17. CULTURAL PRACTICES TO DECREASE LOSSES DUE TO CORN DOWNY MILDEW DISEASE

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Downy mildew has been the most menacing disease of corn in tropical and subtropical and subtropical regions of the world. The pathogen involves are: *Sclerospora sorghi* (Thailand, India, USA), *Sclerospora maydis* (Indonesia), *Sclerospora philippinensis* (Philippines, Indonesia, Nepal, India), *Sclerospora sacchari* (Taiwan, India), *Sclerophthora rayssiae* var. *zeae* (India) and *Sclerophthora macrospora* (USA, Japan) (2, 3, 4, 6, 10).

Losses due to the downy mildew fungi have been high from time to time. In 1969, during a one year period, losses in Texas (USA) alone was amounted to US$2,500,000 (3). The annual losses in Indonesia is more than Rp. 3,000,000,000 (US$7,228,915). Significant steps has been taken in the past decades towards more cooperative efforts in the evaluation and utilization of resistant germplasm materials through IACP (5). Therefore, release of moderate to highly resistant varieties with outstanding performances could be expected in the future through this cooperative program.

Studies on cultural practices for the control of downy mildew are somewhat rare. This review was written with an aim of exposing the various problems that we face in attempting control through cultural practices and to indicate future studies needed.

Time of Planting in Relation to Disease Severity

In Java farmers are advised to plant their crop at the same time in the beginning of each planting season which is in the beginning of the rainy season in case of a rainfed area ("tegalan") and as soon as the wet season rice crop is harvested in case of the "sawah" area. The larger an area with the same planting date the lesser the damage due to downy mildew disease could be observed. We have recorded observations on various field in West, Central and East Java. One of them are presented in Fig. 1 (8).

The above phenomenon are based on disease-escape-principle. Corn plants are increasing in resistance at the later stages of its growth. Above 30 days old, infection of downy mildew does not cause much damage to the plant. In Taiwan, delaying of corn planting after sugarcane has been harvested has reduced the damage by downy mildew considerably (10). Similar principle of disease escape has been practiced for many years in various countries.

In areas where farmers due to one or other reason planted their crop successively, the latest planted crop will get the highest infection rate of the downy mildew fungus. In case of subsistent farming such as what we found in many countries, a simple psychology could explain why it is so. Early the planting season, when only a few plants are infected those farmers who planted earlier are still very much willing to rogue all infected plants in their field. However some farmers fail to do so, so those who planted their crop a little late will generally get a higher infection rate in their field (Fig. 1). If 50 percent or more plants are infected, farmers are not willing to rogue their plants due to economic reason. Therefore, those farmers who planted very late will generally lose a crop due to heavy infection. This is why in such a ease farmers are planting local

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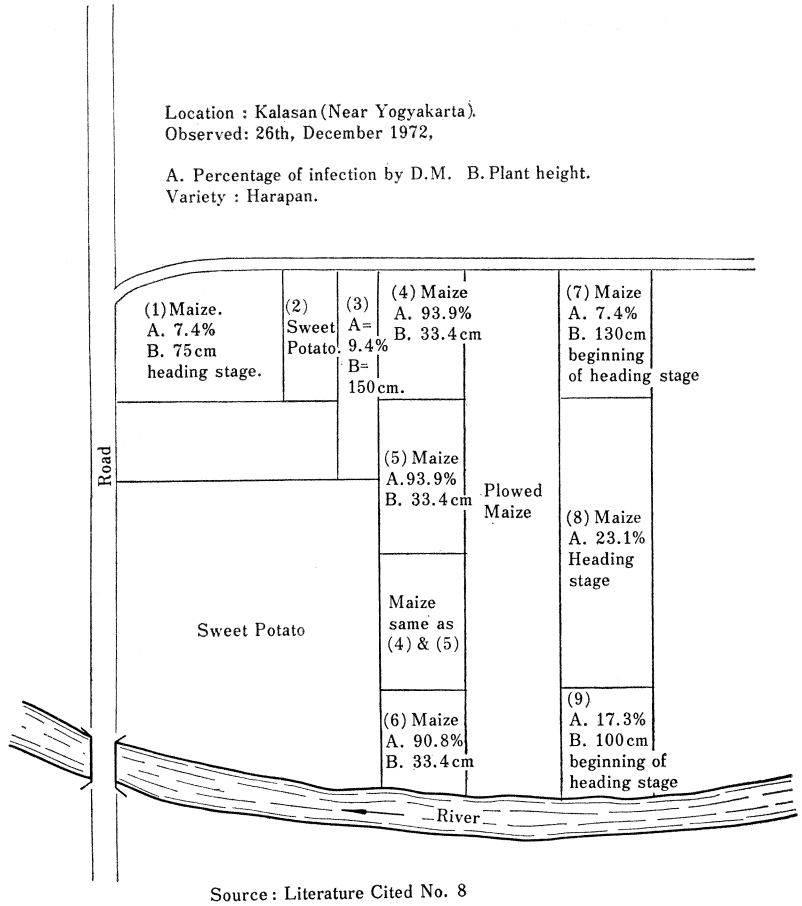

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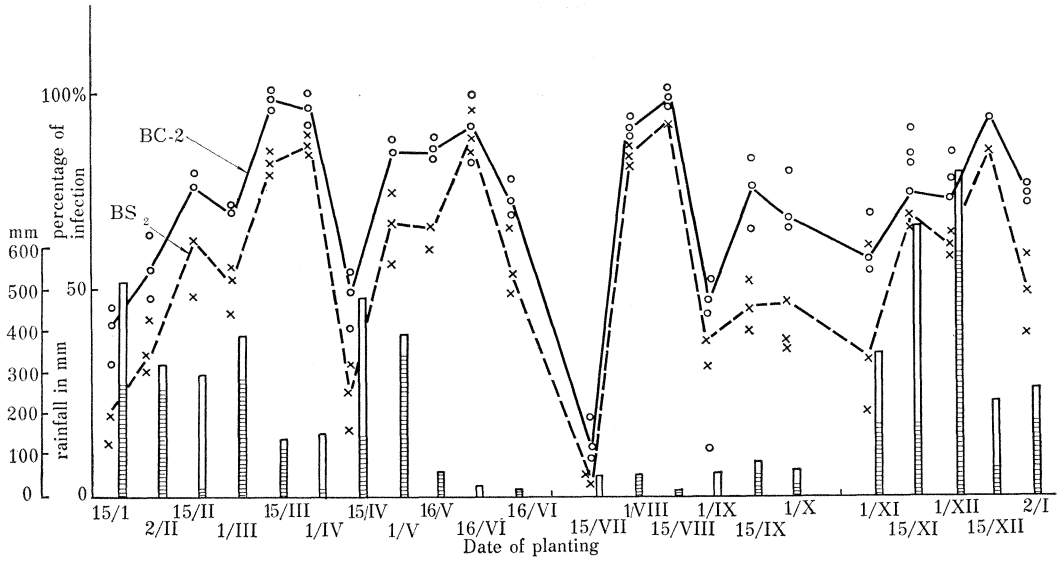
Fig. 1 Result of field observation of corn downy mildew

tolerant varieties even though it haas low yielding capacity.

The effects of seasonal changes in temperature, rainfall, etc. to disease severity has been studied by a few workers (2). Results have been very much depends on the level of inoculum present over the test plots. Our data collected in 1972 may be an illustration of this problem. In our trial, BC_2 and BS_2 were planted in replicated plots at a half months intervals, next to a downy mildew nursery in Bogor. Plot size for each variety was 4.5×4.0 m with three replications. The rate of infection was recorded at 2, 4 and 8 weeks after each sowing date. Results are presented in Fig. 2. The amount of monthly rainfall recorded for each planting date are also stated in the some figure. Our data indicate that the amount of rainfall does not correlate to the degree of infection. Even during the dry season with a limited amount of rainfall the rate of infection was about the same level as in the wet season. This signify the fact that downy mildew fungus, being a nocturnal pathogen almost always succeeded in infecting its host. The presence of a drop of dew on newly emerging leaf or leaf whorl is sufficient for new infection to occur, especially in case where young growing plants are available for infection.



Note: Rainfall were calculated from date of planting to 30 days after planting
Source: Literature Cited No. 8

Fig. 2. Seasonal change of infection and monthly rainfall

Effect of Fertilization on Rate of Infection

Data on this subject are somewhat erratic (1, 2), no clear cut evidence available to justify drawing any conclusion. In India, it has been indicated that for *S. sacchari* application of NPK fertilizer and NPK with additional Zn in Zn-deficient soil could lessen the degree of infection. In one of our experiment in Mojosari (East Java), in which various level of N, P, K were applied by using variety Harapan we obtain data that indicate no effect of any combinations of NPK on the level of infection as compared to check.

Disease Escape Through Isolated Plantings

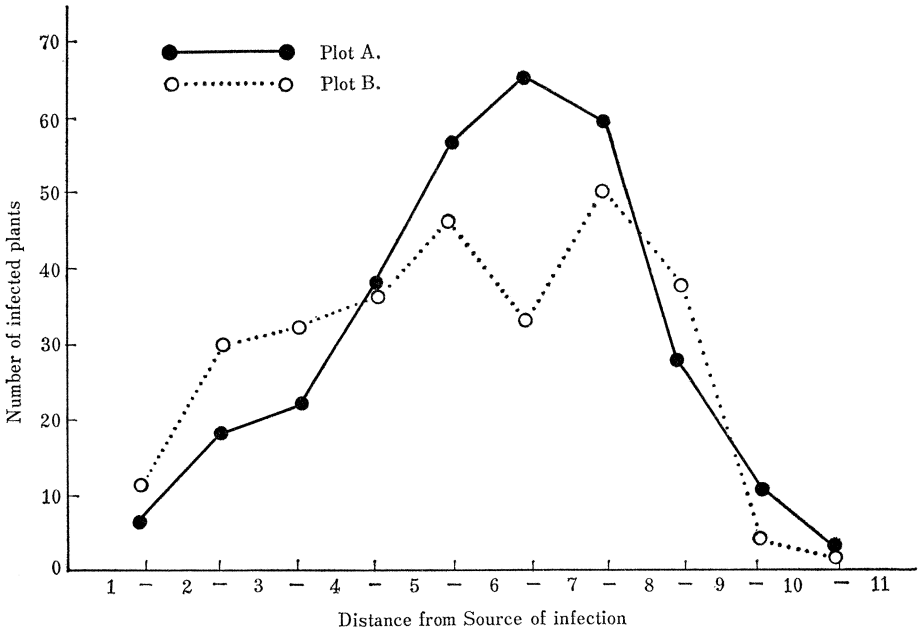
This is one of the principle which we are using frequently to avoid losses due to the downy mildew disease. In all countries where corn are grown and the downy mildew disease present, some part of the country has not been invaded by the disease. In such area, corn growing could be without great problem. However in area where the fungus has already present, in order to utilized the isolation principle, some idea on the distance of spore dispersal are very much needed.

The downy mildew fungus is not particularly notorious for its long distance wind blown spores, such as in the case of rust fungi. The spread of the fungus are rather slowly from one place to the neighbouring reigons, but once it established itself into new area or country, eventually it continue to occur from season to season if host plants are planted regularly (3, 11).

It has been indicated by some wrokers (10) that the conidia of *Sclerospora sacchari* on sugarcane could only reach a distance of less than half a mile from source of conidia.

This is further reflected in the fact that in Taiwan the diisease is always restricted to those areas where both maize and sugarcane are extensively grown. Susceptible varieties of maize grown over one-half mile from a source of inoculum are seldom infected (10).

In order to collect spore dispersal data, one has to find a suitable technique and has to spend a considerable period of time. Besides, his results may not be applicable to other region. However, due to the importance of this knowledge to device the isolation principles in downy mildew control at farm level, we have conducted preliminary experiments by using young plants of a susceptible variety as spore trap (8). In this case we simply brought some infected plants from other areas into an isolated place where no corn was being grown. Seeds of succeptible varieties were planted either around the source of conidia or in rows parallel to source of conidia at 1 meter intervals. Infected plants were counted each day as soon as primary symptoms appeared and after observation, infected plants were immediately rogued. Results of these experiments are presented in Fig. 3 and Fig. 4. Our data indicated that the spore of downy mildew are mainly disperse by the wind in accordance with the prevailing wind direction at night. Results indicated that the main bulks of the conidia are trapped between 2½ m to over 16 m from source of inoculum and decreasing as the distance increased. A significant negative correlation was obtained between rate of infection and distance from source of inoculum. This seems to support the previous ideas mentioned in case of *S. sacchari*. In this case, conidia of *S. maydis* also has a limited range of dispersal in one flight. The



Note: 1) Variety BC-2
2) Planted 20th Sep. 1972
3) Observed from 2nd Oct. 1972 to 11th Nov. 1973
Source: Literature Cited No. 8

Fig. 3. Distribution of the infected plants at various distance from source of infection

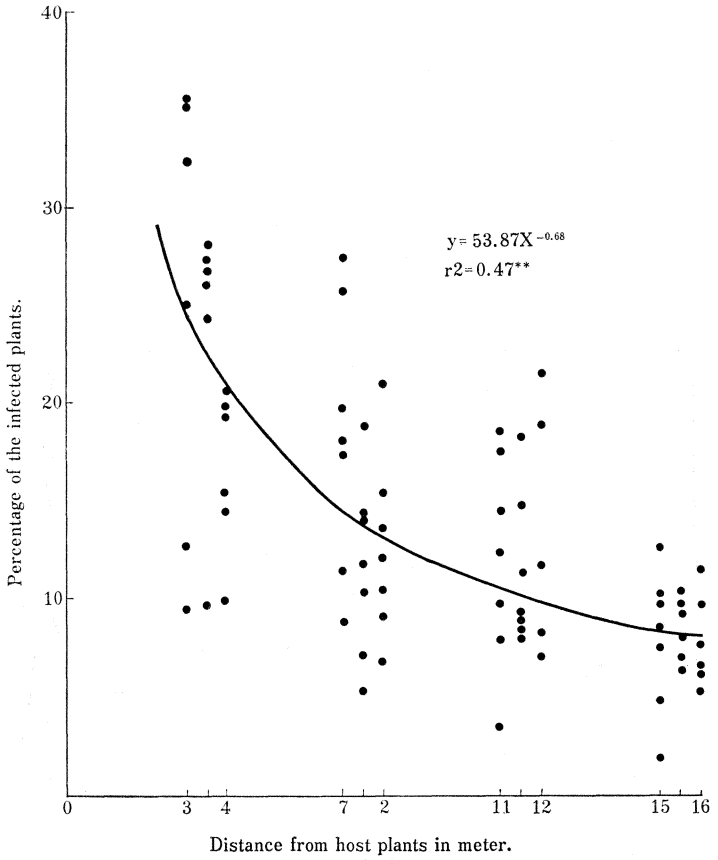


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Fig. 4. Distribution of infected plant

distance that a conidia may travel and still viable seems to be somewhat limited due to various reasons which we do not know yet. One factor which is significant is the wind strength, which are generally calm during the period of conidial dissemination between 2 and 4 a.m.

The degree to which isolated planting could be a successful method of control will be very much depending on other factors such as species of downy mildew and its spectrum of host, farmers organization and governmental support through regulations.

Eradication and Roguing

This is probably the most widely adopted practices as control measures for corn downy mildew disease. In order to achieve a considerable success in this measure, a

regular inspection into the corn planted area backed by organizational and governmental regulation are most important.

In Taiwan (10) downy mildew disease have been brought into a reasonably low level through repeated eradication campaign and regular inspection backed by governmental enforcement regulation. Eradication campaign was conducted in a large scale in 1964 covering over 2850 ha of corn planted area. This campaign was repeated in the next year with additional control measures which was the prohibition of planting the fall maize crop until a resistant variety was developed.

In Indonesia, when we were faced with the introduction of *Sclerospora maydis* into Lampung (9), a rigorous campaign was also launched. To illustrate the various problems one may encounter in such a campaign, I will illustrate the event in a somewhat detail manner in the following paragraph.

On December 8, 1973 we received the first report from the Provincial Extention Service on the occurrence of downy mildew disease in this area. Lampung province in South Sumatra presently have an annual planting of 100,000 ha of corn. Further extention of corn area are anticipated through development of corn estate enterprises

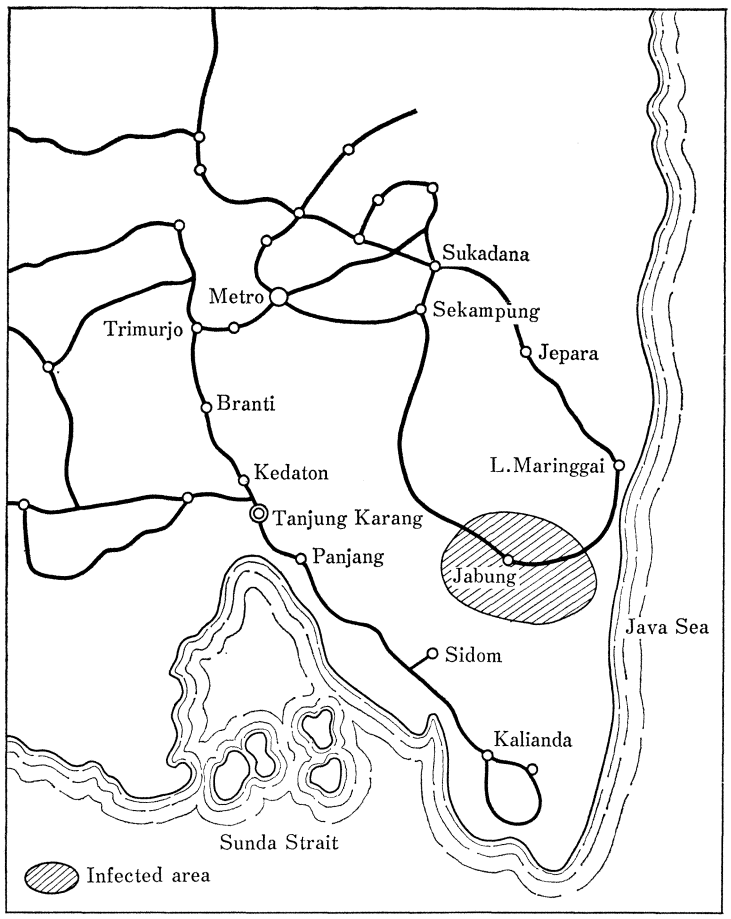

Fig. 5. Site of first infestation of Java corn downy mildew in South Sumatera Dec. 14, 1973

to produce a large quantity of corn for export purposes. There are 4 commercial corn producers already established at present with farm size between 1000 to 3000 ha each. On our inspection on December 14, 1973 (9), we found out that the fungus has already infested the Mitsugoro Co. Farm No. 3 and its surrounding area in Jabung district (Fig. 5 and Fig. 6). Since at that time the fungus are localized in a somewhat limited are of 15 km in diameter with natural barrier around it (Fig. 6), we thought it would be worthwhile to try to eliminate them through a rigorous eradication campaign. Since *Sclerospora maydis* does not produce oospore and its host range is somewhat limited (6, 7) the eradication will be directed towards corn plants only. After completing the eradication, there should be a period of free of corn plant in that area for one season, until the next rainy season which will start in October 1974.

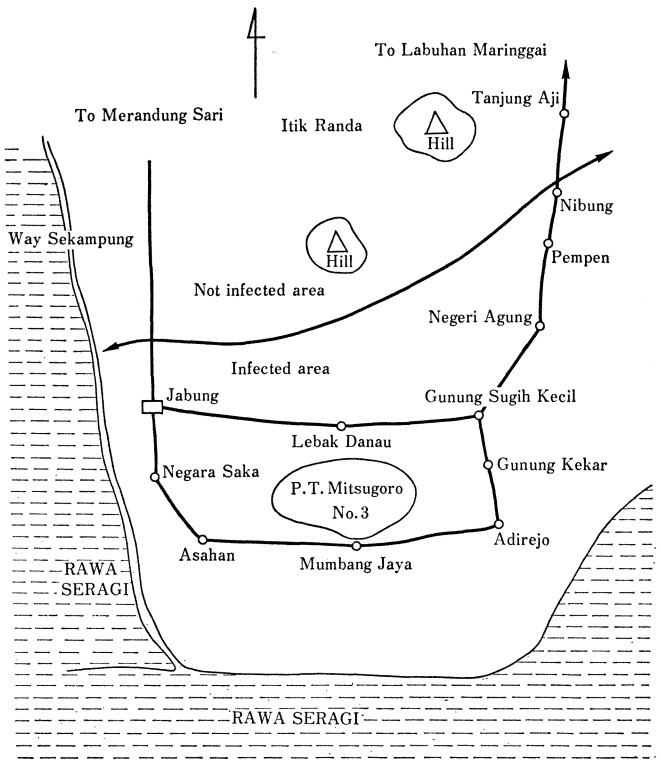

Fig. 6. Areas surrounding Mitsugoro Farm No. 3 with the 8 villages infected with Java corn downy mildew, Dec. 14, 1973

In this campaign, the first of its kind in Indonesia, pathologist are working closely with the Agricultural Extention Service and the local authority in a joint effort to convince the farmers that they have no other choice for their own future benefit.

We eradicated all plants below 2 month old and rogued infected plants which are in a crop of two months or older. From December 16 to December 26, 1973 we already eradicated the entire infected area of 8 villages (Fig. 6) covering 1665 ha of corn which belongs to approximately 1000 farmers. Most of the infected plants were eliminated, some of those which are left were to be finished by the end of December 1973.

Problems that we encountered during the campaign are mainly arise due to local condition mainly the socio-economic aspects of farmers. Most farmers were willing to eradicate their plants but some farmers refuse to do so because their crop was the only hope they have for that season. The Jabung district happen to be an area of new settlement for transmigrant from Java and other islands. Therefore through our request the Government provided Rp. 3,500,000 (US$8,433) for some compensation to their losses which will be used to buy healthy seed for the next year planting. Due to this and variout other problems, on February 1974 the disease has spread further to Labudan Maringgai area 3 km from the border of the previously infected area. Surrounding these area, even more corn were planted. On March 1974 the disease further spread to South Lampung, covering the area of Kalianda, Panjang, Natar and Kadaton which covered more than 3000 ha of corn. By this time farmers were already aware of the danger of this disease and are all willing to rogue their plants so that if we could provide them with seeds of a tolerant variety they will be able to produce a considerably productive crop.

Planting Resistant Variety

Use of resistant varieties is the only effective and acceptable measures for the farmers to use. For these purpose each country has a vigorous varietal improvement program for downy mildew resistance. I will not dwell lengthily in this subject, since much more sessions on this subject will be held. However, I would like to emphasize that results obtained so far has been very encouraging indeed. Tolerant varieties are already utilized by farmers in various regions. In Taiwan, varieties Tainan DMR 10 and Tainan DMR 11 are widely accepted by farmers, in the Philippines, Phil. DMR-1 and Phil DMR-2 and MIT Scl-2 are recommended, in Thailand BS-2 and Thai DMR Composite No. 6 are being utilized. In Indonesia seeds of Phil DMR-3 and Phil DMR 5 are being multiplied in Lampung to replace the local improved variety Metro by the end of 1976. For this program some Rp. 150,000,000 (US$375,000) will be allocated.

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Question and Answer

R. Kenneth, Israel: 1) I think all of us are now in agreement that conidia and sporangia of graminicolous downy mildews do not normally travel to any distance in viable condition. I do not see any reason for them not reaching great distances in dead condition. However, there are perhaps conditions under which they could infest fields some kilometers away. (a) Winged insects, (b) rolling mists in mornings driven by winds after quiet dewy nights. Has any one investigated either of these means of dissemination?

2) Rightly or wrongly, *S. maydis* symptoms have been considered to include tendency to lodge. Is it really so? We found in *S. sorghi* on maize that a small percentage lodged, but 11.5 times as much as that of non-infected plants.

Answer: 1) To my knowledge, no.

2) Lodging normally does not occur at all due to a generally light application of N fertilizer in farmers' fields. Under high N level, lodging may occur, but this is rather rare.

C. G. Shaw, U.S.A.: Do you wish to offer some indication as to how the downy mildew was introduced into South Sumatra?

Answer: The only way would be through seeds. The area is a new settlement area, people are coming to this region from the other regions—Java, mainly. Farmers may have brought seeds to Lampung from the Java area and if they were in a hurry they may have picked fresh seeds from infected plants, and without sufficient drying, may have planted it.

Joginder Singh, India: What would be the role of rogueing the future since you are replacing downy mildew resistant varieties? The cost of rogueing appears to be high and it seems difficult.

Answer: Even if resistant varieties were planted rogueing is still a very important control method. I would like to stress this point again, especially on the earliest crop planted in one season, because as I stated they are the source of infection of the subsequent crop.

N. Yamada, Japan: 1) If we adopt rotation cropping such as maize followed by other crops, except sorghum or sugarcane, instead of practicing continuous cropping of maize, can we expect a reduction of the disease incidence?

2) How much effect can we expect by removing infected plants at a very early stage at the initial time of the crop season?

Answer: Yes, in some areas the farmers have practiced this, and by doing so they have less infection on their next maize crop. The farmers choose their cropping pattern according to how much profit they could obtain in a year. Due to this, many farmers choose to plant corn successively, with the risk, of course, of getting high downy mildew infection.

M. Fukutomo, Japan: What do you think about the reason why the infection is less at a place near to the source of infection in your Figure 3?

Answer: The reason is simply because at a short distance around the source you find less numbers of plants. Farther away, there were more plants. In Fig. 4, I indicated that percent infection is highest at closer distance.

I. J. Dogma, Jr., the Philippines: One of your slides shows diseased plants being **plowed under** with a tractor. Are you not afraid that this practice MIGHT INDUCE OOSPORE FORMATION in which case your control problem will be more grave?

Answer: Our staff has been constantly looking for formation of oospore in *S. maydis*. Up to now we fail to find any. So we believe *S. maydis* does not produce oospores.

A. J. Ullstrup, U.S.A.: 1) Is wilting a symptom in the syndrome of Java downy mildew?

2) Explain the meaning of the term "liejer" as used in describing this disease.

Answer: 1) No, the chlorotic areas of the leaf, dried up, and finally the entire plant.

2) "Liejer" means suffering. The term originated from the sundanese dialect.

B. L. Renfro, IACP (Comment): In Thailand, we have experienced less d.m. infection with N-P (K is not limiting in our soils) than without added fertilizer.

e.g. var. 1	74 vs. 56	Mean (average) of 4 varieties=56 vs. 33
2	55 vs. 31	
3	51 vs. 29	
4	46 vs. 18	

We think it is primarily an increased plant vigor effect. But, any such effect from fertilizer application can be "over-loaded" with high INOCULUM potential.

Answer: Yes, this appeared to be the case in our trial in East Java. Population of conidia was high in the air so that we could not observe any difference in % infection in various treatments.

Ampol Senanarong, Thailand: I understand that most farmers in Indonesia select and keep their own seeds for the next planting season. If so, do you have any recommendation or advise for the farmers in downy mildew infected areas concerning seed selection? What is your opinion about the possibilities of seed transmission of downy mildew under these farm conditions, especially in the new areas?

Answer: Yes, many farmers do take their seeds from their field. In doing so they usually take seeds from healthy plants. However, in badly infected fields, and when they need many seeds for the next planting, they may take seeds from infected plants. But they usually dry the seeds sufficiently before planting. This is the case in general. The possibility of seed transmission can be ruled out, however, because farmers vary from area to area.

Sangam Lal, India (Comment): Following are a few of our observations:

(1) Date of planting plays a significant role in Northern India. May- or early June-planted crops escape the disease. Late June- or July-planted crops show progressively higher incidence.

(2) There are no significant differences in disease incidence among the various

plant population levels i.e. 50, 60, 70 thousand plants per hectare, whereas at 80 thousand level, comparatively higher incidence was observed.

(3) In heavy soil disease incidence is greater in comparison to light soil.

(4) In areas where water stagnates in the field, we get more incidence.

(5) Application of zinc reduces disease incidence.

Sutat Sriwatanapongse, Thailand: With reference to controlling the disease by arranging the date of planting, our experience at Farm Suwan, Thailand, last year showed that the infection did not occur even on the susceptible supersweet corn planted side by side with the heavily infected plants of the first planting. How would you explain this situation? I suppose microclimate also plays a great role in this case.

Answer: I could not find any reason.

Dr. Kenneth answer: Did you notice the the direction of prevailing wind at night? If wind direction was to the other direction, your plants may not get infection.

Dr. Sutat: The newly planted area surounded the infected plot.

Dr. Kenneth: Then I could not explain either.

K. M. Safeeulla, India: In addition to air transmission of conidia and sporangia of downy mildews, we have to take into consideration the possibility of transmission of these propagation by way of rain and irrigation water.

Answer: Yes, I agree, this aspect should be studied also. We have not studied this aspect yet.

M. Yamada, Japan: I have heard that Phil. DMR-3 variety had less productivity in Indonesia, compared with your open-pollinated varieties. If so, have you any other resistant variety except DMR-3 or DMR-5?

Answer: It has a slightly lower yield compared with our Bogor Synthetic 2 (BS2) and Bogor Composite 2 (BC2), but it yields higher than the local Metro, and about the same with Harapan. DMR-3 and DMR-5 seed colors are lighter than Harapan, the most popular variety which is widely planted.

At present, only some local varieties such as Kodok, Kretek, Impa, etc. (low yield, early maturing) are moderately tolerant. Farmers in East Java are still planting these in various regions in Java.