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DOES CAMBODIA NEED INTEGRATED PEST MANAGEMENT? PAST EXPERIENCE, PRESENT KNOWLEDGE AND FUTURE PROSPECTS

By Khun Kimkhuy and Ngin Chhay

Biotic and abiotic stresses in agriculture constrain food production. It is estimated that 33 percent of crop losses in the world are due to weeds, 26 percent to plant diseases, 20 percent to insect pests, 8 percent to rodents, 3 percent to birds and 10 percent to other organisms such as nematodes, parasitic plants and mites (Nagarajan 1994). An insect pest is an organism judged by people to cause harm to themselves, their crops, their animals or their property. In farming, an insect may be classified as a pest if the damage it causes to the crop or livestock is sufficient to reduce the yield and/or quality of the harvested product by an amount that is unacceptable to farmers. Insects can be pests because they cause direct damage to harvestable products, e.g. flea beetles' damage to brassica crops, or because they cause indirect damage or harm in other ways, e.g. by causing a nuisance to livestock or humans or as vectors of plant or livestock diseases. Insects can cause harm in a myriad of ways, and they have done so for the thousands of years that humans have engaged in agriculture. Likewise, attempts to control or manage the harm caused by insects have a long and varied history; sometimes, inappropriate actions have induced more pest problems. Knowledge of this history is an important dimension to the study of pest management. It can provide insights into the driving forces (technical, economic, social and environmental) that have forged current pest management practices and forces likely to be acting in the future (Norton 1993). A recent report by the Food and Agriculture Organisation (FAO 2011) confirms that consumers have grown increasingly concerned about pesticide residues in food. To address this problem, the FAO promotes the combining of different ecologically sound pest control strategies or integrated pest management (IPM). An ecological approach to managing rice pests would improve the agricultural ecosystem, prevent pest outbreaks and contribute to sustainable crop production intensification.

CHEMICAL PESTICIDES ARE NOT ALWAYS THE BEST OPTION

Insect pest outbreaks can be caused by: 1) monoculture plantings consisting of mostly or entirely of one plant species, which increase the attractiveness of crop environments to pests and the number of pest species that colonise them; 2) the use of high-yielding crop cultivars along with high chemical application, especially nitrogen, which provides improved conditions for pest colonisation, spread and rapid growth; 3) the reduction in natural areas around crops, which means that natural enemies of pests must come to the crop from increasingly small and more distant non-crop reservoirs, entering crops too late or in too small numbers to prevent pest outbreaks; 4) the intensification of production resulting in reduced intervals between plantings of the same crop, or overlap of crops, providing a continuous resource to pests; 5) the search for better cultivars and accelerated movement of plant material around the world has accelerated the movement of plant pests and diseases; and 6) agro-chemicals upsetting the natural ecosystem balance (Dent 2000). For all those and many more reasons, farmers struggle to manage insect infestations and usually rely solely on chemical pesticides to regulate pest populations.

The short-term benefits from insecticides can be immense, through reductions in disease

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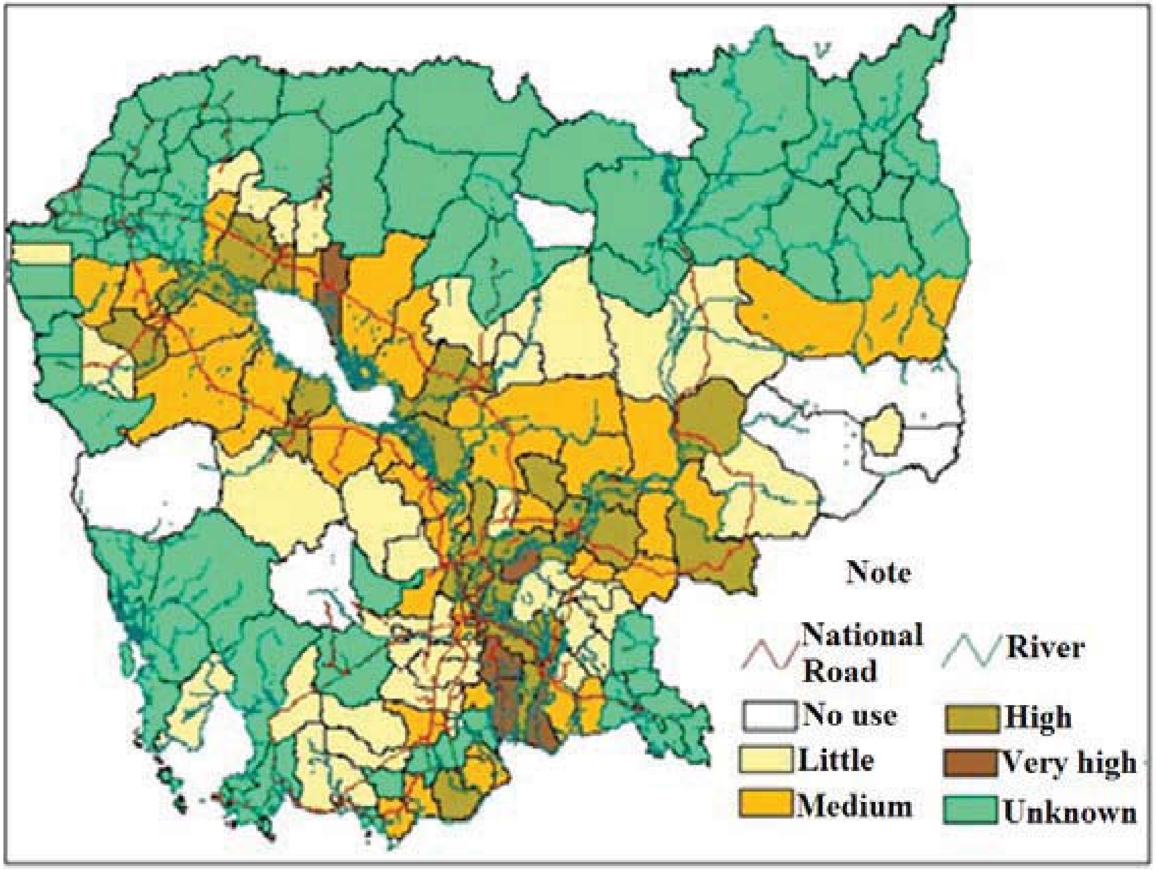
transmission by insect vectors and in losses from field crops, stored products and orchards. Because of these immediate benefits, insecticides have proved popular as a means of pest control, but there are also longer term and indirect costs associated with their use, such as destruction of beneficial organisms, environmental pollution and negative impacts on human health.

Chemical pest management approaches have not always succeeded because of the development of insecticide resistance. Insecticide resistance is the result of the selection of insect strains tolerant to doses of insecticide that would kill the majority of the normal insect population (Cremlyn 1978). These strains tend to be rare in the normal population, but widespread or intensive use of an insecticide can reduce the normal susceptible population, thereby providing the resistant individuals with a competitive advantage. The resistant organisms multiply in the absence of intraspecies competition, and over a number of generations become the dominant proportion of the population. The insecticide becomes less and less effective and the pests become resistant to crop protection products. For example, compared with non-sprayed paddy fields, regular spraying increases the resistance and reproduction of brown planthoppers by up to 10 times as the intensive use or misuse of insecticide disrupts ecosystems and destroys their natural enemies (IRRI 2013). In 2011, the Thai government announced an initiative to reduce brown planthopper damage that included restricting the use of outbreak-causing insecticides abamectin and cypermethrin; the decision was supported by the International Rice Research Institute (Wikipedia 2013).

Aside from insecticide resistance, pesticides have also become a global concern because they cause ecotoxicological problems such as killing non-target organisms and polluting air, soil and water. Most of the time, only 1 percent of applied insecticide reaches its insect target (Graham-Bryce 1977) and a large proportion becomes available in the environment, affecting non-target species and beneficial organisms. Unfortunately, parasitoids and predators of pests are highly susceptible to all insecticides because they are very small and soft-bodied (Aveling 1977, 1981; Jepson *et al.* 1975; Vickerman 1988). For instance, carbamate and organophosphate insecticides have been recorded to cause mortality in earthworms and birds and other vertebrates (Hunter 1995; Edwards 1987). Pyrethroid insecticides, when they get into freshwater rivers and lakes, are known to have an impact on fish. Pimentel *et al.* (1993) estimate that 6–14 million fish were killed annually between 1977 and 1987 by pesticides in the United States. Currently, neonicotinoid insecticides have become very popular for use against sucking insects, some chewing insects and soil insects due to their low toxicity to mammals compared with previously used organophosphates and carbamates. However, this insecticide family has been proven to cause honey bee colony collapse by disrupting the immune systems of bees, making them susceptible to viral infections to which they are normally resistant (Cressey 2013; Dicks 2013). Thus, the European Commission has adopted a proposal to restrict the use of neonicotinoid insecticides for seed treatment, soil application and foliar treatment on bee-attractive plants and cereals in European Union member countries. The restrictions were to take effect from 1 December 2013 (Environmental Protection Agency 2013). In Cambodia, farmers commonly use at least 12 insecticides belonging to the neonicotinoid family (Cheang 2013). These insecticides are not yet included in the country's updated list of banned or restricted pesticides (MAFF 2012).

Indiscriminate use of pesticides not only puts sustainable agricultural production at risk through the disruption of vital ecosystem services, pesticide residues on fresh produce that exceed the maximum (allowable) residue limits (MRLs) also raise food safety concerns and jeopardise export potential. MRLs are standards set by individual countries for traded agricultural commodities according to types of pesticides. Pesticide residues result from: 1) heavy pesticide use on the growing crop; 2) insecticide used in post-harvest management to preserve food during storage; and 3) the persistence and carry-over effect of residues in the soil. Survey studies of pesticide contamination of vegetables in Cambodian markets found produce containing residues of organochlorine (Wang *et al.* 2011), organophosphate and carbamate (Neufeld *et al.* 2010) exceeding MRLs. Cambodia ranks first among 13 countries in the region with the highest pesticide residue on vegetables, particularly leafy vegetables from Kandal (Wang *et al.* 2011). This is the result of the irresponsible and indiscriminate

Figure 1: Map of Pesticide Usage

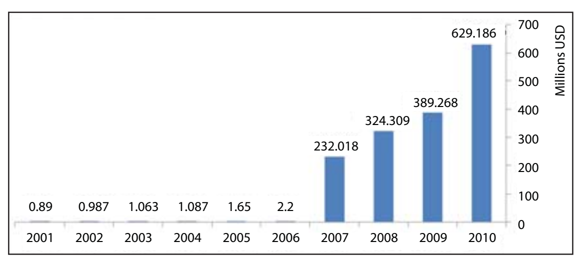


Source: CEDAC 2003

use of pesticides by farmers as well as a lack of understanding about pre-harvesting intervals. A study by the Cambodian Center for Study and Development in Agriculture (CEDAC 2003) found that farmers along the Mekong River commonly used high dosages of extremely hazardous chemical pesticides on vegetables and rice (Figure 1). According to the FAO (2012), the cost of agricultural pesticide imports into Cambodia was estimated at a total cost of USD890,000 in 2001 and this increased to USD2.2 million in 2006. The cost of agro-chemical pesticide imports has rapidly increased up to USD629,186 million in 2010 (at least 285-fold increase in pesticide use over just a five-year period) (Figure 2). The rise of pesticide imports is explained mainly by aggressive promotion by agro-chemical companies and limited farmer education on alternative environmentally friendly pest management options.

The weak enforcement of pesticide regulations in Cambodia does not help farmers who cannot read pesticide labels. In 1994, there were only 30 pesticides in the market; this increased to 63 in

Figure 2: Cost of Agricultural Pesticide Imports, 2001–10



Source: FAO 2012

1998 and 241 in 2000 (CEDAC 2000). Of those 241 pesticides, 42 were prohibited in Vietnam and another 16 were banned in Thailand. Clearly, Cambodia had become a dumping ground for unwanted and dangerous pesticides (EJF 2002). In 2004, 419 pesticides were illegally sold in the country's numerous markets (MOE 2004) and this increased to 517 pesticides in 2005 and 757 in 2009 (CEDAC 2010). However, in 2007, only about 175 pesticides were permitted for use in Cambodia (PAN), most of which were imported from countries in the region. At least 95 percent of pesticides on the market are labelled in foreign languages (Vietnamese, Chinese, Thai or English), making it very difficult for farmers to use them properly (Carmichael 2011; FAO 2013a). The lack of knowledge and wrong perceptions about pesticides, underestimation of the risks and ready access to illegal and extremely hazardous chemical pesticides cause farmers serious problems. These include inefficient usage, health issues and waste of money. For example, a majority of aquatic vegetable growers in Boeng Cheung Aek have reported symptoms of acute pesticide poisoning as a result of underestimating the health effects of exposure to pesticides during handling and spraying. The researchers confirmed that the widespread availability of highly hazardous pesticide has facilitated its use by farmers for committing suicide (Jensen *et al.* 2010; Puddy and Khouth 2011; Vrieze and Chhorn 2011).

INTEGRATED PEST MANAGEMENT, A POSSIBLE SOLUTION

According to the FAO, integrated pest management means the careful consideration of all available pest control techniques and the subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically viable and that reduce or minimise risks to human health and the environment. The emphasis of IPM is to grow healthy crops with the least possible disruption to agricultural ecosystems and to encourage natural pest control mechanisms (FAO 2013b). IPM focuses on the education of farmers to enable them to increase agricultural productivity and profitability in a sustainable manner, leading to better socioeconomic outcomes while safeguarding human and animal health and protecting the natural environment (NIPMP 2003).

IPM involves the following steps: preparation, prevention, monitoring and analysis, and evaluation.

Preparation: Farmers should keep some questions in mind before they start to grow their crops: What pests can be expected during the season and at which crop growth stage? What do these pests look like, and where can they be found at different life stages? What kinds of damage do they cause? What is the expected yield loss as a result of damage? When should the crop be checked for pests and how can they be spotted? What can be done to avoid them? Which tactics should be used to manage them? What are the strengths and limitations in access to labour, equipment, biological control products and markets? What beneficial natural enemy species will help to regulate pest populations, and what should be done to optimise these ecosystem services? Farmers should think about the possible problems before they start planting. For instance, they should check the previous year's production records. This first step will help them consider crop production choices and pest management options.

Prevention: Farmers should think about prevention rather than crop protection. In this step, farmers should consult local experts and reflect on their experiences of the previous year's production. Farmers should consider promoting biological diversity around the farm to give beneficial organisms a helping hand; rotating their crops to break pest life cycles—this practice also improves soil structure and fertility; growing plant varieties resistant to common diseases and insect pests; removing, composting or destroying disease-infected plants and other sources of pest infestation; planting only on sites that meet the crop's needs; building soil health—healthy crops tolerate pests better; cultivating crops that are resilient to common problems; and altering planting times and spacing to discourage certain diseases and insects.

Monitoring and analysis: Farmers should go to their fields every day and observe what kind of insects or diseases are harming their crops and the extent of the infestation. Are they really pests? Farmers should have some awareness of the major and minor pests, as well as the natural enemies of those pests. It is the time when farmers should think about the impact of pests. Do pests damage the whole farm? Will the damage and pest populations exceed a level that could cause economic loss? Before using chemical pesticides, growers should analyse the field situation carefully and determine whether pest populations have reached a scientifically determined level that could cause economic damage. Farmers should make informed decisions needed for agroecological pest management, e.g. by taking into account the dynamics of pests and their natural enemies.

Management and control: Farmers should focus on economically sound decision-making while also taking into account ecological and toxicological factors. Farmers should consider various, or a combination of, interventions including mechanical (hand picking, watering), biological (predators, parasitoids) and cultural (pruning, farm sanitation) to manage pests. Chemicals should be considered as the last option and only if all other options fail to keep the pests at a level where economic loss will not be significant. Growers should select the most appropriate pesticide (most effective, low toxicity, low cost per use, readily available) and calibrate sprayers carefully to ensure proper and even application rate. They should then make sure that the weather conditions will permit good coverage without undue drift. If pesticides are used, they should ensure that the instructions, including safety precautions, have been read and followed. Farmers must remember the slogan "Right type, right time, right dose and right application techniques".

Evaluation: After implementing the management steps, the pest problem should decrease noticeably. The last step is evaluation. Growers should think about questions such as: Did I make the right decision? Did I get the results I wanted? How much has the situation changed since last week? What worked well and what did not? Should the crops be rotated? It is necessary for farmers to answer these questions because it will help them do better in the next year.

IPM may be conceived of as an interactive system at three possible levels of interaction (Kogan 1988): the integration of control methods for single species or species complexes; the integration of the impact of multiple pest categories (insects, pathogens, weeds) on crop methods and their control (community level integration); and the integration of multiple pest impacts and the methods for their control within the entire cropping system (ecosystem level integration).

The Cambodian IPM programme was initiated in 1993 after a national workshop on "Environment and IPM". In 1998, the Ministry of Agriculture Forestry and Fisheries (MAFF) officially declared IPM to be one of the country's key crop production strategies with the aim of making it the standard approach. Furthermore, on 4 July 2002, MAFF issued Prakas No. 205 on the establishment of an integrated crop management programme, the National IPM Programme (NIPMP), to facilitate the coordination of all IPM activities in Cambodia (NIPMP 2003). The overall goal of the NIPMP was to promote food security and food safety by enhancing the sustainability of intensified crop production systems through the promotion of integrated pest and crop management skills at farm level. Since its establishment, the NIPMP has worked closely with provincial departments of agriculture, local and international organisations, research institutions and farmers in 19 provinces to implement capacity building of technicians, participatory action research and farmer education through farmer field schools. Results achieved by the NIPMP include: at least 15-35 percent increase in rice yields or 41-55 percent increase in profits; at least 15 percent increase in vegetable yields or 37-44 percent increase in profits; 43 percent reduction in pesticide application and a 64 percent reduction in the volume of pesticide use (Ngin 2004). By the end of 2013, the NIPMP in close collaboration with relevant organisations, especially the FAO, had trained 918 IPM trainers (346 female), 2797 farmer trainers (997 female) and 198,895 farmers (92,554 female) in rice growing, vegetable gardening and crop planting (NIPMP 2013). IPM training leads to more sustainable and cost-effective production, reduction of ecological disruption and environmental contamination, reduction of public health issues and toxic residues in food, and improvement of livelihoods, biodiversity and marketability of produce. The application of IPM makes a huge contribution to food security and safety, poverty alleviation and, ultimately, to national economic growth, which are priorities of the government (NIPMP 2012).

FUTURE PERSPECTIVES

(1) New generation scientists should adopt integrated and sustainable agricultural development strategies based on crop science, management technologies and modern plant protection techniques. They should focus on the major pests related to individual crops, especially rice, fruits and vegetables. They should also update the list of individual crop pests. This pest list is essential for companies and plant breeders to screen strains that are resistant to specific insect pests or to develop beneficial organisms that counter those pests.

(2) The government should lead the push for the enforcement of policies, regulations and legislation relating to environmental protection and the responsible use of pesticides to reduce the risks and impacts of agro-chemicals use. In January 2012, Cambodia passed the Law on the

Management of Pesticides and Fertilisers. The implementation of the law should be mandatory, not voluntary. Financial or other penalties should be imposed on traders for illegally importing, selling or distributing banned pesticides, and on farmers for using them. Information about the law should be well disseminated and explained to farmers, retailers, importers and border inspectors through newspapers, television, radio and other media.

(3) The government should forge a connection between IPM and ASEAN Good Agricultural Practices (GAP). In 2015, the ASEAN Economic Community will be established and most agricultural products, especially fresh vegetables and fruits, will have to be produced in compliance with ASEAN GAP standards in order to be certified for export to other ASEAN countries. Educational efforts, especially at farm level, are needed to improve compliance with ASEAN GAP standards. Cambodian farmers will suffer from the effects of ASEAN free trade arrangements if the current situation is not addressed in time. Furthermore, the global and domestic markets for organic foods and beverages are growing and the demand for food safety is increasing. IPM is an ideal opportunity for Cambodian farmers to contribute to the development of sustainable agricultural production and to improve market access and the marketing of their products.

(4) The ministry should improve the extension of IPM approaches to cover the majority of farmers in the major production provinces. Research should put more focus on crop-specific recommendations for sustainable production and environmentally sound pest management. The education system should be improved by the inclusion in the curricula of the principles of ecology and field-based study to allow students to develop hands-on applied skills in taxonomy, entomology, plant pathology, weed science, horticulture, soil science and plant breeding. These young scientists could help speed the development of research-based IPM approaches and explore more effective pest management techniques.

(5) The ministry should expand farmers' education on IPM to include the identification and recognition of pest damage and the roles of beneficial organisms, improve methods and activities to promote the safe use of pesticides, awareness of pesticide-related environmental pollution and health hazards, and networking with IPM groups. These services could be successfully provided through the farmer field schools developed and implemented by the NIPMP, where farmers can learn by doing, which allows them to try out new techniques, and through sharing practical experiences with other farmers. The government should also provide policy directions and technical and financial support in close cooperation with NGOs to expand these schools' programmes. Another important element is to encourage community members to work collectively to achieve change and produce desired outcomes.

IPM helps to maintain ecological balance and promotes people's empowerment through informed decision-making. It reduces chemical pesticide use, soil and water pollution, pest resistance, loss of beneficial crop-associated biodiversity and damage to natural ecosystems thereby maintaining pest populations at less than damaging numbers and reducing yield losses to insect pests. IPM contributes to increased production and incomes and facilitates access to high-price, high-value markets. A great deal of research effort has been devoted to solving crop pest problems. Much effort has also gone into addressing the problems created by inappropriate pesticide use. As scientists have tackled the challenges posed by pest management and sought workable solutions, they have acquired more knowledge and technical skills which will enable them to develop more effective pest management technologies for the future. A better understanding of the lessons learned can help to develop successful pest management approaches and avoid mistakes in the future. Chemicals can lead to more pest attacks. IPM can lead to better long-term sustainable pest management, resilience in a changing environment, and improve food security and intensified production.

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The Development Research Forum (DRF) of Cambodia was established following the All-Partners Forum organised by the International Development Research Centre (IDRC) in September 2007.

The DRF vision is of a high capacity, professional and vibrant Cambodian development research community. Its goal is to support and strengthen the capacity of the Cambodian development research community.

The DRF partnership involves the Cambodia Development Resource Institute (CDRI), Cambodian Economic Association (CEA), Learning Institute (LI), National Institute of Public Health (NIPH), Royal University of Agriculture (RUA), Royal University of Phnom Penh (RUPP), Supreme National Economic Council (SNEC) and the International Development Research Centre (IDRC).

In DRF Phase II 2012-15, with financial support from IDRC, the partners intend to work together to build research culture and capacity and to share research knowledge through workshops, policy roundtables and symposiums as well as training and online discussion (www.drfcambodia.net) on six research themes: growth and inclusiveness, governance of natural resources, social policy – education, social policy – health, agricultural development, and Cambodia and its region.

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