ESTIMATION OF YIELD LOSS AND COMPUTERIZED FORECASTING SYSTEM (BLIGHTAS) FOR RICE SHEATH BLIGHT DISEASE

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ABSTRACT

A computerized system (BLIGHTAS) for forecasting the development of rice sheath blight disease was developed based on the ratio of the height of the lesions to the plant height (X, vertical development of the disease) and percentage of the number of diseased hills (A, horizontal development of the disease). In this system, the yield loss of fully ripened kernels in kg per 10 ares (L) is expressed as follows: L=(41.31X-826.2)A/1000. The X value was calculated from the relation between the daily temperature and relative humidity between hills and susceptibility of leaf sheath. The A value was calculated from the relation between the daily temperature and relative humidity between hills and quantity of sclerotia per unit area of paddy fields. BLIGHTAS designed for use on a personal computer consists of three programs, i.e. analytical program of diurnal variation of temperature and relative humidity, analytical program of temperature and relative humidity, and forecasting program for rice sheath blight disease. It has been confirmed that the yield loss predicted by BLIGHTAS was very close to the actual yield loss caused by the disease. This forecasting system may be applied for the development of new strategies to control the disease. It has been confirmed that the yield loss predicted by BLIGHTAS was very close to the actual yield loss caused by the disease. This forecasting system may be applied for the development of new strategies to control the disease.

Introduction

Rice sheath blight of rice plants has spread rapidly in recent years since it was first detected in Japan in 1910, and has become an important rice disease. It is assumed that the recent increase in the occurrence of this disease is associated with early season culture, use of early-maturing, short-culmed and high-tillering varieties, dense planting, and heavy fertilization. The average affected area is estimated at 1.1 million hectares, or about 40% of the total rice cultivation area. The total area treated with chemicals for the control of the disease has reached 1.7 million hectares. Extensive studies on sheath blight have been carried out in Japan (Kozaka, 1961; Hori, 1971; Hashiba, 1982, 1984). It is recognized however, that the forecasting system of this disease has not yet been fully established and still requires improvement. Therefore, a method to estimate the severity of the disease and yield loss will be described first, followed by the outline of a model of vertical disease development represented by the upward development of lesions, and a model of horizontal disease development represented by the percentage of the number of diseased hills. Thereafter a computerized forecasting system for this disease will be described.

Estimation of disease incidence severity by the height of lesions on the leaf sheath

Various methods for the estimation of the severity of rice sheath blight disease caused by *Rhizoctonia solani* Kühn were evaluated with a view to developing a time-saving and simple method. Rice cultivars, including 1,429 foreign cultivars from more than 40 countries of the world and 277 domestic cultivars, were used to measure the height of the uppermost lesions on a leaf sheath, and

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the relative height of the upper-most lesions to the plant height. On the other hand, the degree of disease incidence was estimated by the Yoshimura's method (Yoshimura, 1954). Vertical development of the disease was always more pronounced in the early maturing cultivars than in the late maturing ones. Statistical analysis enabled to estimate the degree of incidence (Y) based on the relative height (X) of the uppermost lesions to the plant height by the following equation,

$$Y=1.6X-32.4 \text{ --------- (1) in Fig. 1.}$$

The value X was estimated as $X=0.73Z-4.13$, where Z is the height of the uppermost lesions. Estimation of the degree of disease incidence by this formula is more efficient and simpler than that by the Yoshimura's method (Fig. 1).

Incidence of diseased hills (Y)

$$\mathbf{Y} = \frac{3n_1 + 2n_2 + In_3 + On_4}{3N} \times 100 \quad \text{(Yoshimura's formula)}$$

$$\|$$

$$Y = 1.62X - 32.4 \quad \cdots\cdots\cdots\cdots \quad (1)$$

$$X = \frac{\text{Height of the uppermost lesions}}{\text{Plant height}} \times 100$$

$$\text{Disease incidence (D)} = (1.62X - 32.4) \times \frac{A}{100} \quad \cdots\cdots\cdots\cdots \quad (2)$$

A: Percentage of diseased hills

Yield loss (per 10 areas)

$$L = (1.62X - 32.4) \times \frac{A}{100} \times 8.5 \times 300\text{g} \quad \cdots\cdots\cdots\cdots \quad (3)$$

$$= (41.31X - 826.2) \times \frac{A}{1000}\text{ kg} \quad \cdots\cdots\cdots\cdots \quad (4)$$

Fig. 1 Empirical formula for estimating the yield loss caused by rice sheath blight disease.

Estimation of yield loss from the height of the lesions and percentage of diseased hills

Estimation of yield loss caused by rice sheath blight disease from the relative height of the lesions to the plant height and percentage of diseased hills was analysed. Whole disease incidence (D) at the maturing stage can be represented as the product of the incidence of diseased hills estimated by the relative height of the uppermost lesions to the plant height (X) and the percentage of the number of hills (A):

$$D=(1.62X-32.4)A/100 \text{ --------- (2) in Fig. 1.}$$

On the other hand, the loss of fully ripened kernels has been estimated at 8.5 g per 3.3 m^2 for each additional 1 % of disease incidence, from which the following equation was derived (L represents yield loss in kg per 10 area):

$$L=(41.31X-826.2)A/1000 \text{ ------- (3) in Fig. 1.}$$

The yield loss actually observed in paddy fields agreed well with the estimation by the formula.

Model of vertical development of sheath blight lesions on rice plants

A variety, Koshijiwase, was grown in paddy fields, and the vertical development of the lesions of sheath blight was analysed. At the same time, an attempt was made to produce a model curve which can represent the actual vertical development of the disease under natural temperature and relative humidity conditions.

First, a model curve was developed as a function of the average temperature in the field.In other words, the rate of upward development of the lesions was calculated on the basis of the relationship between the development of the lesions and the temperature shown in Table 1, and was expressed by a cumulative model curve (Fig. 2, A). Second, this model curve was modified by taking into account the effect of the relative humidity shown in Table 2 to obtain the second model curve (Fig. 2, B). Then, a correction for the susceptibility of the leaf sheath was made in the second model curve (Table 3). When daily values of vertical development of the lesions calculated from the values of temperature and relative humidity were larger than the values calculated from the susceptibility of the leaf sheaths, the latter was adopted instead of the former. Thus, the final model curve (Fig. 2, C) of the vertical development of the lesions calculated from the values of temperature, relative humidity and susceptibility of the leaf sheaths was obtained. This model curve was found to agree well with the vertical development of the lesions actually observed in paddy fields from 1971 to 1982 (Fig. 2, D).

The model curve for the vertical development of the disease (X) was developed on the basis of data on the temperature, relative humidity and susceptibility of the leaf sheaths.

Model curve of horizontal disease development of sheath blight on rice plants

Horizontal disease development as expressed by the percentage of the number of diseased hills was examined using Koshijiwase grown in the field under natural temperature and relative humidity conditions. A model curve of the horizontal development of the disease was developed as a function of the temperature, relative humidity and density of sclerotia.

It was found that the relation of vertical disease development to the average temperature and relative humidity can be used for developing a model curve of horizontal disease development, when the average temperature of each day is higher than 22°C, and at the same time the relative humidity at the height of 5 cm from the soil surface between hills is higher than 96 %. First, a model curve B, shown in Fig. 3, was obtained as a function of the average temperature (Table 1).

The rate of horizontal development of the disease is affected by the difference in the quantity of sclerotia. When the rate for 5×10^4 sclerotia per 10 area was taken as 1, that for 10×10^4, 20×10^4, 30×10^4, 40×10^4 and 50×10^4 sclerotia was 1.4, 2.3, 3.2, 4.1 and 5.0, respectively. Second, when the quantity of sclerotia was larger than 5×10^4 sclerotia per 10 ares, this model curve had to be modified according to the above index of the horizontal development for different quantities of sclerotia. This model curve coincided with the actual horizontal development of the disease observed in paddy fields from 1977 to 1982.

The model curve of the horizontal development (A) was produced on the basis of data on the temperature, relative humidity between hills and quantity of sclerotia per unit area of paddy field.

Table 1 Relation between the vertical development of the lesions on rice plants infected with the sheath blight fungus and the temperature

Average temperature (C)	Vertical development of lesions on rice plants under 100% relative humidity conditions (cm/day)
19	0.27
20	0.48
21	0.70
22	0.90
23	1.13
24	1.24
25	1.35
26	1.43
27	1.51
28	1.58
29	1.55
30	1.50

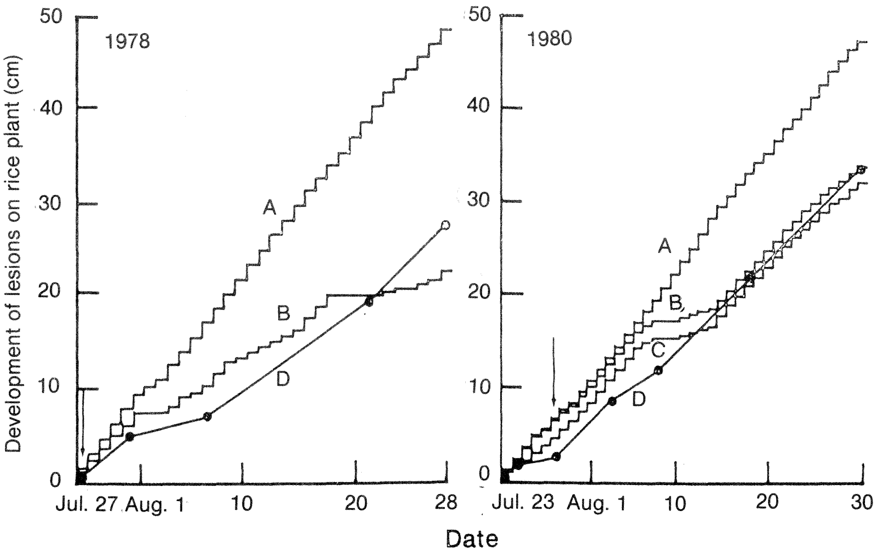

Fig. 2 Comparison between the vertical development of the lesions actually observed on rice plants infected with the sheath blight fungus in 1978 and 1980 and that estimated by cumulative model curves.

A: Cumulative model curve of the vertical development of the lesions calculated on the basis of the average temperature (Table 1).

B: Model curve modified by taking into account the relative humidity (Table 2).

C: Model curve further modified by taking into account the susceptibility of the leaf sheaths (Table 3).

D: Vertical development of the lesions actually observed on rice plants in paddy fields. Arrow indicates heading time.

Table 2 Relative humidity correction for the vertical development of the lesions on rice plants infected with the sheath blight fungus

Relative humidity (%)	Index of vertical development[a]
84	0.10
85	0.24
86	0.38
87	0.52
88	0.66
89	0.77
90	0.87
91	0.89
92	0.91
93	0.94
94	0.95
95	0.96
96	0.97
97	0.98
98	0.99
99	1.00
100	1.00

[a] Ratio of vertical development of lesions under various relative humidity conditions to that under 100% relative humidity condition.

Table 3 Vertical development of the lesions as influenced by the susceptibility of leaf sheaths after heading under the most favorable conditions

Days after heading	Values influenced by the susceptibility of leaf sheaths (cm/day)
-5	0.74
-2	0.79
0	0.86
2	1.12
4	1.25
6	1.38
8	1.54
10	1.71
12	1.66
14	1.61
16	1.56
18	1.56
20	1.56
22	1.56
24	1.56
26	1.47
28	1.38
30	1.29
32	1.20
34	1.11
36	1.02

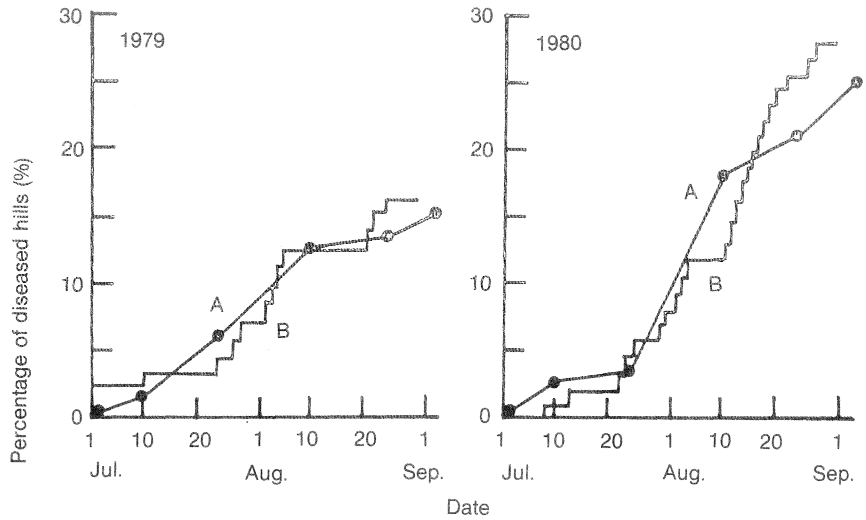

Fig. 3 Comparison between the horizontal development of the lesions actually observed on rice plants infected with the sheath blight fungus in the field in 1979 and 1980 and that estimated by cumulative model curves.

A: Horizontal development of the lesions on rice plants in paddy fields.
B: Cumulative model curve of the horizontal development of the lesions calculated on the basis of the average temperature (Table 1).

Comparison between actual yield loss observed in fields and yield loss estimated by the model

The yield loss measured in paddy fields from 1976 to 1980 almost coincided with that estimated by the model curves (Table 4).

Table 4 Comparison between the actual yield loss observed in fields from 1976 to 1980 and the yield loss estimated by the forecasting model

Year		X	A	D	L
1976	1	45.0%	17.0%	6.9%	13.3%
	2	32.3	22.6	8.4	21.5
1977	1	48.2	23.0	10.5	26.8
	2	51.6	31.7	16.7	42.6
1978	1	37.1	14.0	3.9	9.9
	2	34.0	9.3	2.2	5.5
1979	1	46.0	16.0	6.7	17.2
	2	43.7	19.3	7.6	19.4
1980	1	47.0	25.6	11.2	26.2
	2	51.0	26.4	13.7	34.8

1: Observed value, 2: Estimated value
X: Relative height of the uppermost lesions to the plant height (%)
A: Percentage of diseased hills (%)
D: Disease incidence (%)
L: Yield loss (kg/10 ares)

Construction of BLIGHTAS

A computer can help to estimate the expected yield loss. BLIGHTAS was developed for predicting the effects of rice sheath blight on rice yields.This system can be run on most computers including compatible personal computers. As shown in Fig. 4, the BLIGHTAS system consists of three major programs written in FORTRAN. Each program was constructed with about 30 subroutines. The total number of steps of the the program amounts to about 5,000. The first program which is an analytical program for the estimation of diurnal variations of the average temperature and average relative humidity prepares data files to estimate the diurnal variations. The second program, an analytical program for the estimation of normal values of average temperature and average humidity prepares data files covering a 30 year period. This program enables to estimate the seasonal variations of the average temperature and average humidity. These two programs were incorporated into a computerized forecasting system for rice sheath blight disease.

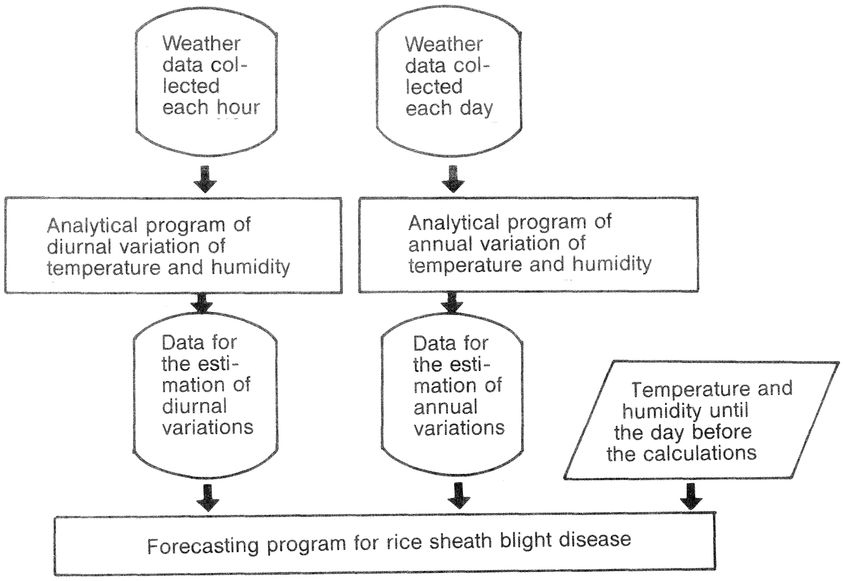

Fig. 4 Construction of the program.

As shown in Fig. 5, the third program, a forecasting program for rice sheath blight disease reads the data files prepared by the above two programs and simulates the yield loss caused by the disease. The computer model is constructed by applying the uniform-increment method so that time is taken into account. First, the first day (i.e. July 1) is entered and the daily calculation of the disease incidence begins. This program supplies information on the weather (average temperature and average relative humidity) and susceptibility of rice plants in the given day, and the vertical development of the lesions (X) can be calculated from these data. Next, the percentage of the number of hills (A) is calculated on the basis of the values of the temperature, relative humidity and quantity of sclerotia. Finally, the whole disease incidence (D) or yield loss (L) is deduced from the values of X and A. The calculation then proceeds to the next day and is repeated until the time required, and the results are filed. A complete simulation can be performed within 15 to 20 minutes on a compatible personal computer.

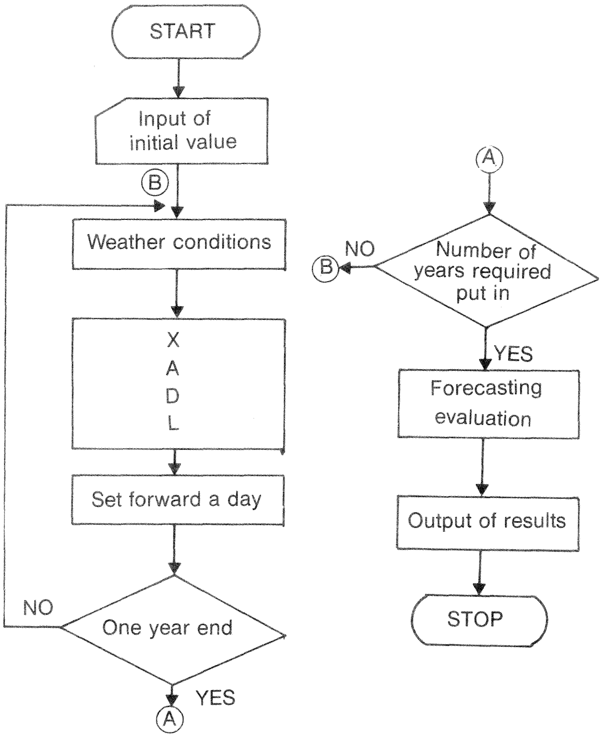

Fig. 5 BLIGHTAS system flowchart.

Accuracy of BLIGHTAS predictions

This system can be tested by comparing the prediction of the yield loss or horizontal development with the actual yield loss or actual horizontal development caused by the disease. Data accumulated from 1977 to 1983 for Joetsu, Niigata prefecture indicate only a slight difference between the actual values and those predicted by BLIGHTAS (Fig. 6). It is thus considered that the yield loss predicted by BLIGHTAS is very close to the actual yield loss caused by the disease.

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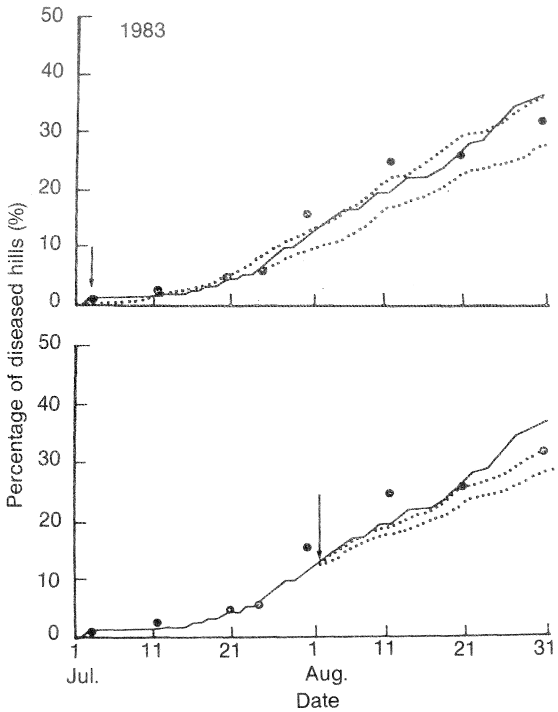

Fig. 6 Comparison between the actual horizontal development of the lesions observed in the field in 1983 and that predicted by BLIGHTAS system.

: Horizontal development of the lesions on rice plants in paddy fields.

: Horizontal development of the lesions estimated by cumulative model curves.

: Prediction by BLIGHTAS system (arrow).

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Discussion

Teng, P.S. (IRRI): How many farmers are using this system?
Answer: Presently the system is being used in 12 prefectures. It is anticipated that after three years all the prefectural agricultural experiment stations will be able to use the system. Presently the system is being tested and is not used by the farmers.

General Discussion

Chairman: Mew,T.W. (IRRI): I would like to suggest that the general discussion should focus on four issues: 1. What are the major diseases of the major crops in the tropics; 2. What are the measures taken to prevent the outbreaks; 3. What is the methodology to assess the crop losses; and 4. What kind of organization structure should be adopted to implement those methods?
Chairman: Nagarajan, S. (India): There are new emerging diseases in the tropics which have not been given the due attention they deserve. For example,the "new cotton wilt" disease in India has occurred in the Maharashtra State for the last 3-4 years. This disease is not due to pathogens and is not transmitted. On plating no organism is detected and there are no nematode populations in the soil. The disease which affects hybrid cotton may be due to sensitivity to insecticides associated with the presence of a genetic factor in the restorer lines. There is no gradient in the fields. I would like to know whether such a problem has been encountered in other countries in the tropics and if there are any chemical-induced disease syndromes. I would like to add that the development of the plant is impaired, the stomata do not close, the plant droops and shows wilt symptoms.
Chairman: Mamluk, O.F. (ICARDA): I believe that the topics for the general discussion suggested here are relevant. However, I am afraid that there will not be enough time to take them up. Therefore, I would like to propose that the discussion be centered on the implementation of the models so far developed in the crop loss assessment.
Chairman: Mew, T.W. (IRRI): Can we identify the major diseases that affect the major crops in the tropics? Thereafter the methodology to assess the damage caused by these diseases could be discussed as well as the implementation of the methods of estimation in terms of organization structure.
de Milliano, W.A.J. (ICRISAT): Although sorghum and millet are important crops in the semi-arid tropics, the diseases of these crops have not been covered much in this conference. However this topic was extensively discussed during the Second Global Conference for Sorghum and Millet Diseases held in Harare in March 1988. One disease which came up as an important disease of sorghum was Striga. In group discussions the most important diseases of these crops were identified by continent and the proceedings of the meeting will be published.
Kajiwara, T. (Japan): The assessment of crop losses is a difficult problem. Each country should select the key disease at first and the damage as well as crop losses should be evaluated even roughly. As data on crop losses are limited in each country, emphasis should be placed on the importance of collecting such data in the tropics in particular.
Chairman: Nagarajan, S. (India): As the number of crops in the tropics is very large, it would be difficult to list them all. One cereal crop could be selected as a model system, for example rice along with a perennial crop such as coconut as a model system as both systems are different. Programs could be made based on these two crops. Various diseases and pests occurring in tropical countries could be listed and systematic loss estimation studies could then be derived.
Teng, P.S. (IRRI): The problem is to determine who is going to organize these systems. It may be appropriate to ask the participants which crops in their respective countries require loss estimates and what are the important diseases they are interested in.
Chairman: Nagarajan, S. (India): I agree with Dr. Teng's suggestion and I would like to ask the representatives of the various countries to tell us briefly whether they are in a position to

interact in the program. I would like to ask Dr. Lu to answer and indicate an annual and a perennial crop that could be selected as a model system for the evaluation of crop loss.

Lu, J.Y. (People's Republic of China): I am sorry but I cannot answer your question as I am not familar with forecasts of crop diseases.

Chairman: Nagarajan, S. (India): May I ask Dr. Ragunathan to outline the crop situation in India?

Ragunathan, V. (India): In India the major food grain crops are rice, wheat and sorghum in rainfed areas. Rice is grown over a large area and people depend on rice for food in India. Therefore, among the annual crops, rice could be selected as a model system for studies on loss assessment while among the perennial crops, coconut which is severely affected by mycoplasma diseases would be suitable for a model system.

Chairman: Nagarajan, S. (India): I would like to ask Dr. Wickremasingha whether the observation of India is relevant to the Sri Lanka's situation.

Wickremasingha, D.L. (Sri Lanka): Rice is one of the most important crops in Sri Lanka and the major diseases include rice blast, rice sheath blight and rice grain spotting. I have no information about coconut since there is a separate institute dealing with this crop. However, among the perennial crops, mango is perhaps the most important one in Sri Lanka. I believe that a crop loss assessment network should be established and coordinated by a well-organized institute. A common methodology should be worked out to collect data to be deposited in a data bank. Methodology should not be too sophisticated but practical and effective.

Chairman: Nagarajan, S. (India): Could Dr. Hasanuddin describe the situation in Indonesia?

Hasanuddin, A. (Indonesia): I shall limit my talk to the food crops. An important issue is to identify the major diseases to be discussed. Also not only the existing diseases but the incoming diseases which are becoming important should be included in the discussion. In Indonesia, there are new diseases such as bacterial diseases (*Pseudomonas*, which affect rice , mainly IR64. There are two main food crops in Indonesia, rice, corn in addition to legumes. The major diseases of rice are as follows: 1. Tungro which presently can be minimized but may give potential outbreaks; 2. Blast which is becoming more serious as it involves upland rice whose cultivation is being promoted in Indonesia; 3. Sheath blight and 4. Bacterial diseases. Corn plants exhibit a variety of symptoms for which the pathogens have not been identified but appear to be viruses. Mosaic virus diseases are very important (PStMv, PMV) in the legume crops such as peanuts and soybeans.

Chairman: Nagarajan, S. (India): Dr Hasanuddin emphasized the need for a pathosystem approach in estimating loss. Programs should be targetted to a number of diseases which can be accounted for the loss and not to a single disease. Could Dr. Reyes describe the situation in the Philippines?

Reyes, T.T. (The Philippines): In the Philippines there is a large number of diseases affecting the major crops, for example rice (tungro, blast, BLB, sheath blight, etc.). The main diseases of corn are downy mildew, rust, bacterial stalk rot. In the case of coconut, the main diseases are cadang-cadang, lethal wilt which is very destructive as palm trees can be killed within 3 to 7 months after the infection unlike cadang-cadang which kills the trees within 2 to 3 years. Moreover the disease is spreading. Sugarcane diseases consist of smut, downy mildew and mosaic. Bananas which are an important export crop are affected by bunchy top (a virus disease) and nematode infestation (black head). Mangoes are affected by anthracnose and by storage diseases.

Chairman: Nagarajan, S. (India): One of the reasons why we wanted to consider coconut and banana as a model system of perennial crops for the estimation of loss is that these crops which are a component of rice-based cropping systems are not taken care of by international organizations. Moreover coconut is a major source of vegetable oil which is being imported by many South-East Asian countries at high cost. May I ask Dr. Supaad to present the situation of Malaysia?

Supaad, M.A. (Malaysia): In Malaysia, among the cereal crops, rice is important. The main diseases are tungro, BLB, sheath blight and blast. Although blast is well controlled, tungro requires more effort.

Chairman: Nagarajan, S. (India): Could Dr. Tanboon-ek give his views?

Tanboon-ek, P. (Thailand): Rice which is a major crop in Thailand is affected by the same diseases as those described in other parts of South-East Asia. In addition, field crops and fruit trees are affected by virus diseases, for example sugarcane (white leaf virus) as well as citrus (tristeza) and papaya (ring spot virus). The diseases of the fruit trees are very severe in the northeastern part of Thailand. Finally vegetables are also affected by virus diseases, such as mosaic yellw leaf curl on tomatoes. Regarding post-harvest diseases, the fungi belonging to the *Colletotrichum* spp. damage fruits such as papaya, mangoes, bananas, etc. and cannot be easily controlled. Mycotoxin contamination is very serious in Thailand which is characterized by a humid climate.

Chairman: Nagarajan, S. (India): May I request Dr. Kajiwara to give his opinion about the situation in South-East Asia?

Kajiwara, T. (Japan): In South-East Asia , rice is the most important crop which is affected by several virus diseases such as tungro and grassy stunt. Sheath blight which is often misdiagnosed may become a very important disease in the region as indicated in Sri Lanka. Moreover, since presently there are no resistant varieties, forecasting of this disease is essential. Blast disease occurs in limited areas in South-East Asia because the climatic conditions are not suitable. However in Egypt there are severe epidemics of blast associated with the persistence of dew for a long period of time in the morning, which favors the invasion of the blast fungus to the plant. Bacterial leaf blight due to *Xanthomonas oryzae* which used to occur severely in South-East Asia (epidemics on IR8) has become less serious since the release of resistant varieties by IRRI. Field crops are often affected by a large number of virus diseases some of which have not been identified. The identification of the viruses would be important because the transmission and the characteristics of the diseases vary markedly depending on the virus involved.

Chairman: Nagarajan, S. (India): Could Dr. Hahn outline the situation in Central Africa?

Hahn, S.K. (IITA): Cassava and plantain/banana are very important staple food crops in Africa. The major diseases of the crops are cassava mosaic virus disease and bacterial blight for cassava and black Sigatoka disease for plantain and banana in Africa. These crops are all vegetatively propagated and long season crops. There are some yield loss studies for these diseases but they are all limited to those at experimental stations. The yield loss assessment should be carried out at the farm level and on a large scale to make the data relevant and reliable. The methods of yield loss assessment for these vegetatively propagated and long season crops should be different from those of short season and seed-propagated crops. Other major crops include maize and rice. Maize streak disease is the main disease of maize. Rice blast disease is perhaps more severe than in South-East Asia as mostly upland rice is grown in Africa. These two crops sould be included in the studies mentioned above.

Chairman: Nagarajan, S. (India): May I ask Dr. Elphinstone to present his views on the Central American situation.

Elphinstone, J.G. (CIP): Potato is not yet a major crop in the tropics. However the acreage of potato is increasing considerably. The major diseases studied by European and North-American researchers are late blight, virus diseases (leaf roll virus, potato X virus) as well as bacterial wilt (*Pseudomonas solanacearum*). Bacterial wilt will undoubtedly become one of the most important diseases in the tropics. The disease affects not only potato but many other vegetable crops grown in the tropics, such as tomato, pepper, eggplant as well as food crops such as cassava. The bacterium can survive for long periods in soil. It is spreading throughout tropical areas of the world since isolates found in different areas are very similar. It would be desirable that research on losses not only in potato but also in other crops be initiated in various parts of the tropics.

Chairman: Nagarajan, S. (India): It is obvious that rice has been ranked frequently by most of the nations. On the other hand, since various crops have been listed second to rice, the selection of a second crop as a model to estimate yield loss should be postponed. There is a general consensus on the need to estimate various biotic constraints faced in the increase of rice production. The next step would be to discuss how to organize a program of monitoring and collection of information on losses caused by various diseases. A standard experimental procedure should be developed to record observations and a data bank should be established on the diseases affecting crops as well as meteorological conditions in a particular location. As many nations do not have the expertise to make an accurate estimation of loss for various reasons, it would be desirable that a reference institute be selected to interact and exchange information. After data are collected during a period of two to three years, a symposium could be again organized to report on the information thus obtained.

Chairman: Mew, T.W. (IRRI): Undoubtedly there is a need to assess the loss due to major diseases of the main crops in the tropics. It is also important to develop a critical mass of scientists in the tropical countries to undertake this task. To collect accurate information quality research should be carried out. It is equally important that the research be recognized and supported. For these reasons, the international agricultural research centers together with other organizations and donors may want to consider to organize a network with adequate financial support to collect data on crop losses and to establish a data bank for the major diseases of the major crops in the tropics. It is important to identify the diseases of the major crops. In this regard, the international agricultural research centers could take the lead in starting with the mandate crops in the respective regions. I would thus like to suggest that teams of work be organized and that the international agricultural research centers and donors become involved in the development of a methodology for the assessment of disease losses incurred by various crops.

Zadoks, J.C. (The Netherlands): It may be possible to initiate an "International Information Network on Crop Losses" using modern information exchange technology in the form of international networks such as BITNET and EARN. A collective data bank could be developed where all kinds of information on crop losses are collected and stored. The methods would not involve the optimum quality work only or the most precise and comprehensive data. Fragmentary information available would be classified according to reliability classes and worked out. I would like to present an example. Many years ago it was felt necessary in Europe to collect information on crop loss on wheat for the purpose of decision-making at the government level, for plant breeders, the pesticide industry, pathologists, in other words for different levels of administration and organizations and various disciplines. The final result was that a sponsor was eventually identified for making an atlas of crop loss on wheat in Europe. To execute this project, data from different sources were collected, weighted, integrated and analysed in a computer to obtain an atlas which was published (Atlas of Cereal Growing in Europe, Volume III). "Iso-loss" lines for 50 to 60 different pests and diseases on wheat in Europe were expressed in percentage loss. I would like to emphasize that the quality of the information may vary. Indeed many initiatives get stranded because the requirements of quality are exaggerated. Whatever information is available, it is possible to use it, classify it, give it a weight, analyse it by computer and put it in a geographical form in an atlas. This can also be performed on a larger scale and the material can be further upgraded.

Chairman: Mew, T.W. (IRRI): On behalf of all the participants, I would like to thank the Tropical Agriculture Research Center for organizing such an interesting symposium to emphasize the importance of assessing crop losses and outbreaks of diseases and also to develop countermeasures.