Nature Farming and Integrated Pest Management in Indonesia

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Abstract.
The rice ecosystem is principally an artificial ecosystem which has limited diversity and, therefore, is susceptible to certain pest infestations and frequent pest outbreaks. However, heavy use of pesticides for plant protection creates new problems for the rice production program. Experience in Indonesia during the Long Term Development Plan (1969-1994) showed that the improper integration of plant protection techniques encourages the development of the brown plant hopper population (BPH). For more than 16 years, Indonesian farmers struggled to overcome the BPH problem. Consistent implementation of IPM in the rice ecosystem enabled significant reduction in BPH outbreaks in major rice producing areas. This paper discusses techniques, services, training and extension systems that are available at the sub district government level and that need to be modified in order to enhance the implementation of IPM. Changes in pesticide regulation policies a re discussed.

Introduction

Increased food production is a major goal of the Government of Indonesia in view of the country's increasing population and demand for basic commodities, particularly rice. Increased agricultural production had been emphasized through the Long Term Development Plan (1969-1994) phase I (PJPT). The increase in food crop production was implemented through four major programs, i.e., intensification, extensification, diversification and rehabilitation. In the early years of PJPT I, the production of food crops (especially rice) was promoted through an intensification program known as PANCA USAHA or five efforts, i.e., soil tillage, better varieties, proper fertilization, better irrigation, and pest control.

The greatest intensification program occurred in the 1970's when the BIMAS Program (mass guidance) was begun. This program developed rapidly and the planted area increased significantly each year. To achieve the rice production goal, a special intensification program (INSUS) began in 1979, and eventually became SUPRA INSUS in 1987. Implementation of the INSUS Program was based on guidelines about the role and function of local farmer's groups, whereas SUPRA INSUS encouraged cooperation among the farmers' groups in large geographical areas.

The advanced technology applied to the food crop subsector through phase I of the Five Year Development Program (Pelita I, 1969) resulted in some positive developments. Rice production increased significantly from 17.7 million tons in 1969 to 38.2 million tons in 1984. This achievement transformed Indonesia from the largest rice-importing country in the 1960's to rice self-sufficiency in 1984. In 1992 (the fourth year of Pelita V), rice production was 46.6 million tons when self-sufficiency was sustained. Even though rice production increased significantly, the rate of production has often fluctuated. This may be attributed to two major constraints, i.e., pest outbreaks and unfavorable weather conditions.

The major pests which frequently affect rice production, are the brown plant hopper (BPH), Tungro, rice stem borer and rats. BPH was one of the most devastating pests during the 1974/1975 planting season. Moreover, the BPH problem may become even more severe with the appearance of new biotypes that could overcome resistant varieties. An outbreak of Tungro occurred in 1970 in South Sulawesi. IR-22, a rice variety resistant to Tungro, was developed. Outbreaks of rice stem borer occurred on the Northern coast of Java in 1988/1989, and rat problems are always present at any season in almost all parts of the country.

To overcome pest problems, and particularly BPH, an Integrated Pest Management (IPM) program was adopted and major components were consecutively implemented, i.e., planting patterns, resistant varieties, and appropriate pesticides if needed. A meaningful pest control program can enhance crop production by helping farmers to achieve optimum yields with appropriate inputs. Unfortunately, there are still many Indonesian farmers who assume that pest control can only be achieved by the use of pesticides. When crop damage from certain insect pests is detected, farmers are advised to apply pesticides as soon as possible. Most farmers spray their plants on a regular basis to avoid the risk of pest occurrence; this method is known as the conventional method.

Table 1. Brown Plant Hopper Infested Areas in Paddy Fields in Indonesia.

Year	Area (ha)	Year	Area (ha)
1968	52,000	1981	58,279
1969	10,000	1982	61,699
1970	14,589	1983	128,591
1971	17,435	1984	19,917
1972	35,459	1985	44,419
1973	32,993	1986	61,255
1974	321,480	1987	30,023
1975	576,680	1988	46,707
1976	454,590	1989	18,887
1977	713,185	1990	10,267
1978	319,087	1991	8,212
1979	244,456	1992	16,226
1980	79,361	1993	1,272

Note: In 1993, data was recorded to April.

The conventional method was recommended during the early part of the intensification program (the BIMAS Program) when pesticides were included in the technology packet. Since the planted area was expanding because of program activity, the number of pesticides increased rapidly.

The increased use of pesticides in Indonesia was promoted by government policy; subsidies provided up to 80 percent of the cost of the pesticides. Through 1989, the cost of government subsidies for pesticides increased by 100 to 150 million U.S.$ per year. This situation caused the price of pesticides to become relatively cheaper than the free market price, thus, promoting even greater use by farmers. Even though some benefit may be obtained from the use of pesticides, excessive use may result in the establishment of pest resistance, pest resurgence, outbreaks of secondary pests, and eradication of non-target Organisms and natural predators; also there are adverse effects on human and animal health and environmental pollution.

In an effort to minimize the agricultural, environmental, and socioeconomic impacts of pesticides, the Government of Indonesia in 1986 implemented IPM policies through Presidential Decree No. 3 with respect to controlling BPH on rice. By this decree, 57 pesticide formulations were prohibited from use since they were suspected to cause resurgence and resistance in BPH and to have other negative effects. Since then, IPM has become the principle strategy for crop protection as an alternative to conventional methods to reduce pesticide subsidies; pesticide subsidies were subsequently terminated by the government in 1989. In accordance with the IPM concept, pesticides will be used only when other alternatives fail to maintain pest populations below the control threshold. In such situations, pesticides are allowed but must be used judiciously.

Food Crop Production System

In Indonesia, the concept of Integrated Pest Management is a principle of food crop protection. In accordance with Law No. 12/1992 concerning the System of Crop Cultivation, Chapter 20 delineates the concept that crop protection shall be conducted with IPM principles. The implementation of crop protection is the responsibility of both the farmer and the government, and it is an integral part of the food production system. Basically, food crop protection is the responsibility of farmers on their farms. The government deals with regulations, development of control measures, pest observations and monitoring systems, information systems, and delivery systems of agricultural inputs to create conditions that encourage farmers to properly cope with pest problems.

Systems of food crop protection consist of subsystems based on the coverage of the working area. The smallest unit is the subdistrict, which, as the pest observer's working area, is considered the frontier area of agricultural development. Therefore, the food crop protection system is also developed at the subdistrict level.

The system of food crop protection emphasizes the farmer's role in awareness, willingness and ability to control pests in cooperation with other components under the guidance of the local government. The failure of food crop protection systems at the subdistrict level may result in an outbreak of pest incidence. In this case, it may lead the district, provincial or central government to extend support for pest control measures. Failure may result if one or more components at any level of the food crop protection system is not well managed.

The implementation of IPM in food crop protection systems needs integrated support from services and regulatory institutions. Integrated plans and actions are executed through the coordination of the Mass Guidance Service (BIMAS). The coordination is conducted through several stages of government, i.e., subdistricts, districts, provinces, and the central government. Regular meetings of all government organizations are held to discuss how farmers can participate in food crop protection activities, and to review more effectively the regulations and services that may encourage or discourage their capabilities and participation. Problems that cannot be solved at a local level are brought to a higher level of government.

Food crop protection matters are expected to be solved at the subdistrict level. The success of food crop protection in rice production programs depends on the activities of farmers and related institutions at the subdistrict level. Services and regulatory institutions responsible for the success of food crop protection at the subdistrict level are:

- Farmers and farmer groups
- Village unit banks
- Village cooperative units and kiosks
- Agricultural extension workers
- Pest observers
- Irrigation services
- Subdistrict governments
- Manpower services

When farmers individually or in groups at the subdistrict level fail to cope with pest problems on their own farms, the subdistrict is responsible for providing control measures with their funds. The district will take action to support pest control by farmers which cannot be handled by the subdistrict. These actions occur regularly, i.e., the responsibility for controlling pest infestations is assumed at higher governmental levels. Generally, lower level government organizations are not able to cope with pest problems in their areas because of a lack of necessary services at those levels. The success of plant protection at any governmental level depends on effective services and institutions responsible for plant protection. Monitoring and supervising by appropriate government officials at any level is essential to achieving better plant protection.

Since fanners are responsible for food crop protection, they should be continuously motivated and guided to awareness of pest problems in their own fields. Thus, their capabilities for dealing effectively with pest problems should be enhanced. Farmers should also be capable of monitoring their own pest situations and of receiving and assessing information in making decisions. Since most farmers own less than 0.3 ha of land, they are advised to work in groups and, therefore, to increase their capability to cope with pest problems effectively, economically, ecologically and socially.

Agricultural extension workers must strive to improve the awareness, knowledge and skill of farmers, and to motivate them to make decisions and to take action. Extension workers are

responsible for providing information on pest conditions and their population dynamics to farmers for consideration, and to help them plan a coordinated pest control program in their areas.
Pest observers are responsible for monitoring the patterns of population dynamics and the factors affecting them. Based on these factors, pest observers are capable of predicting pest population dynamics and probable impacts, and of formulating control recommendations that are sent to farmers through the agricultural extension workers for consideration and action.
Since most rice farmers have limited economic resources, the village unit bank was established to provide the necessary credit for rice production in general and food crop protection in particular. The village unit cooperative, in addition, is expected to play an active role in facilitating special credit arrangements for farmers to increase their production. Village unit cooperatives and kiosks are responsible for developing a delivery system of reasonable quality production inputs to farmers for a reasonable price.
The heads of the subdistrict authority and subdistrict agriculture extension service office are responsible for coordinating the farmer’s activities. Thus, the production process is substantially supported in any one area. The subdistrict authorities also coordinate all regulatory and service institutions; hence, the quality and quantity of production inputs required by farmers should be available when needed.
The irrigation service officers are responsible for making irrigation water available at the proper time so that farmers can facilitate land preparation, planting, harvesting, and other production operations accordingly. Synchronous land preparation and planting used to be limited by water availability; therefore, the irrigation service plays a very important role in coordinating these activities.
Recent labor shortages in rural areas have affected social and economic development. Most young people are not interested in working in the agricultural sector and have moved to the industrial sector in urban areas. Labor shortages generally affect the harvest period and increase the cost of harvesting.
To shorten the critical period during which rice is in the field, simultaneous planting was introduced to the farmers. However, it has been difficult to put this scheme into operation because labor was often not available for land preparation and irrigation.
An institutions at the subdistrict level are supposed to work together to support the food crop protection programs in their area; the success of food crop protection in the area depends upon the institutions concerned. Pest outbreaks or failures in food crop protection are mainly due to mismanagement by the responsible institutions.

Implementation of Food Crop Production Techniques

Introduction of the BIMAS program enhanced the types and availability of pesticides in the market place at a very low cost to farmers because of government subsidies. Thus, pesticides rapidly became the primary means of agricultural pest control and a new phase of pesticide use was initiated. Intensive pesticide use coincided with the heavy use of chemical fertilizers, better irrigation systems, and high-yielding rice varieties. As a result of this highly efficient agricultural system, the country became self sufficient in rice production.
This achievement was rather short-1ived because pest problems soon began to appear with increasing severity, prompting a reappraisal of the entire approach to pest control. The most serious problems appeared in the control of insects through nearly complete reliance on insecticides. Some major pest species developed resistance, e.g., the brown plant hopper (BPH) became resistant to organophosphate insecticides. New pest problems developed because broad-spectrum pesticides virtually eradicated the natural parasites and predators that previously controlled insect pest populations below the economic injury level.
Such change in the ecological balance and the unanticipated negative effects of pesticides on the environment have prompted a reappraisal of their use. Pesticide use is only one of the control techniques that is recommended by the program. Thus, because of a growing awareness of the

negative effects of these chemicals, in 1986 the government banned the use of 57 kinds of insecticides used in paddy fields.

Most of the available techniques for IPM on rice in Indonesia are not new even though some may seem to be. Some techniques simply optimize the existing natural phenomena, while others are artificial. Each technique is more or less feasible and environmentally-sound. There are four techniques that are currently used to control rice pests. These are: 1) cultural control, 2) mechanical and physical control, 3) biological control, and 4) chemical control

Cultural Control

Cultural controls are those methods of planting, growing, and harvesting that prevent or lessen pest damage. This is one of the oldest methods of crop protection in the country. In some cases, a slight modification in the growing of rice greatly decreases pest infestation. A classic example of this is early planting; a slight advance in the usual planting time will control the gall midge on the north coast of West Java Province. In the case of the rice stem borer, however, late planting or a slight delay from the normal planting time is recommended to prevent this pest from developing. Since they are compatible with most other control techniques, it is believed that cultural control practices will continue to be basic tools in pest management.

The development and use of rice varieties resistant or tolerant to its major pests is another applied cultural control effort. Using BPH-resistant varieties is perhaps the most important cultural control for IPM in Indonesia. The development of rice varieties resistant to BPH has been an expensive process but it has provided farmers with an ecologically-sound method for controlling pests. However, the genetic potential in the BPH population has often resulted in new genetic strains capable of infecting the crop when subjected to strong selection pressure by particular resistant genes. These intra-specific genetic variants of the BPH are commonly referred to as biotypes. Distinct shifts in biotypes from changes in rice varieties have been reported in North Sumatra and other regions in Indonesia, where the BPH population has changed from biotype 1 to biotype 3 directly or through biotype 2. To solve this problem, crop rotations are now recommended to prevent shifts in the biotypes. This has been successful in South Sulawesi not only in preventing shifts in BPH biotypes but also in controlling Tungro disease directly.

Mechanical and Physical Control

The use of mechanical and physical means are often the simplest methods for controlling certain pests, but in most cases an excessive amount of labor is needed. Such measures consist of destroying, trapping, or using protective screens or barriers. When comparatively few plants are infested and labor is plentiful and cheap, these control methods can be effective and efficient. The collection and destruction of rice stem borer egg masses is an example of the protection provided by mechanical means. It is successful when used in nursery beds. A rotary plow is also effective in destroying diapausing stem borers in rice stubble. Another example of mechanical pest control is the use of barriers to protect nursery beds from rats. In this case, a plastic screen is placed around a nursery bed to protect the young plants. The plastic barrier supplemented with trap holes is also effective in reducing rat populations. During the fallow period, the only recommended mechanical measure for rat control is digging out the nest and killing the remaining rats. The effectiveness of this method is, however, low when it is applied only in a small area.

Light traps have been used to mechanically control rice pests. For example, light traps were used in West Java Province when a stem borer outbreak occurred in 1989. The insects were attracted to the light and were destroyed by fire or by drowning in water and oil after they were lured into the trap. While a large number of stem borers were caught, the traps were not very effective in reducing crop losses. In fact, they attracted stem borers to the plants in the vicinity of the trap and may actually have increased the infestation. Light traps were useful, however, as a means for determining the time of appearance of certain pests and their population dynamics.

Biological Control

In nature there are many biological factors which tend to impede insect development. These include microorganisms, insect parasites, predaceous invertebrates, insectivorous birds, and amphibians.

The reliance on such insect predators to reduce insect damage to the crop is known as biological control. The objective of biological control is to reduce insect numbers, and consequently, the damage they cause. Even though these natural predators may not achieve total control, they may render partial control to enhance the effectiveness of other methods such as insecticides and cultural practices. There are three methods which are used to achieve this objective: 1) utilizing local or established beneficial natural predators, 2) importing and releasing natural predators into areas where they have either never existed or have become extinct, and 3) conserving natural predators from extinction when pesticides or other harmful control methods are used.

Since 1990, Indonesia has used biological methods for controlling the rice stem borer in West Java Province by utilizing its natural predators and parasites, i.e., *Trichogramma* spp., *Tetrastichus* spp., and *Telenomus* spp. Through periodic collections of the stem borer's eggmasses, the parasites survive longer and may fly into the fields to find the remaining fresh eggmasses. Judicious use of insecticides is also an alternative measure to conserve natural enemies.

Chemical Control

Pesticides arc also used, though judiciously, in crop protection. In fact, they provide a rapid, effective and economical benefit for controlling crop pests. The government policy in using these agricultural chemicals is that pesticides are recommended only when other measures fail to control a target pest. Furthermore, pesticides should not destroy beneficial organisms such as natural predators and parasites, pollenizers and entomophagous species. Specific pesticides should be used against target pests but only at proper formulations, times, methods and rates of application.

Pesticides should only be applied when economically serious damage is likely to occur. Since many of the pesticides are toxic to humans, preventive measures including use of gloves and protective clothing are necessary: removal and washing of contaminated clothing are also recommended. For safety purposes, the government has also advocated the regulation of pesticide use through legislation. New laws contain various regulations, one of which is the requirement for pesticide labelling. The pesticide label must state: 1) name brand or trademark of the product, 2) name of the manufacturer, 3) percentages of active and inert ingredients, 4) net weight or volume of the contents, 5) caution and warning, statement, including an antidote statement if poisoning should occur, and 6) adequate directions for use.

Varietal Resistance to Control the Brown Plant Hopper

The purpose of planting the best rice varieties is obviously to promote increased production of a food crop to correspond with the increased rate of population growth. In 1984, we needed to be food self-sufficient, especially with rice which is our major food source. Nevertheless, there were several constraints that hindered the process of developing resistant varieties such as the appearance of pests and environmental pressures as well as the complexities of applying cultural techniques. One of the major rice pests that frequently threatens production is the brown plant hopper (BPH) which is a highly devastating pest that can also serve as a vector for virus diseases such as grassy stunt and ragged stunt.

BPH has been known since 1931 and was first found in limited-growth areas. BPH was not a major problem until 1951 since the total area of infestation was less than 150 hectares. BPH seems to have gradually increased since 1969/1970 in Java (the center of the rice production area) and since 1972/1973 in North Sumatra. BPH outbreaks of epidemic proportions occurred in 1974/1975 in North Sumatra, West Java, Central Java and East Java. Several years later it appeared in almost every part of the country except Irian Jaya and Maluku. It has been reported that more than 450,000 ha of rice were destroyed by BPH in 1976/1977 and that the resultant financial losses exceeded 100 million U.S.$.

To overcome such problems, experts have intensified their efforts to find the most economically-viable and environmentally- sound control measures. The use of resistant varieties was one of the alternatives that may fulfill these criteria. Several Indonesian rice varieties resistant to BPH have been released; they include Cisadane, Citanduy, Cimandiri, Bahbolon, and Bahbutong. Following the release of these varieties, there were new introductions of resistant varieties by the International Rice Research Institute (IRRI) including IR-26, IR-32, IR-36, IR-42, IR-48, and IR-64. Unfortunately, there is increasing evidence of breakdown in rice resistance because of biotype shifts in the BPH.

BPH biotype shifts occurred along with the use of resistant varieties. The first was in 1976/1977 when IR-26 (monogenic resistance of BPH-1) broke down to BPH biotype 2. The second piece of evidence occurred when IR-42 (monogenic resistance of BPH-2) broke down to BPH biotype 3 in 1981/1982. Other evidence followed in 1985/1986 when Krueng Aceh in East Java, Cisadane in Central Java and IR-36 in Yogyakarta appeared to have broken down to BPH biotype 1 and biotype 2. Some of the BPH biotype shifts could have resulted from excessive use of pesticides that may have contributed to both pest resistance and resurgence.

Research on varieties resistant to BPH was begun in 1974; national and introduced varieties that were resistant to biotype 1 were released, i.e., IR-20, IR-26, Serayu, and Asahan. IR-26 was immediately and continuously planted in large areas. This variety has shown a strong ability to hold the BPH population to rather low levels for several planting seasons. However, it failed to overcome the BPH population in rice after 4 to 5 planting seasons in several of the production centers.

The BPH infestation of variety IR-26, as mentioned above, was biotype 2, therefore, research on new varieties were focused on biotype 1 and biotype 2. Several of the new varieties such as IR-30, IR-32, IR-34 and IR-36 were released to replace IR-26 and other varieties that were resistant to BPH-1 only. Several years later, other varieties (Cisadane, Semeru, Cimandiri and IR-42) were also released. Because new BPH biotype shifts are always possible, it is essential that cultural and management techniques extend the resistance of our rice varieties.

Policy for Pesticide Regulation

Prior to 1970, pesticides were freely imported and used in Indonesia since no government agency was responsible for their regulation. In 1970, the Minister of Agriculture established a pesticides committee that had responsibility to provide assistance to the Minister of Agriculture on pesticide policy. The members of this committee were experts and government officers from related concerned institutions, i.e., Ministry of Health, Ministry of Environment, Ministry of Labor, Ministry of Forestry, Ministry of Trade, Ministry of Industry and the Ministry of Agriculture.

In 1973, Government Stipulation No. 7 was issued on the control of the distribution, storage and use of pesticides. In this decree, it was mentioned that every pesticide, regardless of its target (crop. fish. veterinary, environmental hygiene/customer product, storage, wood preservative, forestry etc.) would have to be registered and its use would be regulated by the Minister of Agriculture. Thus, the use of unregistered pesticides in Indonesia was prohibited.

Requirements for registering pesticides in Indonesia are safety to humans and the environment as well as effectiveness against target pests. Comprehensive efficacy trials are required and are provided by accredited institutions.

Information required for registration of pesticides include the following:

- Physical and chemical properties of pesticides
- Intended use of the pesticides
- Efficacy and phytotoxicity
- Mammalian toxicity
- Environmental toxicity
- other information

Immediately following the governmental decree, the conditions required for pesticide registration (especially mammalian and environmental toxicity) were not restrictive enough and resulted in registration of a number of harmful pesticides. Formerly, the registered pesticides were predominantly organochlorines, organophosphates and inorganic compounds.

To reduce the increasing rate of pesticide registration requests, the Minister of Agriculture in 1984 issued a decree limiting pesticide registrations. Limitations included type and maximum number that may be registered from those that are likely to be eligible for registration. Pesticide control also holds an important role in the management of pesticides; therefore, to be consistent and in line with the existing regulations, the Minister of Agriculture issued a decree on pesticide control in 1985. Pesticide supervisors and pesticide control committees at both provincial and district levels were established.

At the control level, some 73 pesticide formulations were phased out because existing regulations were not met. Today, 713 formulations are registered in Indonesia; these consist of 438 formulations for crops and 275 formulations for non-crops.

Prospects for EM Technology in IPM

In general, agricultural practices attempt to exploit and manipulate the natural resource base for man's benefit. Agriculture is not always compatible with the interdependent mechanisms of major components of the ecosystem. Therefore, the stability of agroecosystems is quite different from that of natural ecosystems. The stability of agroecosystems is artificial and needs a continuous energy subsidy. Furthermore, the pressure on agroecosystems toward ever greater levels of production has created new environments for pests. As a result, agroecosystems often have become more vulnerable to pests. Changes in tillage, water management, crop varieties, fertilization regimes, and other agronomic practices greatly influence pest incidence, very often in favor of pest abundance. The increased complexity and intensity of agricultural production practices along with reduced genetic diversity in many crop species combine to produce a new magnitude of crop hazards.

Scientific pest control has always required a knowledge of ecological principles, the biological intricacies of each pest, and the natural factors that tend to regulate their numbers. Today, it is more important than ever to take a broad ecological overview of these problems and to consider all possible factors, both natural and artificial, that can be used against crop pests. We can no longer afford to disregard the considerable capabilities of pests to counter control efforts. Most of these organisms are extremely fitted to thrive in our agroecosystems and to adapt to changing crop production conditions. It is for this reason that we must understand nature's methods of regulating populations and then maximize their application. This clearly requires a realignment of practices. A unified, balanced approach is needed and may be predicated mainly on widely proven principles of pest control and ways of implementing them, and on recognizing the limitations as well as the advantages of any new methods that are evolved.

The overall philosophy of pest management employs a strategy for maximizing natural control forces by utilizing any other technologies with a minimum of disturbance only when crop losses justifying action are anticipated. The integration control practices must be based on the realization that individual pest species are single components of a complex agroecosystem and that interaction among the components cuts across artificial lines created by taxonomically-oriented scientific disciplines involved in crop protection. Therefore, the development and implementation of IPM requires both a disciplinary and an interdisciplinary approach. Entomologists, microbiologists, and agronomists must be knowledgeable about pests and their control and must address themselves to the concept of integrated control.

Effective microorganisms (EM) is a prospective agent for implementing integrated pest management since it consists of beneficial microorganisms useful in maintaining plant health, particularly roots. We know that, in some cases, the failure or poor yield of a crop may be due to a lack of ability of the root to extract nutrients from the soil. Certainly, root health is a prerequisite to stability of the agroecosystem. Some beneficial species of the genus Bacillus have been identified among the soil bacteria. Occupying the rhizosphere, they may protect plant roots from infection by soil-borne pathogens. They may favor crop growth by producing growth-stimulating hormones such as indoleacetic acid or gibberellic acid, by mineralization of soil organic matter, or by destruction of toxins of microbial origin that would injure the crop. The complex interactions of these beneficial species among themselves, with other components of the soil microflora and microfauna, and with the cultivated plant are essential to the stability of the agroecosystem.

Though we view the agroecosystem as a simplified plant community, which it is in terms of cultivation practices; it is supported below ground by microbial interactions that are undoubtedly complex, and the microbial complexity that affects the agroecosystem stability. Therefore, careful management of the ecology of the plant root, particularly of the rhizosphere through maximizing the potential effectiveness of EM, will be a critical factor in agroecosystem management of the future.

Conclusions

Rice is a staple food of the Indonesian people and it has an important role in economic development. Through a massive intensification of rice production in the Five Year Development Program, Indonesia attained self-sufficiency in food production in 1984. Even though rice production increased significantly, the rate of production seems to be unstable as a result of some constraints such as pest outbreaks and unfavorable climatic conditions.

To cope with pest problems, the IPM concept has been adopted in pest control measures. The implementation of IPM, in addition to providing insurance for the achievement of potential yield, conserves natural resources and the environment.

Some plant protection techniques are implemented according to the IPM concept, i.e., cultural control, mechanical and physical control, biological control and chemical control. Cultural control employs methods of planting, growing and harvesting crops which will prevent or lessen pest infestation. Mechanical and physical methods control by trapping and destroying the pests, and by using protective screens or barriers to prevent pest infestation. Biological control is the manipulation of local natural predators and parasites to suppress pest populations. In line with the IPM concept, chemical control, i.e., the use of pesticides, is the last alternative if other techniques should fail.

To support IPM implementation, pesticide management is conducted by an interdepartmental pesticide committee. The government has promulgated some decrees and regulations to administer the distribution, and the use and storage of pesticides. The decrees and regulations are aimed at avoiding the negative impacts of pesticide use on humans and on the environment.

One component of cultural control is the planting of resistant varieties; resistant varieties have a remarkable ability to cope with BPH problems. However, as an insect pest, BPH has a high rate of adaptability to its environment including plant varieties. Therefore, along with the shifting of BPH biotype from biotype-1 to biotype-2 and biotype-3, the breeder and other concerned researchers have been working to develop resistant varieties to overcome BPH biotype shifts.

EM is a promising new dimension for enhancing the effectiveness of IPM since it contains beneficial microorganisms useful in maintaining root and plant health and ultimately plant growth. The interactions of beneficial species among themselves and with other soil microorganisms are essential for stability of the agroecosystem. However, integration of the use of EM with IPM implementation in food crop protection should be supported by positive evidence that would substantiate the claims of EM efficacy. Therefore, experiments need to be conducted to determine the effectiveness of EM and to integrate EM with all other aspects of sustainable agriculture. Furthermore, EM integration in agriculture is related to “LISA” which refers to Law Input/Sustainable Agriculture aimed at conserving natural resources and creating sustainable agriculture without negative impacts on the environment.