CHAPTER II

LITERATURE REVIEW

2.1 Integrated Pest Management

With the introduction of chemical insecticides following World War II, plant protection specialists were able, almost without restriction, to make use of powerful poisons. The goal of plant protection specialists in the early 1950's was 100% control (eradication). Entomologists such as Ray F. Smith and A. E. Michelbacher sounded warnings against such unrestricted use and proposed an approach that tolerated low levels of pest populations to allow natural enemy populations an opportunity to suppress pest populations. They proposed an approach to crop protection that was based on the analysis of the ecology of a given agro-ecosystem and included biological controls. Their work resulted in the development of what was known as Integrated Pest Control (Litsinger *et al*., 1982).

The ecological approaches inherent in Principles of Integrated Pest Control (IPC) as presented by R.F. Smith and H.T. Reynolds (cited in Pontius et al., 2002) to FAO symposium in 1966 are:

1- The use of chemical pesticides, without regard to the complexities of the agro-ecosystems in which they are used has been a major cause of disruption and undesirable side effects. Undesirable side effects include: target pest resistance and/or resurgence, secondary pest outbreaks, residue problems, and environmental pollution.

2- The agro-ecosystem is a unit composed of the total complex of organisms in the crop area together with the overall conditioning environment. There must be an analysis of the agro-ecosystem to determine population dynamics and mortality factors operating on pest populations.

3- The kinds of crops, agronomic practices, patterns of land use, weather, total complexity, and self-sufficiency of the agro-ecosystem affect the stability of an agro-ecosystem. As complexity increases, particularly among trophic interactions, there is usually an increase in the stability of the agro-ecosystem. IPC should seek to preserve or improve this complexity.

4- Levels or limits of tolerable damage are more important than pest population levels. Tolerable levels of damage vary with market conditions, stage of the crop, local conditions or grower economics, and the personal values of the people concerned. These levels will vary widely. The presence of pests is not an indication of a threat of economic damage to the crop.

5- In more sophisticated programs, individual fields are surveyed for populations of pests, parasites, predators, and pathogens. On the basis of this information and a consideration of the time of the year, stage of growth of the crop, and weather conditions a prediction can be made of population trends and potential damage. This type of sampling and prediction requires a solid base of fundamental biological and ecological data.

6- All but the most sterile of man made environments have some biotic agents influencing pest populations. Appropriate consideration must be given to biotic control agents. In some fortunate situations, the biotic agents are all that is necessary to have satisfactory economic control. The failure of natural enemies to keep a given pest under control should not cause us to invoke control practices that disrupt the controlling action of natural enemies of other species in the same agro-ecosystem.

Integrated Pest Management (IPM) is an approach to pest management that integrates all available types of pest prevention and control in crops. IPM has become an important means to reduce pesticide use on crops and to manage biological constraints by integrating agro-ecological knowledge and producer participation (Yazdani and Agarwal, 1997; Dent, 1995; Ooi *et al.*, 1992).

Human have attempted many approaches to alleviate insect pest problems through the years with an objective to reduce the losses from pests. However, decades of struggle by human were seen to have followed by a steady incremental increase in the use of pesticides resulting in numerous adverse effects. One of numerous consequences stemming from the use of pesticides is the harmful effect on non-target organisms leading towards the upsetting of natural balance (Yazdani and Agarwal, 1997; Dent, 1995; Ooi *et al.*, 1992a).

Alternatives to enhancing this situation have been the emphasis on the ecologically non-destructive methods of control (Smith *et al.*, 1976; Paul, 1974), which is widely known as the integrated pest management. Being considered as a product of discontent with the purely insecticidal approach to pest control of the 1950s, Larry (1999) deemed the evolution as a newly emergent concept of pest management, and advocated explicitly that recently there has been no approach that is more popular than the "IPM" that deals with all kinds of pests with a prime objective to reduce losses from pests in ways that are effective, economically sound, and ecologically compatible. To achieve this ultimate objective, as clearly defined by Cuperus *et al.* (2000) and Strand (2000), IPM encompasses a wide breadth of control measures combining biological, cultural, physical, and chemical tools.

Based on the concepts and principles of ecology, the implementation of IPM approach is concerned chiefly with the relationships of organisms either among themselves or to their environment. One of the many applications in terms of pest management in association with IPM is known to be the biological control. By definition, biological control is an important regulatory function of natural enemies to maintain another organism's population density at a lower average than would otherwise occur on the insect pest population (Paul, 1974; Hoy, 1994) to cause severe damage of crop. However, although having recognized such a regulatory function of beneficial insects, de ONG (1960) noticed that the reduction of population of the injurious insects often reaches a point where man can survive but is faced with a dangerous remnant. And according to Decker (1956) and Hagen and Smith (1958) should this remnant be of sufficient size to cause economic loss then it must be checked by the use of chemicals or other control measures or the consequences be suffered (de ONG, 1960). The applications of this economic loss concept in relation to pest damage and chemical control are well defined in what is globally known as the IPM approach.

Economic decision levels are the cornerstone of insect pest management because they indicate the course of action to be taken in a given pest situation (Headley, 1982). In association with pesticide use, they specify the possible pesticide use only with an understanding of the insect population level that causes economic damage (Larry, 1999). Overall, economic concept of pest management covers two key technical terms commonly known as economic injury level (EIL) and economic threshold (ET). The EIL is defined as the amount of injury which will justify the cost of artificial control measures, while ET is defined as the numbers of insect (density or intensity) that should trigger management action. The functional relation of these two terms is that ET is considered as the first front where control measures are taken to force down the population of insect before it could reach EIL (Dent, 1991; Luckman and Metcalf, 1982; Horn, 1988).

In reality, by using the above two important concepts and the knowledge of pests and their natural enemies, IPM attempts to reduce costs of production in crop husbandry, thus improving production efficiency, and enhancing sustainability and viability of agro-ecosystem via reducing detrimental side effects from the use of agrochemicals, especially those coming from the pesticide use. However putting IPM into practice at the farm levels in order to achieve these important objectives is not that simple if its many complex, operational mechanisms are taken into account. This has very often resulted in a rear adoption by farmers, thereby leading to the failure in its implementation in the farm level in many regions (Ooi, *et al.*, 1992b). Heong and Sogawa (1994) reported that farmers do not adopt this integrated approach because they do not perceive it would make them better off as no significant yield increase was observed (Normiyah and Chang, 1997; Kartaatmadja *et al.*, 1997).

Moreover, the need to go to rice fields for frequent surveillance under IPM was a burden and tedious, especially for old farmers (Normiyah and Chang, 1997). Untung (1996) estimated that the resulting reduction in pesticide use in Indonesia is around 50-60 percent. As suggested by Hildebrand and Poey (cited in Norman *et al.*, 1995) acceptability index can be used to access insights on spontaneous adoption of technology.

2.2 Chronology of farmer field school

Food security was endangered and political stability threatened in several countries as a result of severe losses in rice production caused by the brown plant hopper (*Nilaparvata lugens Stål*) (Winarto, 1995; van de Fliert *et al.*, 1995; Conway and McCauley, 1983).

Research carried out in the Philippines (Litsinger, 1989; Gallagher, 1988; Kenmore, 1980) and confirmed in Indonesia (Untung, 1996) demonstrated that indiscriminate pesticide use in rice crops not only induced resistance in *N. Lugens* but also eliminated its natural enemies, resulting in severe outbreaks. In Indonesia these processes were accelerated by frequent aerial applications of pesticides during the 1970s (Schmidt *et al.*, 1997). The first serious outbreaks of *N. lugens* in Indonesia in 1975 and 1977 caused estimated losses of US$1 billion. The plant hopper reappeared in the mid-1980s because of continued heavy insecticide use and the rapid breakdown of resistance in new rice varieties (Schmidt *et al.*, 1997; Untung, 1996). Indonesia's goal of self-sufficiency in rice production, reached in 1984, was reversed in 1985-1986 when *N. lugens* destroyed 275,000 ha of rice (Röling and van de Fliert, 1998).

For the FAO Inter-country IPM program-the innovators of the farmer field school-the plant hopper outbreak was symptomatic of a major problem in modern agriculture, pesticide dependency. Moreover, the technical recommendations made by the formal research system had limited applicability in farmers' fields, and concepts such as economic thresholds proved irrelevant as decision-making criteria. Some research products (e.g. resistant varieties) had the potential for managing pests but were not fully exploited because farmers opted for the less risky option of pesticides (Matteson *et al.*, 1992).

This initial classical farmer field school for Integrated Pest Management on rice was subsequently broadened in a second generation of farmer field school to address other crops and topics (van de Fliert, 1993). Farmer field school was the first developed for training rice farmers in Indonesia on IPM in 1989 with a very specific focus on IPM. This involved 200 FFSs in four districts of Yogyakarta initiated by the Indonesian National IPM program with funding from the Government of Indonesia-United States Agency for International Development (GOI-USAID) and technical assistance from the Food and Agriculture Organization (Pontius *et al.*, 2001).

By 1990 the Indonesian national IPM program scaled up and launched 1,800 farmer field schools for Rice IPM and the pilot farmer field school in IPM for rotation crops was initiated while the farmer field school program spread out to different countries in Asia during 1991. From 1991 to 1994, with support from the FAO Inter-country program, Rice IPM farmer field schools expanded to Bangladesh, Cambodia, China, India, Lao PDR, Philippines, Sri Lanka and Vietnam. The farmer field school program moved from its single-crop focus to include secondary or rotation crops within rice based systems and also vegetables in both low and high land systems. Around 1995, the farmer field school programs began to broaden the scope (beyond IPM) to cover other commodities or socio-ecological conditions. These included sweet potato for Integrated Crop Management (ICM) and utilization of marketing by CIP; Integrated Plant Production Management (IPPM) by GIPMF in East Africa and farmer field school on livestock and public health issue.

In 1997, the FAO program started promoting the community IPM approach in Asia to sustain and expand the learning achieved in FFS. Meanwhile, the FFS approach continued to be adapted to other sectors and contexts, leading to the adoption of IPM in schools and non-formal education programs that were initiated in Thailand. Others carried on with their adaptation of the FFS that even in Cambodia farmer trainers were tapped to run a "Teacher FFS" (CIP-UPWARD, 2003).

Over two million rice farmers in Asia and South-east Asia participated in rice IPM farmer field school between early 1990, when the first farmer field school was conducted in Indonesia, and the end of 1999. During those 10 years, farmers, agriculture extension field workers, plant protection field workers, and NGO field workers learned how to facilitate the farmer field school approach and conducted over 75,000 FFSs. Farmers who have participated in field schools have reduced their use of pesticides, improved their use of inputs such as water and fertilizers, realized enhanced yields, and obtained increased incomes (Pontius *et al.*, 2002).

2.3 Limitation of farmer field school

Van de Fliert (2002) in "Farmer Field Schools, from IPM to platforms for learning and empowerment" proposed some limitations of the farmer field school initiatives in Indonesia. He said that farmer field school programs are resource-intensive and hence suffer easily from the fact that they are project-dependent. The learning process is often interrupted when facilitators have to move on the next village; sustained learning and collective action could possibly be encouraged by a broadened scope of interrelated farm management topics and skills in the farmer field school content, and involvement of community-based organizations and farmer leaders in FFS implementation and follow-up, on the other hand.

Thijssen, (1996 cited in CIP-UPWARD, 2003) indicated that inadequate inclusion of local knowledge and practices because of time limitation, relative narrow focus and general approach of farmer field school are also the limitations for farmer field school activity.

2.4 Farmer field school approach

Farmer field schools for vegetable IPM are designed for 20-25 participants from one community. This number is intended to develop a critical mass, around which collective action and follow-up activities can be consolidated after the farmer field school activities end. Interested farmers are invited to a community meeting at which farmer field school objectives and processes are explained, as well as the importance of attendance at weekly meetings throughout the crop cycle.

CIP-UPWARD (2003) indicated three main activities of the FFS as (a) weekly meetings in the field where farmers improve on their observation, data analysis and decision-making skills, (b) farmer experimentation where farmers learn how to work together and solve problems systematically, and (c) farmers' forum where they discuss existing problems, share experiences and co-develop plans for the future while at the same time enhancing their organization and communication skills.

As Pontius (2001) reported the four principles of IPM farmer field school are:

1- Grow a healthy crop: the first principle means healthy plants are stronger and thus better equipped to withstand attacks by pests and diseases. IPM farmers are aware and make use of all factors that contribute to the health of crop (e.g. good crop variety, healthy seeds and healthy seedlings, land preparation, correct spacing, fertilizer management, water management, crop rotation).

2- Conserve natural enemies: the second principle implies that natural enemies of pests are the defenders of the crop. IPM farmers know the defenders and understand their role through regular observations of the agro-system. They avoid using poisonous chemicals that kill the beneficial insects. Maintaining a healthy balance between pests and natural enemies become their first priority.

3- Conduct regular field observations: the third principle asserts that IPM requires farmers the ability to regularly observe, analyze, and take informed discussions based on the conditions of their agro-ecosystems. It is important to monitor the field situation at least once a week (observe soil, water, plants, pests, natural enemies, etc.).

4- Farmers become IPM experts: the fourth principle points out that because of local specificity, farmers are better positioned to taking the decisions relevant to their fields than agriculture specialists in a distant city.

Farmer field school was designed to address these problems and to empower farmers in the longer-term so that they could influence policy makers. The main objectives were to improve farmers' analytical and decision-making skills, develop expertise in IPM, and end dependency on pesticides as the main or exclusive pest-control measure. To accomplish this, farmers had to gain an understanding of the ecological principles and processes governing pest population dynamics.

Farmer field school is an approach to educate farmers in their own environment (Röling and van de Fliert, 1994). Farmer field school provides an opportunity for learning-by-doing, based on principles of non-formal education. Extension workers or trained farmers facilitate the learning process, encouraging farmers to discover key agro-ecological concepts and develop IPM skills through self-discovery activities practiced in the field (Ooi, 1996).

Farmer field school approach in implementing IPM has been used with great success in many Asian countries in rice and vegetable cropping systems. This approach combines training with field-based, location-specific research to give farmers the skills, knowledge and confidence to make ecologically sound and cost-effective decisions on crop health (Brigitte *et al.*, 1995).

Farmer field school model recognizes the characteristics of sustainable agricultural development being people-centered, knowledge intensive and location specific (van de Fliert *et al.*, 2002a). It attempts to tackle the needs for change towards agricultural sustainability by applying the principles of non-formal education, which is experienced-based learning linking to living problems. It seeks to empower people to solve problem and create initiatives by fostering participation, self-confidence, open dialogue, joint decision-making and commitment.

The IPM farmer field school has become a model approach for farmer education in Asia and many parts of Africa and Latin America. The approach has been used with a wide range of crops including cotton, tea, coffee, cacao, pepper, vegetables, small grains, and legumes. It is designed to capacitate farmers by enhancing their agro-ecological knowledge, and develops skill needed for problem solving, such as field monitoring, agro-ecosystem analysis, farmer experimentation and farm economic analysis (van de Fliert *et al.*, 2002b). Farmer field school has proven effective at involving a wide range of people in the learning process, from school kids to the handicapped. Farmer field school approaches have been replicated both inside and outside the countries where they originated (Settle *et al.*, 1998).

Table 1 provides some indicative numbers concerning the implementation of FFS in Asia through 2000. The IPM farmer field school has become the approach for IPM training in the countries listed in the table. Most of these countries have also adopted national policies supporting IPM and limiting the use of insecticides.

Table 1. Indicative numbers from member countries of FAO community IPM program in Asia implementing IPM field schools (through 2000)

Country	Start year	Rice FFS	Farmers trained	Other FFS*	Farmers trained	Farmer IPM trainers trained
Bangladesh	1994	5,490	141,470	373	9,410	679
Cambodia	1996	670	20,000	85	2,500	254
China	1993	1,306	37,877	13	390	1,817
Indonesia	1989	37,429	935,152	6,388	159,600	29,522
India	1994	6,302	189,683			
Laos	1997	280	7,767	45	1,350	
Nepal	1998	209	5,415			156
Philippines	1993	6,000	180,000	1,200	336,000	
Sri Lanka	1995	510	9,700	34	610	240
Thailand	1998	525	12,027			
Vietnam	1992	19,876	515,927	1,993	55,098	6,178

*Primarily vegetable FFS, but also includes soybean and mungbean FFS

Source: Ten years of IPM training in Asia, 2002.

CIP-UPWARD (2003) also referred to the statement of Michel Pimbert that "Farmers field schools are a form of social learning, negotiation and effective collective action that focuses on society's relationship with nature".

Jules N. Pretty (cited in the Pontius *et al.*, 2002 publication "Ten Years of IPM Training in Asia"), enumerated five key principles of the farmer field school that are as follow:

1- What is relevant and meaningful is decided by the learner, and must be discovered by the learner. Learning flourishes in a situation in which teaching is seen as a facilitating process that assists people to explore and discover the personal meaning of events for them.

2- Learning is a consequence of experience. People become responsible when they have assumed responsibility and experienced success.

3- Cooperative approaches are enabling. As people invest in collaborative group approaches, they develop a better sense of their own worth.

4- Learning is an evolutionary process, and is characterized by free and open communication, confrontation, acceptance, respect and the right to make mistakes.

5- Each person's experience of reality is unique. As they become more aware of how they learn and solve problems, they can refine and modify their own styles of learning and action.

Röling (2002) stated that farmer field school is an alternative to existing extension services or used in place of the transfer-of-technology (TOT) approach. The differences between farmer field school and transfer-of-technology compared with the seven key dimensions important to today's agricultural extension and rural development work as shown in Table 2.

Table 2. TOT and FFS compared according to key dimension

Item	Transfer of Technology	Farmer Field School
Definition of farmer	End user	Expert
Desirable practices	Use of component technologies to control target variables	Management of the farm as an agro-ecosystem so as to enhance its self organization
Learning required	Individual adoption of innovations	Group learning based on field observation and inference, and on experimentation. As long as the decision-making process is right, the decision is right
Assumed autonomous scaling up mechanism	Diffusion of innovations among users	Spontaneous local dynamics started up by empowered FFS alumni
Facilitation required	Extension: transfer of knowledge by demonstration, lectures, etc.	Adult education: nondirective methods that energize and foster discovery learning
Institutional support	Linear organization of science-to-practice continuum so as to allow uninterrupted flow of technology from science to farmer	Decentralized organization that allows making available process expertise & resources to foster local dynamics and farmer-driven FFS
Conducive policies	Support for R&D and extension services, Subsidies on input use. Treadmill policies.	Abolish subsidies on input use. Support and finance for local dynamics & networking. Encourage farmer organizations and local R&D. Support of ecological (e.g. organic) food labeling and local market

Source: Röling and Wagemakers 1998, cited in CIP-UPWARD, 2003.

2.5 Farmers' training

Education and training is the most important thing that an 'extension' program can do and farmers are the most important person being educated. Within the educational approach, communication must take place at the field level, dealing with field issues in a dialogue with learners. However it can be done within the context of the farmer field schools. The field school deals not only with the practice that farmers want to learn about but also with farmers as farmers. Farmer field schools are conducted for the purpose of helping farmers to master and apply field management skills. The farmer implements his or her own decisions in his or her own field.

In the farmer field school approach all research is based on training needs or is an adjunct of training. Farmers have become a part of the research network supporting educational programs.

As suggested by Taylor (1998) farmer field school complements the importance of farmers' role in the development of education and training programs that affect them directly. According to van de Fliert *et al.* (1999) also confirm that intensive farmers' training is needed to achieve the overall objectives of enhancing the capacity of problem solving and decision-making under smallholder conditions.

Education and training enhance farmers' ability and willingness to make successful changes to their management practice (Kilpatrick, 2000). In the similar tone, Marcotte *et al.* (2002) have stressed the need of farmers' training as one of key mechanism in disseminating knowledge and technology to a broad audience and development of human resource capacity essential in enabling individuals in acquiring knowledge, skills/tools and abilities that will ultimately enhance productivity, income and livelihood.

Although NGOs play an important complementary role within national extension strategies, the FAO team felt that the limited scope of their projects prevented them from being the main channel for diffusing IPM extensively (Matteson *et al.*, 1992). The only way to reach a significant number of farmers and ensure continuity and quality of IPM training and extension was to integrate these processes within a national program agenda for each country. In Indonesia, for example, field leaders and pest observers were trained for 15 months in IPM and facilitation skills in regional IPM training centers (van de Fliert *et al.*, 1995). The program's strategy was not to train individual farmers but to establish an IPM capacity in each community and then support its horizontal diffusion (Settle *et al.*, 1998; van de Fliert *et al.*, 1995).

Training farmers in IPM farmer field school will have increased their understanding of agro-ecosystem of their crop. They will be aware of the dangers and limitations of pesticides application and be able to take decision based on the actual situation in the field. They will also have reduced their dependence on outside advice and/or be able to judge such advice on its merits. IPM farmers may be able to increase their production and/or profit by higher yields and more efficient use of inputs (DANIDA, 2002).