best data available on a pesticide at a particular point in time, scientists can state in all honesty that no significant problems exist with it. In reality, however, many reasons exist why we may never know whether it is safe under all circumstances, nor can we predict with certainty its performance in hypothetical or future situations. Scientific investigation is bound by the tools and techniques available and new developments continually redefine our capabilities.

Normally, extensive scientific data are required in support of pesticide products for registration. But, the more data we have, the more questions we ask and science often stops short of definitive answers. Problems can span many disciplines e.g. medicine, chemistry, and biology, which make solutions evasive. Similarly, scientific knowledge regarding exposure and the potential for health effects from residential use of pesticides is a highly complex area of study that draws on evidence and expertise from a number of different disciplines, includ-ing toxicology and epidemiology. Toxicological studies are an important foundation for our understanding of the potential for health effects from exposure to pesticides and for establishing reference doses. It has been argued, however, that they cannot fully predict the nature and magnitude of the health effects from the real world circumstances of our environmental exposures. We will never know if pesticides are safe in the absolute sense of the word. Science may never define safety, nor prove it. But the 'what ifs' will continue to drive regulatory agencies, manufacturing, marketing, public interest groups, application industries, judicial processes, and science. Even with extensive scientific data in hand, there is also an interesting and unintended side effect. The fact that many data analyses are often disputed among scientific, government, and industrial interests cultivates a public mindset of distrust and disbelief. We school the public to rely on experts, but we caution them that experts disagree. Thus, on one hand, we extol the power of science; on the other hand, we caution that science cannot always answer the 'what ifs'.

Conclusion

Understanding generates perspective, no matter the subject; and understanding the benefits of pesticides is essential to weighing the risks. To identify potential risks associated with pesticide use, it is necessary to understand how risk is determined, what factors (including characteristics of the exposed population) control the potential for risk, what experience has shown about the risk, and what can be done to minimize the risk. Conclusions then must be weighed against the benefits of pesticide use, factoring-in any available alternatives as well as the benefits and risks of those alternatives.

Unquestionably, the use of pesticides has been and always will be controversial in our society. It involves very real and important trade-offs that concern people. It is difficult to get people to understand and accept risk. It is also difficult to get those who ignore risk to acknow-ledge and respect it. As individuals, we base our beliefs on what we know; and what we know depends largely on our source of information. A person's knowledge on pesticides, coupled with their own personal values, forms the basis for their stance on the issue.

There are myriad views on pesticide risk, but people tend to key into concepts that complement their own agenda, that is, concepts that validate their own preconceptions. Technical information alone probably will not address public concerns effectively, nor will it necessarily reduce regulatory restrictions. Effective risk communication requires staying always abreast of scientific developments, presenting concepts that are clear, understandable, and non-threatening to the audience, and also understanding the public concerns. Questions, responses, discussions, and what may seem to be unreasonable concerns (or lack of concern) must be treated with equity. The main goal is to reduce unreasonable fears, heighten awareness, foster support, and steer good public policy.

People who argue against the use of pesticides believe that pest elimination can be achieved without their use. While this may be true in a few isolated situations, most pest management programs on the farm, around the home, in parks, natural areas, and so on often rely on a combination of non-chemical and chemical control methods. The most promising opportunity for maximizing benefits and minimizing risks is to invest time, money, and effort into developing a diverse toolbox of pest control strategies that include safe products and practices that integrate chemical approaches into an overall and ecologically based framework which will optimize sustainable production, environmental quality, and human health.

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