The Changing Role of Pesticides in Future Pest Management Programmes

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After 1940, the use of synthetic chemical pesticides remained the major tactics in pest control. When properly used they provide an efficient, fast, reliable and cost-effective means of pest control. Until 1962, pesticide use in agriculture and public health was indiscriminate. Only after the publication of “Silent Spring” by Rachel Carson in 1962 people’s awareness towards the ill effects of pesticides increased. The drawbacks most often cited with injudicious and indiscriminate use of pesticides include development of pest resistance to pesticides, destruction of natural enemies, poisoning of man and animals, environmental pollution, minor pest assuming major status and increasing costs etc. Then a change in the attitude of policy planners of pesticide use, researchers, pesticide manufacturers and users of pesticides was observed. In addition to the conceptual shift concerning pesticide use and manufacture, the selection and extent of pesticide use in pest management is strongly influenced by a host of multifarious factors. These factors exert unseen positive or negative pressures on the need for pesticides in agricultural and health situations, the selection and availability of specific compounds and the extent to which they are used. Recognition of these factors is critical to an understanding of the changes in pesticide use in the tropics.

Changes in Pesticide Policy and Legislation

Several international actions have been undertaken on pesticide use in developing countries. Such policies and legislation are aimed at improved pesticide management, a practice that can help avoid pesticide misuse and the possible loss of a valuable and badly needed pest control tactic in the third world. Food and Agricultural Organization (FAO)/ World Health Organization (WHO) established the Codex Alimentarius Commission in 1963 to harmonize international pesticide residue standards through legislation that affect shipment of food item. The commission established Maximum Residue Limits (MRL) for food coming into international trade. These are offered to participating countries for acceptance. Similarly, an International Code of Conduct on the distribution and use of pesticides was developed by the FAO conference in its 23rd session in 1985. Besides, the member countries have their own regulatory infrastructures for pesticides.

In India, the Directorate of Plant Protection, Quarantine and Storage organization was set up in 1946 under the Ministry of Agriculture, Government of India, which was later, shifted to Faridabad in 1968. This organization looks after the registration, banning, quality testing
and setting up laws for pesticide use. Besides, some other laws enforced by Government of India to prevent environmental pollution are Environment Protection Act, 1968, Water (Prevention and Control of Pollution) Act, 1974 and Water Cess Act, 1977. As of this time, over 40 pesticides are included on the suspended, cancelled and restricted use list by Government of India. Clearly, the outright banning or cancellation of pesticide registrations, particularly those in use for many years can have significant, but hopefully beneficial impact on pest management programmes.

Change in Public Perception

In spite of much intensified and restrictive requirements for registration of pesticides and a greatly accelerated programme for the re-registration of existing pesticides as well as substantial scientific conclusions on pesticide safety, agricultural pesticides are still perceived as unacceptably hazardous to human health and the environment. These perceptions, added with pressure from environmentalists encourage the development of additional pesticide regulation. The resulting decline in available pesticide choices will severely limit not only chemical pest control options but also the flexibility they offer in terms of developing Integrated Pest Management (IPM) programmes. IPM is a subject to credibility with farmers. Farmers often receive distorted views of IPM as “pest control without synthetic chemical” or as “biological control” and as a result become reluctant to relinquish their pesticide-oriented but dependable pest management programmes.

Changes in Pesticide Manufacturing Attitude

It is the older, less expensive chemical that are often used in developing countries and most of the pesticides those are obsolete or banned in developed countries are manufactured in developing countries without compliance with safety requirements or the production standards of the multinational companies. The brightest example is the case of Union Carbide in Bhopal gas tragedy. But, now a days the pesticide industry has redirected its efforts to more IPM compatible products i.e. more selective chemicals with better target specificity. Directed and selective use of pesticides results in better resistance management, longer product life, improved grower satisfaction, minimum operator contamination, support from public and policy makers and also meets the FAO code of conduct commitments.

Recent advances in the understanding of insect ecology, biology, physiology and biochemistry are providing new impetus and opportunities for insect pest control. Increased knowledge of such insect hormones as brain hormone, moulting hormone, and juvenile hormone has made it possible to synthesize them. Introduction of devices that emit synthetic hormones offer the potential to disrupt normal highly insect selective functions such as breeding, growth and moulting, thus controlling the pest population. Insect pheromones are used commercially to monitor, detect and predict insect populations and to control several insect species on a variety of crops. One of the most promising areas for circumvention of the problem of current pesticides is the development of new materials with new mode of action to reduce host damage, particularly when compatible with additional pest management tactics. These 4th generation biorational pesticides offer new modes of action with less environmental disruption. For example, fenoxycarb is a “juvenoid” insect growth regulator developed by Rohm and Hass Company that help control pest populations of the mining moth in Japanese apple orchards in two phases, initially by fenoxycarb and secondly by the native endoparasitic hymenopterans which begin building
up in the second season. Similarly, the biopesticides of \textit{B.t.} available in the market are well compatible with endosulfan insecticide. Such an approach has the added advantage of helping to delay resistance build up in insects.

\textbf{Change in Population}

As per FAO report, the land availability in 1965 per person was 0.4ha versus only approximately 0.25ha per person in 1988. The world food production was approximately 2.2 billion metric tones in 1965, which has almost doubled to 4.5 billion tones in 1990. In spite of doubling of food production, some 950 million people, mostly in low-income countries, had food intakes below the critical minimum for adequate health. World population, which reached 6 billion in 2000, is expected to increase to 8.2 billion by 2025. Even with no increase in nutrient intake per caput, world population will demand a doubling of food production by 2025. The father of “Green Revolution” Dr. Norman Borlaug pointed out that about 80\% of the projected population increase will be in the low income and food deficit countries of Africa, Asia and Latin America. So food production must not be increased but it must be safeguarded as well. Intensification of production will lead to intensification of pest problems. Therefore a sustainable crop protection strategy, such as IPM, which utilizes all available tactics including modern pesticides, must be used.

\textbf{Availability of Practical IPM Programmes}

The adoption of IPM is practically low because the method is tedious, time consuming, requires new skills and has marginal benefits in terms of money. The failure and complexities of practical IPM systems, particularly monitoring and determination of crop loss and economic thresholds by small and marginal farmers will discourage the adoption of the IPM approach and encourage over reliance on single tactics such as the use of pesticides. This has happened in 1997 by the cotton-growing farmers of Andhra Pradesh and Karnataka. Over reliance on single tactics like pesticides caused insect resistance in \textit{Helicoverpa} and a crop failure, compelling many farmers to commit suicide. The use of resistant crop varieties offers an ecofriendly crop protection tactic that requires minimum extension inputs. The introduction of transgenic cotton variety “Boll guard” developed by Monsanto Company of USA in the two states could stabilize the situation. Unfortunately, only few new resistant varieties of only few crops are being released, and these are intended for monocultural markets rather than for the less profitable, mixed cropping systems used on small farms. However, genetic engineering technology promises to accelerate breeding for pest resistance.

Their natural enemies prevent most pests from causing excessive crop losses. However, scientists have identified successful and cost effective biological methods of control for many crops by introduction of non-endemic predators to parasitoids and augmentation of natural enemies. Besides, natural enemies those have increased tolerance to pesticides are now being identified. One such type is a \textit{Trichogramma} egg parasitoid resistant to endosulfan insecticide. Therefore it can well be released in areas where the insecticide will kill insects and the rest are controlled by the parasitoid. Increasing the efficiency of natural enemies of crop pests through genetic engineering offers new vistas in crop protection. The success of such programmes can have significant impacts on the amount of pesticides required for crop protection.

Cultural control practices represent another cornerstone of biointensive IPM. Pesticide use may play a greater role in the absence of suitable resistant plant varieties or
classical or augmentative biological control tactics, but the reverse is often the case with cultural controls. It should represent the first step in the development of local IPM programmes but due to the time and labour constraints involved in their use, they are often replaced with pesticide tactic. Many cultural tactics continue to fit to the social and economic needs of the small farmer. Regrettably, the “lure” of chemical pesticides is gradually eroding the indigenous crop protection knowledge of cultural tactics and unless they are documented and extension personnel are trained in their use, they may become lost and less available just like IPM tactics.

Innovative Technologies

The introduction of resistant genes into commercial plant varieties, use of antisense technology, virus coat proteins or satellite RNA to prevent spread of viral diseases in plants and many other technologies through modern biotechnology is envisioned by some to be the answer to crop protection problems. Clearly, they must be unaware of similar claims made many times throughout history and the miraculous adaptability of microorganisms and insects. Alternative tactics such as male sterilization technique, male annihilation technique, use of sex pheromones of important crop pests, use of chitin synthesis inhibitors, juvenile hormone analogues, anti juvenile hormones, non steroidal ecdysteroids and non terpenoid juvenile hormone compounds in pest management can significantly reduce pesticide use, particularly when used in combination with other control tactics. However, they are often extremely selective in action, depend on long term development, are too few in number, are geared to large scale agriculture, and do not preclude the development of resistance or acquaintance.

Changing Patterns in Pesticide Use

Synthetic pesticides have been extensively used in developing countries mostly after the adoption of green revolution and the control of vector borne diseases. By the early 1980’s the developing countries were thought to use 10 – 25% of the world pesticide production. However, about 1/3rd of the crops were still lost to pests each year and malaria alone affected 100 million people annually. By 1990, the third world countries used 26% of the world pesticide production. Around 55% of agricultural land situated in these countries is related to much lower consumption of pesticides than developed countries. Taiwan tops the list using 17 kg a.i./ha followed by Japan (12 kg a.i./ha) and Africa, the least with 0.13 kg a.i./ha, while India used 0.57 kg a.i./ha in the year 1998. Many developing countries including India, China, Bangladesh and Indonesia are participating in the global expansion of agricultural output. The value of pesticide imports to Asia increased three fold between 1970s to 1980s. The fastest growing pesticide markets are India, Brazil, China and Spain. Of the total world pesticide production 24% reach the developing countries, 12% goes to Asia, 8% to Latin America and 4% to Africa.

In India, the total amount of pesticides used in the country increased from 2.35 thousand metric tones in 1950-51 to nearly 85,000 metric tones in 1993-94. Earlier projections had put the pesticide demand by 2000 at nearly 1-lakh metric tones. But in view of the high priority being accorded to IPM, the pesticide consumption has shown a decreasing trend in the recent years. In Tamil Nadu the synthetic pesticide consumption has decreased by more than 50% during last 7 years, a decreasing trend has also been recorded in Andhra Pradesh and Karnataka. In contrast pesticide consumption continues to rise rapidly in
Punjab and Rajasthan. In 1992, the world consumption of herbicides was 44%, insecticides 30%, fungicides 20% and others 6% of the total pesticide consumption compared to 77% insecticides, 12% herbicides, 8% fungicides and 3% others in India. When cotton utilized 54%, rice 17%, cereals and millets 6%, and others 23% of total pesticide consumption in 1979 in India it was 39% in cotton, 35% in rice, 17% in cereals and millets and 9% in others in the year 1988. In contrast to this, 27% of the total pesticides were used in horticulture, 17% in rice, 24% in cotton, 7% in maize and 25% in others in the world in 1992. The world market on pesticides is estimated to grow @ 4.5% each year with the largest growth occurring in herbicides. The average growth rate in Asia Pacific region is approximately 5–7%, but in Indonesia and Pakistan, the market is expanding @ 20-30% per annum. Along with the increase in the amount of pesticide consumption, there is a change in the potency of some new chemicals observed in recent past. DDT was applied @ 1-2kg a.i./ha for the control of different pests, the organophosphates in general are effective @ 250-500 g a.i./ha, synthetic pyrethroids @ 12.5-100 g a.i./ha. Some recently developed chemicals like nitroguanidines are effective @ 25 g a.i./ha. Thus there has been more than 100-fold increase in the potency of new insecticides.

**Future of Pesticide Use**

The future of pesticide use in IPM is expected to depend on the continuation of existing pest management tactics and technology including the use of pesticides. Although the present environmentally conscious society rules out the placement of pesticides in IPM but it is technically correct for the pesticides to find a place, may be as the last alternative of IPM. Certainly, if we are to maintain a suitable IPM programme at higher than subsistence agriculture level, we must intelligently integrate as many compatible and available strategies as possible, including that of synthetic chemical crop protectants. We have learned from our past experiences that chemical pesticides alone cannot control pests and also it is increasingly apparent that alternative tactics alone cannot control them. Some consider that pesticide use for small and marginal farmer is not a future option but an immediate urgency. The developing world is on the threshold of large increases in the use of pesticides and they offer an opportunity for a nearly 50% increase in food production. Some predict that pesticides will be used more sparingly in the IPM era (1976 onwards) and the cost within an IPM system will be lower than those where pesticides alone are used. They opined that pesticides will continue as an essential, perhaps the major, component of IPM system and must be available when needed. This group of scientists believed that chemical pesticides were part of all producer supported IPM systems and projected that use of pesticides will continue worldwide with the greatest increase occurring in Africa, Latin America, the Far East, the Middle East, and South East Asia in order.

While IPM and other alternative systems often require fewer pesticides on a per hectare basis, it is expected that pesticide will remain routine and occasionally invaluable production inputs in future in most of the crops, vector control and control of migratory pest outbreaks. Control of locust outbreak is a major problem because of the sheer magnitude and logistics of control operations. The desert locust has an invasion area of 28.5 million square kilometer covering North Africa, Middle East and Asia equaling about 20% of the earth’s land surface. Crop protection during outbreaks remains almost entirely dependent on the use of pesticides. Similarly, outbreaks of
plagues have never been broken. Their management results from either prevention or strategies involving protection. Theoretically, prevention can be accomplished, particularly with the advantages of modern technologies and shared cost for surveillance. Such advantages would permit control in the recession areas prior to outbreaks. Some controversy exists over the relative value of massive aerial spraying to control the pest versus applied crop protection but there exist situations where both becomes appropriate. Therefore, pesticide use in the third world is a matter of public controversy and debate, which can only be settled through the promotion of suitable IPM programmes and the incorporation of intensified pesticide management in future.

Through ages the biological effectiveness of pesticides have increased at least 100-fold. For example, in 1945, DDT was applied @ of about 2Kg a.i./ha but with the more potent insecticides available now similar effective control is achieved with 10g a.i./ha in case of synthetic pyrethroids like deltamethrin. There exist a clear trend of decline in the use of Organochlorines in agriculture as a result of policies to phase them out due to environmental pollution and risks posed by residues. Many of the organophosphates (OP’s) are also banned for use in agriculture and some are restricted and in the process of phasing out. The use of synthetic pyrethroids, their combination products (pesticide mixtures) with OP’s and others and the use of herbicides seem to be increasing. Pesticide use practices have also changed in the use of newer molecules that are applied at much lower rates as discussed above. The use of pesticide mixtures may increase in future as they are recommended as a means of delaying build-up of resistance due to completely two different modes of action. While such strategies may be useful if used properly, there exists great danger if they are used arbitrarily at the farm level. Wisely developed mixtures can simulate insect control with natural plant products, which offer a mixture of different allelochemicals. Decreases in the amount and number of applications of pesticides have occurred in some situations such as cotton and may also be adopted in other crops like vegetables in future. In other crops the number of applications may remain the same or increased while the volume of insecticides used will certainly decline.

The pesticide industries should orient towards i) lower margins, ii) financing IPM research and extension in countries where national institutes are weak, utilizing their marketing skills in the promotion of IPM and iii) organizing small-scale farmers so that they can benefit from knowledge as much as the large scale farmers. The direction of pesticide development should be clearly in the direction of developing low risk materials. It may be necessary to create special situations whereby the high-risk materials may be used in special situations in special manner, placing them in a “prescriptive” use category.

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