Discussion of the Country Reports

Chairman: Chiang, H.C. (U.S.A.): It seems to me that as far as pest management is concerned, there is little difference between the developed and the developing countries: in either area this problem is its early stage of development. This symposium made me fully realize that rice is the most important cereal crop, particularly for the countries of Asia. Also I was impressed by the fact that for the last 15 years the concept of pest management has evolved from the simple practice of spraying or dusting as it used to be. Now it includes a broad spectrum of measures such as the use of host resistance, biological control and cultural methods, sanitation, quarantine as well as chemical control which remains an important strategy.

The main problems confronting the implementation of pest management will be briefly taken up.

Let us begin by discussing some aspects relating to host resistance. The main problem is to determine what is the level of resistance one should strive for. One should not overlook the fact that there are regional differences in the levels of resistance. From our experience with corn resistance to the European corn borer it appears that precise levels do not matter so long as some progress is achieved. In the case of corn a 30% resistance level was deemed acceptable as the combination of host resistance to other control measures should enable to increase the effectiveness of pest management.

As far as biological control is concerned, it is evident that we become increasingly concerned about the effect of insecticides on the natural enemies. In addition to the effectiveness of insecticides against the target, their safety must also be thoroughly assessed. The problem is to determine whether biocontrol should be promoted as a single strategy or be associated with other measures. The exchange of biological control agents should be expanded and it seems that the People's Republic of China from which many crops-hence insects-derive their origin would be a particularly important country to cooperate with in this regard. The U.S.A. has initiated such a program and is awaiting a direct air-link between the two countries, which would facilitate the transport of materials.

Cultural control is perhaps the most important approach to the successful implementation of pest management. It is however difficult and unpractical at the farmer's level as it requires a synchronization of the efforts over large areas, which necessitates intensive manpower and the existence of an elaborate organization. In China, for example, pest control measures aim at the reduction of the insect population at the overwintering stage and after insect emergence from the overwintering habitat before crops are being reached.

An other major problem for the region is the severity of the brown planthopper (BPH) outbreaks calling for special attention on the part of the entomologists. The dispersal aspect should be studied thoroughly as knowledge on the origin of infestation by BPH will affect the control measures taken (this aspect is similar to the situation of bean and potato aphids in Europe). In this respect, cooperation between the countries in the region is crucial.

As for chemical control, the trend is for more selectivity in the use of insecticides. One should bear in mind the fact that specific insecticides are more expensive to develop and have a smaller market. Such considerations bring about the problem of government subsidies for the development of insecticides. The main strategy will emphasize care in selecting the insecticides as well as timing and area of application.

As a result, there will be a need for improving and promoting ecological and biological studies on insects, which could lead to the establishment of a monitoring system as well as economic and control thresholds. It will also be necessary to adopt a multi-disciplinary approach to solve these problems and a close collaboration between entomologists, plant pathologists, nematologists and weed scientists should be actively promoted.

Needless to say, training of key farmers, extension agents, pest observers is of paramount importance and the role of progressive key farmers should enable to increase the degree of self- reliance for crop protection.

Finally I would like to mention that more coordination among governments could help avoid the harmful effect on the environment resulting from experiments on chemicals which are authorized in one country and banned in an other country. International organizations such as the Food and Agriculture Organization (FAO) could contribute to some harmonization in this regard.

Now I would like to ask Dr. Mochida, the co-chairman of this session to make a few comments.

Mochida, O. (Japan): I would like to emphasize two aspects: 1) It seems that the role played by insect pests varies with the countries. However, it is evident that the brown planthopper is one of the most important pests of rice in South and Southeast Asia, followed by the rice gall midge. 2) The concept of pest control for rice in Japan is centered on the use of insecticides. In other countries, the farmers and the government officials think more in terms of integrated pest control whereby the use of resistant varieties prevails over that of insecticides.

Kiritani, K. (Japan): I would like to make a few comments on the points raised by Dr. Chiang in the beginning of the discussion.

With regard to host resistance, a computer simulation study recently conducted enabled to demonstrate that the leafhopper population could be reduced below the economic injury level when the use of natural enemies was combined with 30% varietal resistance.

It may be true that in Japan there is an over-dependence on the use of insecticides for pest control, as stated by Dr. Mochida. However, the role of the application of agricultural practices has been equally decisive in controlling *Chilo suppressalis* infestations. As far as the exchange of biological control agents is concerned, in Japan, unlike in the U.S.A., most of the insect pests are endemic so that a complex of natural enemies is in operation. The use of biological agents is not always effective, however, as in the case of the *Trichogramma,* for example.

I also agree with the emphasis placed on the application of cultural practices. In Japan, for instance, synchronized planting enabled to significantly reduce the incidence of *Tryporyza incertulas* whose occurrences are now being sporadically recorded in the southermost part of Japan only.

As regards the brown planthopper, unlike in Japan and in the temperate regions where there is a long history of outbreaks, in Southeast Asia, the brown planthopper has become a serious pest only since the beginning of the 1970s, perhaps in relation to the introduction of rice high yielding varieties (HYVs). It thus appears that although the brown planthopper is a r-strategy pest, other factors such as that mentioned above may be required to enhance its potential as a harmful pest.

Finally, I would like to indicate that although the training and education level is comparatively high in Japan, the implementation of integrated pest control is somehow behind that in other countries.

Reddy, B. (FAO, Bangkok): I believe that cooperation between Governments and multinational corporations should be promoted when it comes to the regulation (application, ban, specification, etc.) of agricultural chemicals for pest control, in addition to the efforts made by FAO.

Dyck, V.A. (International Rice Research Institute, the Philippines): I am somewhat concerned about the fact that proper timing of insecticide treatment, economic threshold and minimal application of insecticides are rather complex and that farmers are slow in accepting this concept. Following economic thresholds has considerable implications to risk-taking and farm economics.

To achieve better pest control presently, should we advocate calendar or crop-age-based applications until proper pest management systems are better developed and can easily be implemented?

Reddy, B. (FAO, Bangkok): I do not completely agree with your suggestion. It is true that most farmers actually use pesticides, which is much easier than following the pest management control schedule recommended to them, except for the use of resistant varieties and cultural practices.

Likewise, integrated pest management is difficult to implement when you are dealing with a large number of farmers owning not more than 2-3 hectares of land and when you realize that farm operations are not synchronized. However, more work and research should be conducted in this regard. I believe that surveillance based on field operations as well as the application of selective and safe chemicals combined with the use of resistant varieties is more important than following schedules.

On the other hand, the determination of the injury level or threshold is certainly difficult as it varies from season to season, pest to pest and country to country. It requires an effective organization at the farmer and government level to be successful.

The problems to consider are chiefly: 1) To what extent should injury levels be taken into account and 2) How can injury levels be applied to permanent crops?

Ishikura, H. (Japan): As regards the comment made by Dr. Dyck on the determination of timely application of pesticides in relation to the stages of growth of the plant, I would like to mention that in Japan, after the initiation of the forecasting system and the introduction of pesticides, the application time was set according to the time when the pest appears. However we have observed that rice insects such as the stem borers prefer a particular stage of growth of the crop and the infestation varies according to the planting date.

As the injury is more related to the conditions of growth of the plant, it seems that at least in the case of the stem borer in the first generation in particular, the time of application of insecticides should be set according to the date of transplanting of the crop rather than in accordance with the emergence curve of the moth for instance.

Yoshimeki, M. (Japan): I believe that the timely application of pesticides offers many advantages over the calendar application in reducing the number of applications and in preventing environmental pollution as well as the build-up of resistant pests.

With regard to the comment made by Dr. Ishikura, I would like to add that rice growing conditions in Southeast Asia are different from those prevailing in the temperate zone, as in the former area a particular stage shows wide fluctuations extending over a period of one month, sometimes. Thus, the determination of the most appropriate time for the spray according to the rice growth stage may not be adequate in practice.

An other point I would like to emphasize is the lack of synchronization of rice growing in Southeast Asia in relation to the time when irrigation water is supplied. As a result, the stages of growth vary from field to field. I would therefore like to suggest that the time of spraying of pesticides should be set according to the planting date of the crop.

Mochida, O. (Japan): I would like to point out that in Southeast Asia the concept of "monitoring" seems to prevail in contrast with that of "forecasting" which is usually understood in Japan, for example in the case of the brown planthopper surveillance as it is practised in Kyushu (southwestern part of Japan).

With regard to what Dr. Yoshimeki just mentioned, I would like to add that it is not enough to set the time of application of pesticides according to the transplanting date. For example in the case of the brown planthopper the peak of occurrence in the irrigated areas of Indonesia extends over a very long period of time (seedbed to harvest) and shows wide variations.

Chang, P.M. (Malaysia): The timing of application of pesticides may create several problems such as insect resistance to insecticides if continuous spraying is carried out over a long period of time. Also the farmers who are poorly educated may be tempted to apply excessive amounts of pesticides too frequently and the situation may go out of hand.

In Malaysia, in addition to monitoring, the use of natural enemies is being promoted and as these are still very effective spray may often become unnecessary.

We place emphasis on the training of the farmers by the extension workers so as to have the farmers familiarized with the pest and subsequently with the timing of application of pesticides.

Sanchez, F.F. (the Philippines): In the Philippines we try to create a corps of well trained technicians to guide the farmers. It seems that the farmers can be instructed easily and that the concept of integrated pest control is perfectly adapted to the conditions prevailing in the developing countries.

As a result of the implementation of integrated pest control we have even succeeded in avoiding pesticide applications.

Tanongchit, W. (Thailand): In Thailand rice insect control seems to require less insecticide application than in the case of cotton or vegetables. As a rule, the farmers do not like to use insec-

ticides unless they are compelled to do so by the extension workers.

Sadji, P. (Indonesia): I would like to comment on what Dr. Chiang previously said. I feel that the timing of application of pesticides is difficult to determine on the basis of monitoring records. It depends on the plant age and the insect growth stages (counts of egg clusters, catching of moths).

In Indonesia, the effort is placed on the use of high yielding varieties and on the application of high levels of fertilizers so as to increase production. The farmers prefer to spray crops according to the plant age rather than the insect appearance. I also believe that the timing of application of insecticides depends on the country and the pest.

In the case of the brown planthopper (BPH) spraying can be done on the basis of counts whereas in the case of the stem borer and the gall midge plant growth parameters are preferable.

As far as the use of resistant varieties is concerned, it seems that such practice is suitable for the BPH although new biotypes causing damage may develop. Other pests may also create problems. Presently the incidence of rice stem borers and rice gall midge is increasing. Some of the rice varieties which are resistant to the gall midge may be susceptible to the BPH and the stem borers.

As far as the cultural control is concerned, it is undoubtedly an important approach to pest management but it is fairly difficult to implement it. Indeed it is necessary to mobilize a large number of small farmers for carrying out planting according to regulations as the schedule of the operations often depends on the pest.

Reddy, B. (FAO, Bangkok): I am most impressed by the fact that both Malaysia and Thailand do not use a large amount of pesticides although rice yields are comparatively high (Malaysia's yields come next to those of Japan and Korea). Fertilizers are applied and high yielding varieties are being cultivated. It is possible that when rice double cropping will become more wide-spread (presently rice is chiefly being cultivated during the rainy season) insect problems may become more conspicuous. I believe that the reasons for such a situation should be investigated carefully.

Koyama, J. (Japan): In Japan where pesticide application is the most important measure of pest control the determination of the economic injury level is needed to reduce the frequency of spraying. On the other hand, is the concept of economic injury level as relevant in other countries where the use of resistant varieties, for example, is deemed more important than the application of insecticides as a control measure?

Chairman: It depends on the case, the location and other factors. I believe that the concept of threshold is related to the degree of precision. Most of the recommendations made require a high level of knowledge and technology and are not necessarily practical. The criteria should be made simpler as the operational level of precision is often more important for the farmer than the technical level of precision. What kind of a control should we aim at, particularly in the developing countries in relation to the input/output ratio?

Indeed the percentage of insect damage which is tolerable varies depending on considerations such as pollution/production. Socio-economic factors should be taken into account and above all the needs of the growers should be given priority.

Roberts, D.W. (U.S.A.): Dr. Reddy mentioned that there is a correlation between areas with few brown planthopper outbreaks, hence little use of insecticides and areas where rice is grown primarily in the rainy season. It is possible to consider that the wet weather might be conducive to the growth of fungal pathogens of the brown planthopper and other pests so as to make the use of insecticides unnecessary.

Pathogens of rice pests have not been surveyed thoroughly. I would like to propose that such studies be carried out in an effort to identify and develop new population management tools for incorporation into integrated pest control programs. One may even conceive that insects affected by diseases caused by various pathogenic agents (fungi for instance) would experience a population decrease and act like insecticides.

Litsinger, J. (International Rice Research Institute, the Philippines): I would like to point out that from the experience I have accumulated for the last 6 years in trying to bridge the gap between research and extension I am convinced that the chemical control implemented by the farmers is

rather erratic. Technology pertaining to pesticide application is not adequately transmitted and there is a wide-spread misuse of insecticides which has been responsible for many cases of poisoning among the farmers.

Biological control appears to be better accepted as many farmers are reluctant to use pesticides. I believe that the extension set up should be reconsidered and that there is a need for a hierarchy of trained and knowledgeable people to secure a continuity over a long period of time so as to ultimately enable the farmers to reach a level of self-reliance.

Reddy, B. (FAO, Bangkok): I would like to reiterate the point that so far most of the rice protection technology has been developed either in research, ecology or control chiefly for irrigated rice. Emphasis should be placed on the situation of pests in rainfed areas (70% of the cultivated zone) as well as in the case of deep water rice (30 million hectares are under such cultivation in the region).

Litsinger, J. (International Rice Research Institute, the Philippines): As far as rainfed rice is concerned, some varieties with drought tolerance have been developed. Insect pests are usually fewer than in irrigated areas for several reasons. The existence of a dry season greatly contributes to the decrease in the insect population.

The practice of inter-cropping is also very useful in decreasing the number of insects. The in-between crops are the most important in this regard. Breaks in rice sequence also reduce the insect population along with the avoidance of ratoons or weedy fallows.

In the case of maize and millet yields cannot easily be improved nor cultivation made more profitable for the farmer. In the case of legumes integrated pest control is almost impossible to achieve. However rationalization of the use of insecticides can be promoted.

Yoshimeki, M. (Japan): If rice yields in irrigated areas are higher than those in rainfed areas it is chiefly due to the fact that the farmers take better care of irrigated rice than of rainfed rice. Also the level of technology is higher in the former than in the latter. On the other hand there are fewer insect problems in rainfed areas than in irrigated ones owing to the complexity of the agro-ecosystems in the former.

Yasumatsu, K. (Japan): On the basis of the studies on the natural enemies of rice pests of economic importance which have been carried out in Thailand for about 6 years in collaboration with Dr. Tanongchit and his colleagues, it was possible to demonstrate that the fauna of natural enemies was almost the same in fields with one crop of rice as in those with the second rice crop.

Such findings can be ascribed to several factors:

1) In the irrigated areas of the Chiang Mai Province in the north of Thailand for example, the second crop of rice is often cultivated along with vegetables, which is conducive to the preservation of the fauna of natural enemies.

2) When farmers wish to cultivate crops other than rice they use irrigation water. When the water is brought to the fields the diapause of larvae or pupae of rice stem borers is broken and the moths emerge prior to rice transplanting. The moths die due to the lack of rice which is the only host plant of these insects.

3) Many weedy areas have leguminous plants acting as refuge areas for the natural enemies which subsequently move to the rice fields. Also I would like to emphasize once more the harmful role of insecticide sprays which interfere with the beneficial effect of natural enemies.

Kenmore, P. (U.S.A.): I would like to point out that the brown planthopper has become a serious problem in many tropical countries only in the last 15 years along with the introduction of high yielding rice varieties as well as with the extensive use of insecticides often responsible for the destruction of the fauna of natural enemies.

Chang, P.M. (Malaysia): I would like to mention that when the first outbreak of brown planthopper occurred in Malaysia in 1967 no insecticides had been used. However the population of natural enemies was very low due to heavy rains and floods.

Hidaka, T. (Japan): The rice gall midge which is the main pest in the rainfed rice fields of the northern, northeastern and eastern part of Thailand has been attacking the second crop of rice cultivated in the Central Plain during the dry season since 1976. This phenomenon may be ascribed

to the fact that susceptible varieties are cultivated over large areas and also to the presence of high humidity due to irrigation which increases the rate of egg-hatching. Therefore if rice yields in the dry season crop are increasing, so is the infestation with the gall midge.