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Biological Control and Integrated Pest Control in the Tropics - an Overview (**)

ABSTRACT. — A general review is given on the impact of the green revolution on tropical agricultural pest control systems. The trend of development in biological control and integrated pest control (IPC) and the current status of biological control in agricultural integrated pest management (IPM) systems were discussed and critically analysed, taking into consideration the development achieved in the developed and developing countries. It was also advocated to optimize the dependence on the use of pesticides in pest control and to incorporate biological control into the IPC programs planned and implemented in the developing countries in the tropics.

INTRODUCTION

Dramatic differences do exist in the management of pests and pesticides between developed and developing countries of the world (Tait, 1986). Developed countries are generally struggling to cope with food surpluses, produced by only a small proportion of the total population, and a success story is partly attributable to the use of pesticides. On the other hand, many developing countries have a serious food deficit but have a majority of the total population engaged in agriculture. As such, plant protection and pest control strategies adopted and implemented in the developed and developing countries do vary and differ to a very large extent, together with their impact and concern from economic, social and environmental quality points of view. The evolution of worldwide patterns of plant protection, using cotton ecosystem which is also applicable to many other crops as an example, through various phases from the subsistence

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to the integrated control phases given by Smith (1969), is a typical scenario of agricultural pest control in both developed and developing countries of the world. However, the impact of the "Green Revolution" on plant protection has had its greatest effect in the tropical and subtropical areas (Smith, 1972).

In the current and worldwide situations pertaining to crop production systems, advocations are made and emphasis given to the "alternative" strategies, methods and systems of pest control as opposed to the past traditional systems dominated by the use of pesticides. Ironically, biological control and integrated pest control (IPC) have been identified among several others as such "alternatives" by many, despite the fact that these control measures have long been in existence but largely overlooked and neglected. It will be more appropriate to refer to these pest control strategies as being the "under-utilized" rather than the "alternatives", judging from the fact that many of the successful cases of pest control achieved through biological control predated the era of agrochemicals; and the use of the term "integrated control" was introduced as early as 1952 (Frisbie and Adkisson, 1985) and by Stern *et al.* (1959) or thought of in the early part of this century (Smith, Apple and Bottrell, 1976; Flint and van den Bosch, 1981; Huffaker, 1985). Being so long forgotten and dominated by the use of agrochemicals, biological control and IPC are now identified and considered as alternative methods of pest control, together with other non-pesticidal or biologically-based control measures termed "parabiological controls" by Sailer (1981).

No attempts will be made here to create more than adequate discussion and argument which has already appeared in the literature on the concepts, philosophies and definitions, especially when IPC and integrated pest management (IPM) are concerned. While IPM will be considered here more as a conceptual matter, IPC will be referred to and treated as one of the most commonly advocated tactics in the agricultural IPM systems.

Ironically again, the "tropics" in most contexts should not always denote or imply or be considered synonymous with the "developing" countries nor the "Third World" countries, as often thought of and perceived largely in the developed countries.

While distinction was made in dealing with IPC for the developing world, such as that of Brader (1979), and IPC in the developed world, no obvious distinction along the same line has been made in dealing with biological control on a global basis. It has been a common encounter to find that developing countries are customarily required or requested to prepare certain reports such as a feasibility study on pesticide use, national profile on pests and pesticide management, and many others to satisfy the "curiosity" of counterparts from the developed world. From the developing country's point of view, such reports from the developed countries are also highly needed and should be made available for the colleagues in the developing countries as well.

It is not known how long such perception will last, but one is left to accept such interpretation due mainly to the influence of western technologies,

which have resulted in the *Green Revolution* and pest control dominated by the overdependence on pesticides.

The main purpose of this paper is to provide a general overview on the development of biological control and IPC in the tropical countries. As stated by Lim (1974) and Brader (1979), much information may exist, but it is inaccessible beyond its sources, and thus, it is inevitable that such presentation may weigh more heavily on evidence from some countries than from others. No attempts will be made to cite or exemplify thoroughly any case study in biological control or IPC programs being implemented in the tropical countries, as is often done by many authors. Nevertheless, one must admit that no matter how highly diversified they may be, tropical countries in all continents do share more or less common but universal characteristics and varying levels of development in terms of biological control and IPC. Emphasis will be given to the general and current development of biological control and IPC, and the current status of biological control in IPM System in the developing countries.

Development of Biological Control

Biological control in the tropics will refer to traditional biological control, whose definitions are: "the study and utilization of parasites, predators, and pathogens for the regulation of host population densities" when considered from the filed of biological control covering basic study, importation, augmentation, and conservation of beneficial organisms or natural enemies for the regulation of population densities of other organisms; and "the action of parasites, predators, or pathogens in maintaining another organism's population density at a lower average than would occur in their absence" when considered from an ecological viewpoint as a phase of natural control, as given by DeBach (1964). Other control tactics some would include in biological control such as the use of resistant varieties, use of semiochemicals such as pheromones, use of insect growth regulators and others not involving the use of natural enemies as stated by Maxwell and Harris (1974), Huffaker (1985) and those termed "parabiological controls" by Sailer (1981), will be totally excluded in the discussion on the development of biological control in the tropical contries.

By its inherent nature, biological control is international in itself, embracing both the tropical and temperate regions of the world, and may or may not be so confined to certain geographical areas. A world review of introduced parasites and predators of arthropod pests and weeds by Clausen (1978), other pertinent literatures, especially reviews of biological control of various insect pests and weeds of different regions such as Rao *et al.* (1971) for Southeast Asia and the Pacific, Greathead (1971) for the Ethiopian region, Liang and Hamai (1976), Luck (1981), and Julian (1982) on a worldwide basis are sufficient support of such nature. However, it should be realized that these literatures refer mainly to classical biological control, and naturally-occurring biological or natural biological control had not been extensively dealth with. Classical biological control

programs are generally less pursued in the developing countries, where there exists a need to thoroughly explore and evaluate their native natural enemies which may be or are most likely not yet identifiable in most countries at this stage of development.

Taking into consideration all forms and approaches to biological control, accounts on various biological control attempts and their development in the tropical countries on a country-wide basis, as for example, are those of Ooi *et al.* (1979) for Malaysia, Baltazar (1980) for the Philippines, Napompeth (1982) for Thailand, Napompeth (1983, 1986) for Vietnam, Kim (1984) for Korea, and Bao (1985) and Cock (1985) for China, reports of this nature will serve as useful reference and communication for biological control among the developing countries. At the First Meeting of the South and East Asia Regional Section (SEARS) of the International Organization for Biological Control (IOBC) held in Kuala Lampur in 1982, members from other countries were urged to prepare a review on biological control for their own respective areas such as that of Napompeth (1982) for Thailand.

In general, the development of biological control in the tropics has evolved with the age-old and traditional agricultural practices. The use of common red ants for the control of citrus and litchi insects in China and the use of ants to control date palm insects in Yemen ca 1200 have been documented and frequently cited in the literature on the history of biological control (Doutt, 1964; DeBach, 1974; Simmonds, Franz and Sailer, 1976; van den Bosch, Messenger and Gutierrez, 1982). It was under these rather primitive situations that natural biological control with minimum effort on augmentation was responsible for pest control. In the later days of agricultural production and prior to the introduction of synthetic organic pesticides and the *Green Revolution*, naturally-occurring biological control had the greatest impact serving as a "hidden" control measure resulting in "invisible" no-pest situations. The existence and achievement of these natural biological controls have been overlooked and moreover neglected due to such a revolution. To worsen the situation yet, most agricultural pest control systems have adhered so total dependence on pesticides to such an extent that many of the beneficial natural enemies have been slowly but steadily and indiscriminately destroyed. It was not known how many of these beneficial organisms could have become extinct due to the widespread use of pesticides in our agricultural production systems.

The extent of the extermination of natural enemies may be greater in the developed countries, where pesticides have been used extensively on various crops for an amenity purpose. Fortunately, in the developing countries such extermination may not be that pronounced due to the commonly expressed views such as the "lack of pesticides", "not having enough pesticides", or "pesticides not available", for example. It is, therefore, obvious that such prevailing situations in the tropics, on the other hand, will lead to a more conducive environment for the implementation of biological control programs designed for the native pests, or even for introduction programs involving the utilization of exotic natural enemies.

Using the Third World countries as a "dumping ground" for pesticide disposal by the developed countries should be condemned and avoided to prevent and slow down the rate of such extermination, no matter how justifiable the need for pesticides in the Third World countries will be. The tropical countries not dominated by the use of pesticides at this time could take a short cut to develop their own pest control strategies on a sound pest management basis to suit best their own needs and available resources rather than experiencing and repeating the negative impact of the overuse and over-reliance on pesticides witnessed in the developed countries.

Development of biological control in tropical countries in specific areas of biological control ranges from being non-existing in many countries to equally or even more successful than those found in the developed countries in some tropical countries. Also, successes in classical biological control have been witnessed in several countries in the tropics, and augmentative biological control has been achieved in many developing countries (Huffaker and Messenger, 1976). Complete success in biological control of either terrestrial or aquatic weeds achieved in the developed countries has also been accomplished in many developing countries (Julien, 1982). However, in microbial control where insect pathogens are utilized, while most basic investigations are being undertaken in the developed countries, the developing countries deprived of such resources for basic development in the tropics are waiting to utilize the final products whenever they become available. Relatively recent development in biological control of plant pathogens, and the utilization of plant pathogens to control certain weeds are being more or less equally pursued and investigated almost simultaneously in developed and developing countries. Even more recent in its development, the application of genetic engineering and biotechnology in the area of biological control amenable to such techniques is being seriously considered if not substantially undertaken in the developed countries as well as developing countries in the tropics.

Development of biological control thus overviewed indicates the extremes of development. Such a scenario is again phenomenal for biological control, which within itself is strictly a discipline explained and expounded by its inherent cooperative and collaborative nature, operating with no recognizable national or political boundaries.

For a considerably long period of time and in the past the Commonwealth Institute of Biological Control (CIBC) has been largely responsible to help promote biological control in developing countries on a global basis especially those under the Commonwealth. The U.S. state and federal agencies have also been known to have extensive networks of biological control activities in other countries as well as those of the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO). The former have contributed greatly to the impact and benefit from biological control in many developing countries of the world, but the latter seem to derive benefit, up to recently, largely and enormously for their own countries. It is only recently that such benefits are

being shared and made available to the developing countries, whose resources in biological control are either extremely limited or merely lacking, particularly in the area of foreign exploration in classical biological control.

It was also of recent development that developing countries have begun to realize the importance of biological control. Some local governments are beginning to provide support to biological control by establishing biological control laboratories and research agencies of their own on either a national or regional basis. Examples of these institutions are the Biological Control Laboratory of the Chinese Academy of Agricultural Sciences in Beijing, China; the National Center for Biological Control of the Indian Institute of Horticultural Research in Bangalore, India; the National Biological Control Research Center (NBCRC) of Kasetsart University and the National Research Council of Thailand in Bangkok, Thailand; and the Africa-wide Biological Control Project (ABCP) at the International Institute of Tropical Agriculture (IITA) in Ibadan, Nigeria.

Presently the promotion of biological control on a worldwide basis is being carried out by various institutions at the national, regional and international levels irrespective of geographical regions and countries. Outstanding among them is the International Organization for Biological Control (IOBC) with its headquarters located in Zurich, Switzerland. IOBC's regional sections are located in both developed and developing countries, and those which are currently in operation include the West Palaearctic Regional Section (WPRS), the East Palaearctic Regional Section (EPRS), the South and East Asia Regional Section (SEARS), the Nearctic Regional Section (NRS), and the Latin American Regional Section (LARS), while the African Regional Section and the Pacific Regional Section are in the process of being materialized.

Recently the Food and Agriculture Organization (FAO) and the United Nations Development Programme (UNEP) have also contributed to the promotion of biological control in developing countries. This is evident in their attempt to prepare a handbook on biological control originally designed for China in the FAO/UNEP/Government of China Expert Consultation on Developing Country Capabilities for Biological Control of Agricultural Pests Meeting held at Guangzhou, China, in 1985. It was decided later that such a handbook is also needed in other developing countries and revisions are being made so that other developing countries can receive similar benefit from such achievement by FAO and UNEP.

Development of Integrated Pest Control (IPC)

Unlike and relative to biological control, which is international in its nature, IPC is very specific and highly localized. IPC can be location-specific as well as commodity-specific, and for the same commodity or crop it can be location-specific, or even pest-specific. IPC of insect pests of rice in tropical Asia will differ from that in tropical African or Latin American countries. Within

tropical Asia, differences also exist as far as IPC of insect pests of rice in different countries is concerned.

IPC referred to in this paper will be IPC according to the definition developed by the FAO Panel of Experts on IPC, i.e., it is "a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury" (FAO, 1973). It will be used not interchangeably with integrated pest management (IPM) as done by many such as Frisbie and Adkisson (1985), but rather as an action for pest control derived from a decision made in the IPM program that for a certain pest it is justifiable that IPC is needed and suitable, or in any non-integrated pest management program where IPC is automatically recommended for use. Normally and in most cases, IPC programs are recommended, designed and tailored for the persistently and potentially harmful key pest or occasional pests known on certain crops, and these pests always occur in the outbreak proportion if there is no measure to control them.

While IPC in the developed countries seems to occupy a very distinctive facet of an IPM system, its development especially in the U.S. has been highly sophisticated to such an extent that its practicability is doubtful and its acceptability in the developing countreis is even more questionable. A similar trend of such development is also proliferating in Europe and Australia (Brader, 1979). Characteristic of the developing countries in the tropics are subsistence farmers, marginal farmers and the so-called small farmers who form the larger proportion of the total population and lack even minimum means to undertake an IPC method. Together with other prevailing socio-economic conditions of the farmers in developing countries, there exists a wide gap of IPC technologies between them and those in the developed countries. Any IPC method to be developed for these poor farmers must take into consideration the simplicity and practicability.

Despite such a fact, according to Lowe (1982), a stage has been reached where the term IPC is commonly used by most plant protection workers in developing countries throughout the world. This does not mean that adequate IPC practices are commonly used in these areas. In fact, most IPC programs currently under way in the developing countries focus attention on pesticide use and the integration of other pest control measures is subservient to pesticide application. In contrast to Lowe (1982), who indicated that given the conditions that exist and persist in many of these areas, the current position of IPC in developing countries must be considered as favorable; such IPC practices should be discouraged and abandoned as much as possible for inevitably obvious and undesirable reasons.

Most IPC programs in developing countries, as well as some in developed countries, are nothing more than modified spray programs which may or may not be based on sound pest surveillance methods. In most instances, rather than

depending on pesticides as the last resort, priority is given to the use of pesticides, assuming and anticipating always an increasing pest population. This is also characteristic of several IPC projects supported by UNDP/FAO in many African, Latin American and Asian countries. In a more integrated manner certain IPC programs advocate the use of plant resistant varieties together with scheduled spray programs. A relatively few IPC programs known in the developing countries of the tropics have taken into consideration the role of natural control factors at least by incorporating the natural enemy population encountered into the pest surveillance or pest monitoring systems.

The development of IPC in the realistic sense in the tropics has been rather sluggish due to several reasons. Farmers who are so accustomed to scheduled spray programs when pesticides are easily available would be reluctant to change and adopt it, especially when they have to carry out regular pest monitoring programs by themselves. At times, pesticide salespeople do intervene for fear of losing their customers. The existence and role of natural enemies in keeping pest population in check are also not recognizable readily to them nor the extension workers who give them advisory service in pest control. It is not at all uncommon among many such farmers that sometimes they are advised to spray their crops whenever parasitized host insects mistaken as pests are detected in the fields. For farmers in areas where pesticides are relatively scarce, most of them would rather ask and insist upon the use of pesticides to help relieve their pest problems, believing that pesticides are the only available means for pest control, as medicines are to cure their sickness.

Reports on the status of either IPC or IPM are as rare in the developing countries as in the developed countries. IPM current status in U.S. agriculture was given by Frisbie and Adkisson (1985). While Lowe (1982) gave a relatively general but pertinent account of IPC in developing countries with no reference to any particular country, Brader (1979) reviewed the development of IPC using selected crops in selected countries of Latin America (Peru, Nicaragua, El Salvador, Guatemala, Mexico and Colombia), Africa (Egypt), Asia (China, India and Malaysia), and the South Pacific regions. Other accounts of IPC/IPM in the tropical countries are those of Lee, Loke and Heong (1985) for Malaysia, and Napompeth (1975, 1981a, 1981b, 1985) and Napompeth, Rumakom and Meksongsee (1986) for Thailand. IPM from the sociological perspective of farmers' perceptions and practices in both developed and developing countries has been substantially dealt with by Tait and Napompeth (1986).

To promote and assist the development of IPC programs in the developing countries, mention should also be made and acknowledgments are due to the FAO/UNEP Cooperative Global Program for the Development and Application of Integrated Pest Control in Agriculture and several other FAO/UNDP Strengthening Plant Protection Projects located in various developing countries throughout the tropics. The intercountry programs under FAO/UNEP, some planned and implemented, are the Near East intercountry program for cotton, including Pakistan, Iraq, Syria, and Turkey; the African intercountry program

for cotton, with major emphasis on Egypt and Sudan; the Latin American intercountry program for cotton, including Mexico, El Salvador, Guatemala, Colombia, Peru, Bolivia, and Brazil; the Southeast Asia intercountry program for rice, comprising Bangladesh, India, Indonesia, Malaysia, Philippines, Sri Lanka, and Thailand; the Sahel intercountry program for basic food crops covering Cape Verde, Mauritania, Senegal, Gambia, Mali, Upper Volta, Niger, and Chad (Brader, 1979).

Current Status of Biological Control in IPM Systems

In its generally and academically accepted concepts, if it exists, biological control should be considered and utilized at the maximum capacity as the main component of IPC in agricultural IPM systems. It is only when biological control does not exist or does exist but is not adequately effective, that it could be underestimated. The general trend of development of biological control and IPC in the tropics seems to differ to a great extent when comparison is made between the achievements in developed and developing countries. However, the current status of biological control in IPM systems in both developed and developing countries does follow the common trend of development and share similar obstacles, which may be different only in terms of magnitude.

As pointed out earlier by Smith (1972), the biotic elements of population regulation have developed and have become dominant in regulation in tropical and subtropical areas as a result of evolution over eons; there is thus a special opportunity for IPC approach, utilizing biological control components in tropical and subtropical countries. Huffaker (1985) gave an entomological perspective of biological control in an IPM system in the U.S. context which may not differ much from those prevailing in the developing countries. Klassen (1981) emphasized that high priority should be given to system research to optimize the joint use of biological control agents with other control methods in IPM systems for insect pests, plant pathogens, nematodes, and weeds. A brief overview of the current status and future prospects of biological control in agricultural IPM systems was also given by Tauber, Hoy and Herzog (1985). In the course of its development, it refers to the adaptation of a particular tactic such as biological control within IPM to specific agricultural conditions. This may involve multiple pest situations and the integration of biological control with multiple tactics such as cultural, plant resistance and chemical control, into a unified strategy.

Incorporation of biological control as a main component in the IPM systems will be highly desirable and should be encouraged as much as possible in the developing countries. However, in so doing, a number of obstacles may exist. Such obstacles are not characteristic of the tropical countries, but are also being experienced in the developed countries as well. As pointed out by Klassen (1981), biological control has been inadequately studied, and biological control agents have been studied largely as an end in themselves rather than as synergistic

components within IPM systems. It has also been well acknowledged that biological control in any form, natural, augmentative, or classical, should be a key component in the IPM systems whenever it does exist. Thus there is a need to take a second look at many if not most of the biological control investigations in the past and in the future and search for a clue to make them more synergistic to IPM. In addition, as remarked by Huffaker (1985), biological control can be either a part of an IPM program or, at times, of great practical utility standing alone, as has been the case with many outstanding examples of classical biological control.

Further, as stated by Tauber, Hoy and Herzog (1985), biological control and IPM, together and separately, face serious problems. These originate from the lack of fundamental biological data and the lack of knowledge necessary to develop economically and environmentally sound crop and animal production systems, and the problems have three dimensions: 1) developing efficient and effective biological control methods, 2) expanding and integrating biological control into IPM systems, and 3) providing the scientific, social, economic and educational framework for public acceptance of biologically-based IPM techniques in agricultural production. These characteristics of the current status of biological control in agricultural IPM systems in the developed countries are nevertheless applicable and equally shared among the developing countries in the tropics.

Conclusions and Future Prospects

As suggested in the theme of this conference: From chemical to new biological technologies in agriculture in the tropics, the wind of change is breezing through developing countries in the area of agricultural production, especially in the area of integrated pest management (IPM). Any attempt by the developed countries or the developing countries themselves to increase the total dependence on pesticides in pest control in the "dumping ground" countries should be discouraged and prohibited. To accommodate the solution to pest problems, provisions should be made in such a way that the developing countries subscribe and adapt themselves to the IPM approach to pest problems, utilizing at their fullest capability the incorporation of biological control components into the IPM systems. This will be certainly of a direct benefit to them as viewed from various environmental, economic and social points of view.

The development of biological control and integrated pest control (IPC) in the tropical countries at any rate is also taking the right path and direction in many parts of the world. Such development may take its own natural course or is being guided and supervised by various forms of cooperation, collaboration and assistance when needed. As a desirable component of an IPM system, biological control should receive priority in further practical development. To achieve and expedite such an objective, an adequate support should be provided to prevent it from being stagnated and underexploited as in the recent past during

the reign of the first "Green Revolution". It is only when these basic conditions and requirements are met and fulfilled that the development of biologically sound IPC programs in developing countries in the tropics will be possible. Support from the public and administrators is also essential. They have to be convinced that the overuse of biological control and biologically-based pest control methods will not be detrimental to the environment and their overuse should be encouraged and promoted to the fullest extent. It will be then that the second *Green Revolution* will be fully materialized.

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