Chapter II

Literature Review

2.1 Pest Surveillance in Rice Production

Pest surveillance implies keeping close and regular vigilance over the development of insect pests, diseases, weeds and bio-control agents in a crop ecosystem. Surveillance is an effective tool in the overall pest management strategy. The word "pest" refers to organisms such as insects, pathogens, weeds, nematodes, mites, rodents and birds that cause damage or annoyance to man, his animals, crops or possessions. To increase crop production it is imperative to reduce the crop loss caused by insect pests and diseases.

The incorporation of the rice macro surveillance system into plant protection extension has contributed significantly to rice production. It helps farmers to decide on the proper timing of pesticide applications. Routine surveillance of the paddy fields and the release of warnings do a great service to the farmers and improve the quality of rice protection very much. In order to cope with the changing agriculture, however much effort should be made to re-evaluate the whole system, including management of the personnel and technology involved (Hong, 1971).

Most rice pest surveillance systems have been designed to address the problems of policy makers, extension officers, and researchers. Many countries have not yet been able to provide farmers with appropriate real-time information for pest management. Rice pest surveillance systems in Asia began as early as the 1940s, after heavy pest infestations in Japan led to food shortages (Yoshimeki, 1967). Pest surveillance was initiated in India in 1969, after a widespread epidemic of tungro. In Malaysia, a pest surveillance system was established in 1979, following outbreaks of the brown planthopper (Ooi, 1982). Pest surveillance and early warning systems began in the Philippines in 1975 and in Thailand in 1983, through the German agency for technical cooperation. In Indonesia, pest surveillance started in 1975; there are now more than 2000 pest observation units. Pest surveillance in South Korea started in 1958; today 151 observation units are used to collect rice pest and disease information (Song and Park, 1985). In China, pest surveillance is an important component of rice pest management; more than 4,000 pest observers are employed by general plant protection stations throughout the country (Lewis, 1983).

2.2 Current Situation of Rice Pest Surveillance in Bangladesh

In Bangladesh, chemical control has been the principal method of pest control. Although pesticides may provide temporary relief from pest problems, long-term dependency on pesticides is not desirable. To avoid such consequences and at the same time to increase the crop production on a sustainable basis, a viable alternative to single dependence on chemicals for pest management is needed. Integrated pest management (IPM) is the best alternative strategy (MOA, 2008). Pest surveillance had been first initiated by the Bangladesh-German plant protection project in 1980. However, the application was not functioning effectively. Then in the year 2000, DAE-DANIDA had started a new surveillance method. At present in Bangladesh the measurement of specific pest outbreak occurs with the help of block level (smallest unit of extension in Bangladesh) monitoring. The monitoring is taking place with random wise survey and sampling method (SPPS, 2001). But some constraint still running in the field level to adopt the improved surveillance and monitoring practice also IPM practices. The pest management wing has a plan to implement and expand on the computerised system for pest surveillance. But they are hampered by a lack of computer skills to organize the system internally. The facts is that (a) Bangladesh needs to increase its food production on a sustainable basis, (b) pests and diseases continue to cause serious crop losses, (c) the use of chemical pesticides is the main means of pest management, and (d) continued reliance on chemicals for pest control would lead to serious environmental and human health problems, pest resurgence, new pest problems, etc. There is a need for an alternative method rather than to rely solely on pesticides. The integrated pest management (IPM) has now been considered as the most appropriate one in this respect. The main barrier is the lack of capacity for the organization of a computerised database system within DAE and the lack of computer skills. There is also a need for further training of DAE staff at the district and Upazilla administrative levels in computerized systems. An additional problem is that the current pest surveillance system (based on hand-filled paper system) is essentially defunct. Thus most stakeholders in the field have limited knowledge of pest surveillance systems and the benefits they can bring to the application of pest management. Thus, there is also a need for promotional work on the benefits of pest surveillance and forecasting and how the system can support farmers; and help in what they are learning through farmer field schools.

2.3 Three Major Rice Insect Pests of Bangladesh

According to mode of infestation three insect pests considered as major for rice crop in Bangladesh. The rice stem borer *(Scirpophaga incertulas),* which infest the plant from seedling to maturity, are worldwide in distribution (Dale, 1994) and are considered as most important of all (Pathak, 1975). In Pakistan rice crop is attacked by about 70 species of insect pests and out of these, rice stem borers are by far the most pervasive and injurious insects to rice. These borers vary in severity of damage and population intensity (Hashmi, 1994). In India Abrol and Gadgil (1999) reviewed the status of stem borer incidence in 21 states of India and reported that the level of pest was 'severe' in 7 states, 'moderate' in 6 states and 'low' in 6 states. In Nepal, among the rice insect pests, stem borers, mealy bugs and leaf folders are important constraints, which affect rice productivity (Dr. B.K. Gyawali, pers. comm.). In Bangladesh out of more than 175 insects and several vertebrate pest species that cause damage to the rice plants, rice stem borers, rice hispa, brown planthopper, white backed planthopper, and bandicoot rats are the key pests. Among these, stem borers are the chronic pests (Anonymous, 1995; Islam et al., 2001).

Brown planthopper *(Nilaparvata lugens)* is the second most destructive insect pests of rice. There has been a history of planthopper outbreaks in Bangladesh. The first hopperburn by brown planthopper was recorded in the year 1976. It was in Boro season near Dhaka city which affected about 4 hectares. In the next Boro season 20 hectares were affected, and by 1978 planthopper damage had increased to 8,000 hectares in six districts. Hopperburn then spread to other parts of the country, and localized outbreaks became common. Initially, outbreaks were in the Boro season while outbreaks started to occur also in the Aman season from 1982. The most serious planthopper incidence was recorded in 1983 when widespread outbreaks were reported in 7 districts in Boro and 8 districts in Aman (monsoon) season (Islam and Haque, 2009).

The third major rice insect pest in Bangladesh is rice hispa *(Dicladispa armigera).* It is a serious pest because it can be damaged half of total crop. In other countries in tropical Asia it is also considered as serious pest. The rice hispa are almost everywhere in small numbers and, given the right conditions, plagues erupt dramatically. This insect is a problem pest particularly in Bangladesh. Records show that it can infest large areas and causes yield losses of up to 20% (Islam, 1989). The integrated pest management (IPM) is best suited for all of three major insect pests control.

2.4 Integrated Pest Management (IPM)

FAO estimated the global harvest losses due to pest to be about 42% of attainable production. It highlighted the paradox between the increase of global crop losses over time and the growth of chemical pesticide use. Experts believe that if current trends continue dependence solely on chemical pesticides, it will not be a sustainable solution from either an economic or an environmental point of view. Integrated pest Management (IPM) is seen as the way forward to achieve sustainable agricultural production with less damage to the environment. While IPM has no standardized definition, it is commonly referred to as a diverse mix of approaches to manage pests and keep them below damage levels, using control options that range from cultural practices to chemicals. In practice, IPM ranges from chemically based systems that involve the targeted and judicious use of synthetic pesticides, to biologically intensive approaches that manage pests primarily or fully through non-chemical means. Cink et al. (2003) compared various pest management regimens in Texas school districts. Their finding was that schools using sanitation, exclusion, and bait application with limited and prescriptive pesticide use provided the best management option compared to those that had limited (eg. pesticides only) pest management options. Brenner et al. (1998) used spatial analysis in precision targeting for IPM. They used trapping information to pinpoint concentrations of pests and target pest management to those areas of infestation as well as determining why the infestation existed. The development of proper institutions, that can continue the development and transfer of IPM technology after the IPM CRSP (Integrated Pest Management Collaborative Research Support Program) terminates. It is a key component of the IPM CRSP approach to the globalization of IPM training of scientists (and others) is a key component in the building of IPM capacity within a country and a region. Capacity building involves giving an identity and visibility to IPM programs in each country so that they are appreciated and supported by the countries themselves, and thus, maintained after the IPM CRSP leaves. It involves setting up methods for scientific planning, participatory conduct, review, and evaluation of IPM research and technology transfer activities so that they are recognized as being of high quality and relevant ecologically based IPM. Regional IPM centers will follow an ecologically-based approach centered on four basic tactics: biological control, host plant resistance, resistance management, and habitat management. These tactics will be supported by social, gender, and policy/regulatory analysis to create the necessary environment for IPM adoption and proactively linked to communications, training, and educational programs to accelerate and broaden adoption in biotechnology. Regional centers will incorporate biotechnology components where appropriate. The program will interact with on-going national and international programs that are attempting to generate GMOs (Genetically Modified Organisms) for specific pest problems in developing countries.

Recent works (Shour, 2004), have documented that IPM can be successfully implemented into school systems. It will be utilized existing programs as a basis for this project, with funds used to document the pests and pest management practices, to provide project oversight, and to develop and delivery educational programs. This project is designed to utilize existing relationships with schools, PMPs (Pest Management Professionals), and the SWTRC (Southwest Technical Resource Center), and expand that into a state-wide school IPM program for Oklahoma. For the improvement of surveillance and forecasting system IPM will be a valuable tool. IPM includes divergent approaches ranging from methods based on rational management of chemical pesticides to systems based on ecosystem management that include health issues and human capital development. Ten indicators were selected to classify the IPM definitions used by the different organizations. Most organizations use IPM definitions that combine several of the elements. Meanings of such IPM definition indicators are as follows:

- Mix of techniques: This includes the basic techniques of IPM without indicating a preference. In practice, this can mean the use of chemical pesticides as a default option if preference for these strategies is heavily entrenched.

- Economic factors /Economic and damage threshold levels: Farmers base their decisions on a comparative assessment of the potential crop loss and the costs of pest control. In many cases, this may lead to a rationalization of previous overuse of chemical pesticides. However, actual substitution of other pest management practices for pesticide use hinges critically on the availability of locally adapted information about thresholds and the risk and time preferences of the farmers.

• Preference to non-chemical measures: Alternative methods of pest management are chosen over the use of agro-chemicals wherever feasible.

• Sustainability concept: IPM is regarded as a holistic approach for sustainable development combining economic, social and environmental aspects. Almost all of the definitions agree on some basic elements of what constitutes IPM. These basics include the technical and economic dimensions, as well as the reduction of health and environmental risks and a farmer-centered view.

Within the IPM group of farmers, IPM activities have existed for ten years, so it is reasonable to assume that most farmers have at least some information about them. Farmers' adoption of IPM may depend on a variety of factors, including personal characteristics such as education and experience, farm characteristics such as production scale and selective judgments by agriculture ministry official charged with promoting such programmes. Some personal and farm characteristics that influence IPM adoption could also affect productivity, so it may be important to introduce controls for these variables in a comparison of IPM and conventional farming.

2.4.1 Current Situation of Rice IPM in Bangladesh

In Bangladesh, IPM activities first started in 1981 with the introduction of the first phase of FAO's inter-country programme (ICP) on IPM in rice crop. However, it was in 1987 that IPM activities began to expand and became a popular topic among people from all walks of life. From 1989 to 1995, the ICP played a strong catalytic role in promoting the IPM concept and approach among the government officials and donor community. This programme provided IPM training to build the training capacity of the Department of Agricultural Extension (DAE) and introduced Farmer

Field Schools (FFS) for training of farmers. A number of persons from the non-government organizations (NGOs) were also given training on IPM.

2.4.2 Impact on IPM Training

The impact of the IPM training to farmers for DAE-UNDP/FAO IPM project was assessed by the planning and evaluation wing of DAE. The findings showed that the knowledge on rice insect pests, parasites and predators of these rice pests, rice ecosystem, effective pest management practices, adverse effects of pesticides on health and environment, and farmers ability to make crop management decisions have increased tremendously among the trained farmers. It also revealed that the IPM trained farmers have reduced their pesticide application by 86%, which reduces the cost of production and increases the profit.

To measure the impact of IPM, DAE-DANIDA SPPS project conducted review workshop after the end of every crop season and collected data on the application of pesticides, money spent on pesticides and yield. The data from 583 rice FFSs that were conducted within the last transplanted Aman/2000 were used for the analysis. Data were collected from FFS farmers before the start of the training (benchmark survey) and at the end of the FFS season (follow-up survey). Likewise, at the end of the FFS season, data were collected from untrained farmers. As few of the FFS farmers cultivated local variety, only the data of HYV (high yielding variety) are presented.

Results are more impressive when data of before IPM training and after IPM training are compared. Trained FFS farmers spent during the T. Aman (transplanted Aman) 2000 season 738 Taka per hectare less on pesticides, compared to the previous season (T. Aman 1999), which is a reduction of 87.6%. At the same time, they produced a 474 kilogram higher yield per hectare, which is a yield increase of 13.9%.

2.4.3 Integrated Pest Management (IPM) Policy Developments

IPM has created much awareness among the farmers, policy makers, politicians and the general public in the country. As a result, the Government of Bangladesh is giving due importance to IPM, which has been reflected in the fifth-five year plan and also in the National Agricultural Policy (NAP). The government is actively considering formulating a National IPM Policy. The goal of the Policy is *"to enable farmers to grow healthy crops in an increased manner and thereby increase their income on a sustainable basis while improving the environment and community health."* A draft IPM policy has been prepared jointly by the DAE-UNDP/FAO IPM Project and DAE-DANIDA's SPPS project. Several working groups were formed for the draft policy. A national workshop was also organized to discuss on the draft policy. The draft policy is now in the Ministry of Agriculture for the approval of the Government of Bangladesh.

2.4.4 Developments of Community IPM

Over the last decade, there has been a significant shift in the emphasis of IPM programmes throughout Asia, towards a more participatory, decentralized, community-based approach, termed as community IPM in which the farmers become the initiators, implementers and promoters of IPM and not just the recipients. In community IPM, farmers organize, manage and implement their own IPM activities, analyze problems, design field studies and carry out experiments and undertake efficient farming practices. By producing a significant number of IPM trainers from DAE and by creating great awareness on IPM, the project has helped to lay a solid foundation for IPM in Bangladesh. It is now the right time to begin to concentrate on the matters related to expansion and sustainability of IPM. To this effect, both the DAE implemented projects have been giving emphasis upon community IPM. These projects have already started several IPM training activities related to community IPM.

2.4.5 Farmer-Farmer Training

Farmer-farmer training is considered to be a cost effective, decentralized, community based, farmer first approach that will promote sustainability and expansion of IPM. It will help strengthen the interaction between farmers; the DAE trained field staff and NGOs and set a stage for the continuation of IPM activities beyond the present phase of the project. In order to train the farmers to become farmer-trainers (FTs), the projects taking into consideration of the Bangladesh conditions, designed a training programme, conducted curriculum development workshops and FT-TOTs (Farmer Trainer, Training of Trainers). The projects have already produced 829 farmer trainers. These trainers are currently running FT-FFS.

2.4.6 IPM in Schools

Student Field School (SFS) is viewed as a means to promote lateral spread of IPM knowledge from the school children to their families and ultimately to the community. The SFS participating students are learning the integrated crop management practices through practically doing in the field. They can easily identify Bandhu (friendly insects) and Shatru Poka (pests of crops) in the rice field. Also they know the biology of major insect pests, the damage symptom caused by pests, predation and parasitization and about the agro-ecosystem analysis (AESA). SFS has created a lot of interest among local farmers in the area, parent-farmers, school children, teachers and the public. Last year, one SFS even received a visit from the honourable Minister for Agriculture. The projects so far conducted 20 SFS and the performance of these SFS was found to be highly satisfactory.

2.4.7 IPM Clubs/IPM Congress

In many places in the country, the IPM trained farmers have spontaneously started IPM clubs. Owing to the close interaction of the club members with the grass-root DAE staff, local leaders and farmer groups in the community, IPM clubs are proving to be a key factor for the promotion and sustainability of community IPM in Bangladesh. The range of activities varies among clubs but all are engaged in providing some sort of IPM training to the neighbours and this includes training through season-long FFS. Selected members of some clubs have already completed their Farmer-Trainer training provided by the project and they will continue to establish FFS using the club funds. Many clubs have their own ways of generating funds which include pest management in rice fields (of club and non-club members) on a contract basis, production of seeds of improved varieties, fish cultivation in rice fields, etc.

2.5 Geographic Information Systems (GIS) and IPM

GIS are commonly used in large scale agricultural research projects such as the ones in IPM CRSP. These two technologies are ideal tools for managing data about the nature, location and spread of pests, analyzing the trend and pattern, and making pest management decision. They provide the capacity for tracking the result of the actions such as biological control application. Integrated pest management and information technology specialists at North Carolina State University are helping developing countries use the internet to manage old pests and to guard their borders against new pests. Funded by the U.S. Agency of International Development Integrated Pest Management Collaborative Research Support Program (USAID IPM CRSP), Yulu Xia and Ron Stinner with the Center for Integrated Pest Management (CIPM) are developing a network of pest databases for developing countries around the world. The center is housed in the college of agriculture. Several tools are proposed for the analysis and management of geographically referenced data for a territorial approach to IPM of pest crops. The geographic information system was used to manage spatially correlated data on infestation of *Bactrocera oleae* (Gmelin), the "key-pest" in Italian olive groves (Petacchi et al., 1980).

Digital tools such as geographic information systems and global positioning systems allow very precise mapping of agricultural areas. These technologies, combined with soil mapping and yield monitors have led to the production methods referred to as "Precision Agriculture". The basis of precision agriculture is applying agrochemicals only where necessary. The point of IPM is to apply pesticide only when it's necessary. By using these technologies in IPM, we can develop "Precision IPM", only applying pesticides where and when it is necessary. So, next discussion will provide an overview of some aspects of GIS and Global Positioning Systems (GPS) and provide some suggestions as to their possible use in IPM.

Geographic information systems are essentially relational databases. The relationship between items in the database are their locations, either in real-earth coordinates (eg. UTM, or longitude/latitude), or on a grid (ie. X, Y coordinates). GIS combine digital mapping, database functions, and spatial analysis. Basically, GIS are computer software packages that are capable of assembling, storing, manipulating, and displaying geographically referenced information. The system itself includes the operator. As with any computer program, a GIS cannot confirm the quality of the data being input or interpret the output. These two tasks require an operator familiar with the field for which the digital tool is being used.

Another useful feature of GIS is the ability to link databases whose items have locations associated with them. If we have other data that is associated with a geographic position, we can combine it with the existing database and examine trends of Russian wheat aphid (RWA) damage across an entire area. We can combine datasets by using exact-matching spatial data (eg. if we have the coordinates of other sample sites outside Colorado, we can simply add these to our map and extend its boundaries). In this manner, GIS facilitates the examination of population dynamics on very large geographical scales.

2.6 Pest Population Mapping

Scouting and monitoring pest populations and making control decisions based on those population estimates is one of the bases for IPM. The ability to accurately and precisely map the density and location of pest populations has obvious advantages, especially in regard to application of control tactics.

The warning and prediction system for crop diseases and pests based on super-map is NET geographic information system (GIS), which was developed by super map company. In this system, the author used GIS and remote sensing (RS) technology. The system could transform data information into a geographical information map to show the occurrence degree and distribution on various diseases and pests. Finally, the system realized successful the warning of the wheat stripe rust in Xifeng region of Qingyang city in Gansu province in 2002 and the prediction result was satisfactory. It indicated that we could classify and predict diseases and pests, and select right time and technology to control the diseases and pests by this GIS system (Luo et al., 2009).

Monitoring programs can now digitally map the location of sample sites (taken in the field with a GPS) and the resulting GIS layers can then be used to interpolate the pest population over the sampled area. This is not a new technique have been used to estimate populations. However, a GIS layer will not only estimate populations but can be linked to other similar layers throughout a region, resulting in regional maps which estimate pest populations. This technique is used when constructing state or region wide estimates of pest populations or crop damage.

Typically, sampling has been done on a field level but this might not accurately reflect the driving influences behind a pest population outbreak. Populations tend to function on much larger scales and immigration from population sources can greatly impact the pest population in a field. If the boundaries of the monitored area are wide enough, source populations responsible for subsequent re-infestations of fields can be identified.

The use of GIS technologies has had considerable impact on pest management authorities. Allowing information on pest activities to be collected, stored, manipulated and analyzed enables accurate monitoring of pest activities. So, appropriate preventative measures can be taken in a timely manner. Financial savings are realized, as spraying and poisoning methods can be used more wisely and efficiently. And public safety issues are addressed as the spread of pests can be more accurately predicted, and controlled.