DAMAGE CAUSED BY MAJOR PLANT DISEASES AND PLANT PEST FORECASTING PROGRAM IN JAPAN

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ABSTRACT

Rice is one of the major crops in Japan. Rice diseases of main concern in Japan are blast and sheath blight. 1. As for blast, the outbreak area ratio (outbreak area/planted area) has decreased, since 1985 for leaf blast, and since 1983 for panicle blast. The ratio of chemical treatment area for leaf blast increased gradually from 1955 to 1980 and has remained stable since 1981, while for panicle blast it increased gradually from 1955 to 1980 and has decreased since 1981. The ratio of damaged quantity to normal production has decreased since 1981. The main contributing factors to this change are considered to be favorable weather conditions and effective control by newly introduced pesticides. 2. The ratio of outbreak area for sheath blight increased gradually from 1955 to 1971 and has remained stable since 1972. The ratio of damaged quantity to normal production is around 1% each year. The cause of the outbreak change depends on the planting density. The stability of the ratio of damaged quantity, despite the increase of the ratio of outbreak, is attributed to the spread of chemical control. 3. Computer-assisted pest forecasting programs have been developed and are being used for predicting the initial occurrence of blast and the ratio of affected hills by sheath blight.

Agriculture in Japan

Arable land area in Japan covers 5,360,000 ha, accounting for 14.4% of the national land area. Major crops are rice, wheat, potato, soybean, citrus and apple and the area cultivated to rice amounts to 2,303,000 ha, accounting for 43.0% of the total arable land area. Rice is the most important crop in Japan. This paper reports on rice diseases, mainly blast and sheath blast (Table 1).

Table 1 Planted area to major crops (1986)

Rice	2,303,000	Japanese radish	66,300 (ha)
Wheat	245,500	Carrot	24,400
Two-rowed barley	75,700	Chinese cabbage	33,100
Potato	130,060	Cabbage	42,200
Sweet potato	65,000	Spinach	26,200
Tea	60,200	Welsh onion	24,400
		Eggplant	18,900
Soybean	238,400	Tomato	15,200
Red bean	57,000	Cucumber	22,800
		Pumpkin and Squash	17,300
Unshu mandarin	108,400	Water melon	25,900
Other citrus varieties	49,640	Taros	28,300
Apple	54,700	Onion	20,700
Grape	28,000	Lettuce	21,300
Persimmon	29,600		

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Changes in rice varieties and methods of cultivation

1 Change in rice varieties

Paddy rice in Japan consists mostly of nonglutinous rice (93.0% of planted area) and the major varieties have changed significantly during the past 25 years. The cultivation of the Nihonbare and Toyonishiki varieties which had increased rapidly until 1976 was replaced by the cultivation of the Koshihikari and Sasanishiki varieties in the last 10 years (Fig. 1). These changes are due to the demand for rice with a good taste as the taste of Koshihikari and Sasanishiki is superior to that of Nihonbare and Toyonishiki. In contrast Koshihikari and Sasanishiki are less resistant to blast than Nihonbare and Toyonishiki. Besides, as Koshihikari and Sasanishiki are prone to lodging it is difficult to cultivate them (Table 2).

Since the area planted to Koshihikari and Sasanishiki will increase in proportion to the damand, it is anticipated that pest control will become more important for rice.

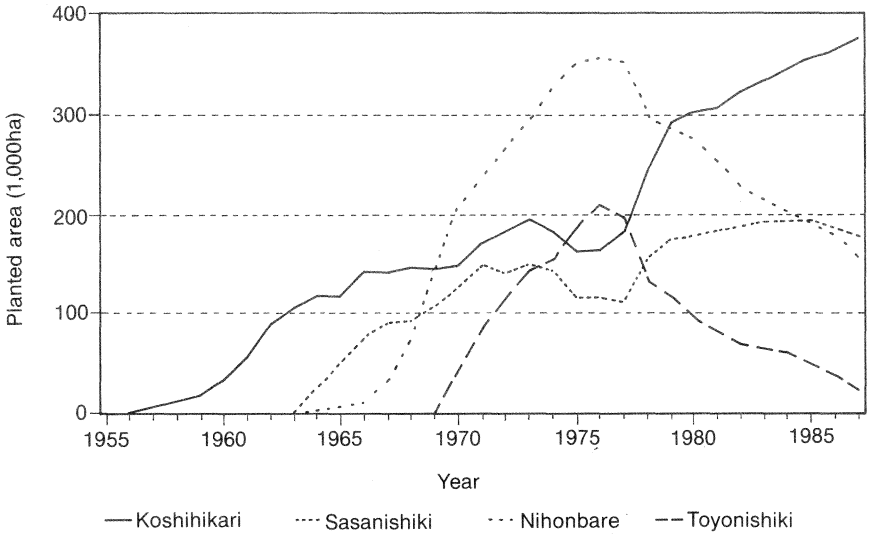


Fig. 1 Changes in the area planted to major varieties of nonglutinous rice.

Table 2 Characteristics of major paddy rice varieties

Variety	Quality	Taste	Blast resistance	Sheath blight resistance	Cold resistance	Lodging resistance
Koshihikari	A	AA	B~C	A~B	A~B	C
Sasanishiki	A	AA	B~C	A~B	B~C	C
Nihonbare	A	A	B	B	Ç	A
Toyonishiki	A	B	A~B	B	B	A

2 Changes in the method of cultivation of rice

Machines for the transplanting of rice seedlings have been introduced since 1970 and the ratio of the planted area in which these machines are used was 61% in 1975, 91% in 1980 and 96% in 1986 (Fig.

2). Although agricultural mechanization has contributed to the decrease of the working hours and modernization of agricultural practices, the transplanter has increased the plant density, which has resulted in the increase of the occurrence of sheath blight.

Application of fertilizers also influences the occurrence of diseases. The amount of chemical fertilizers applied (N,P,K) increased from 1965 to 1985, while the amount of compost used decreased from 1965 to 1980 (Table 3). Although it is difficult to establish a relation between the occurrence of diseases and the amount of fertilizers applied, in 1987 the Plant Protection Division, MAFF sent questionnaires to plant protection officers. It was eventually concluded that the method of application of the fertilizers rather than the amount of fertilizers applied affected the disease incidence.

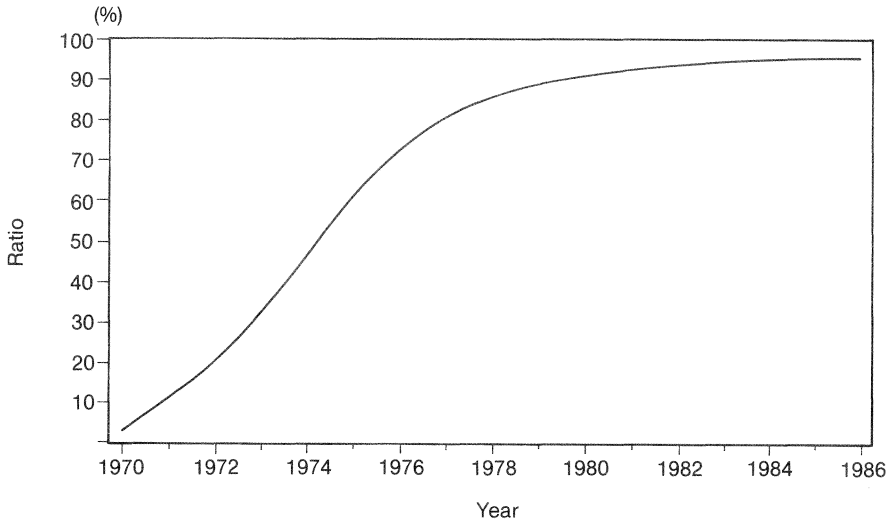


Fig. 2 Changes in the ratio of planted area depending on the use of machine for transplanting rice seedlings.

Table 3 Changes in the amount of fertilizers applied

Fertilizer	Element	1965	1970	1975	1980	1985
Chemical fertilizers	N	8.53	10.01	9.93	10.17	10.89
	P_2O_5	7.45	10.72	10.48	11.04	11.13
	K_2O	7.21	9.15	8.90	9.56	9.84
Compost		545	451	268	199	203

Kg/10 a

Changes in the outbreaks, damage and control of diseases

1 Rice

1) Rice blast

Blast is the most serious disease of rice.

The ratio of the area with outbreaks (area with outbreaks/planted area) is about 40% in years with severe outbreaks of leaf blast and panicle blast. In 1980 and 1982 panicle blast occurred severely. In 1980 the area with outbreaks was 898,000 ha with a ratio of area with outbreaks of 38.2%. In 1982 the corresponding values were 664,000 ha, and 30.0%. In these years the weather was cold and the rice yield was low.

On the other hand, in 1984 leaf blast occurred severely, (area with outbreaks was 827,000 ha and the ratio of the area with outbreaks was 36.2%). However the yield loss caused by blast was not severe due to the favorable weather in summer and the thorough control of leaf blast. Panicle blast outbreaks affected an area of 451,000 ha accounting for 20.0% of the planted area. In recent years the leaf blast and panicle blast occurrence has decreased continuously. In 1986 leaf bast affected 471,000 ha (ratio of the area with outbreaks was 20.6 %) and panicle blast affected 343,000 ha (the ratio of the area with outbreaks was 15.1%). In 1987, it is anticipated that the area with outbreaks will be smaller than in 1986 (Fig. 3).

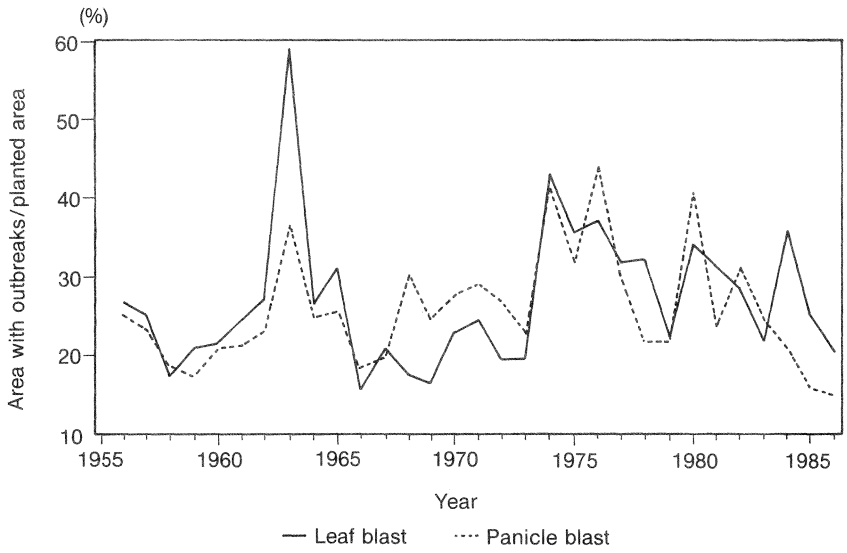


Fig. 3 Changes in the area with outbreaks of blast.

In years with severe outbreaks the ratio of the damaged area was about 40-50%. However the damage due to blast has decreased continuously since 1981 and in 1986 the ratio mentioned previously was the lowest for the past 30 years (Fig. 4).

The ratio of the control area has been increasing continuously from 1955 to 1980 and blast control was disseminated.In 1980 when blast occurred severely, the ratio of the control area for panicle blast was 180%. However since 1981 with the decrease in the damage and occurrence of blast the ratio of the control area has decreased. Fig. 5 shows that blast is controlled depending upon the occurrence.

2) Sheath blight

Sheath blight is the most serious disease next to blast. The ratio of the area with outbreaks increased gradually from 1955 to 1971.

The outbreaks of this disease were severe from 1982 to 1984, especially in 1983 the ratio of the area with outbreaks was 54.7%. One of the factors responsible for the increase of the area with sheath blight outbreaks, until the first half of the 1970s was the increase of the planting

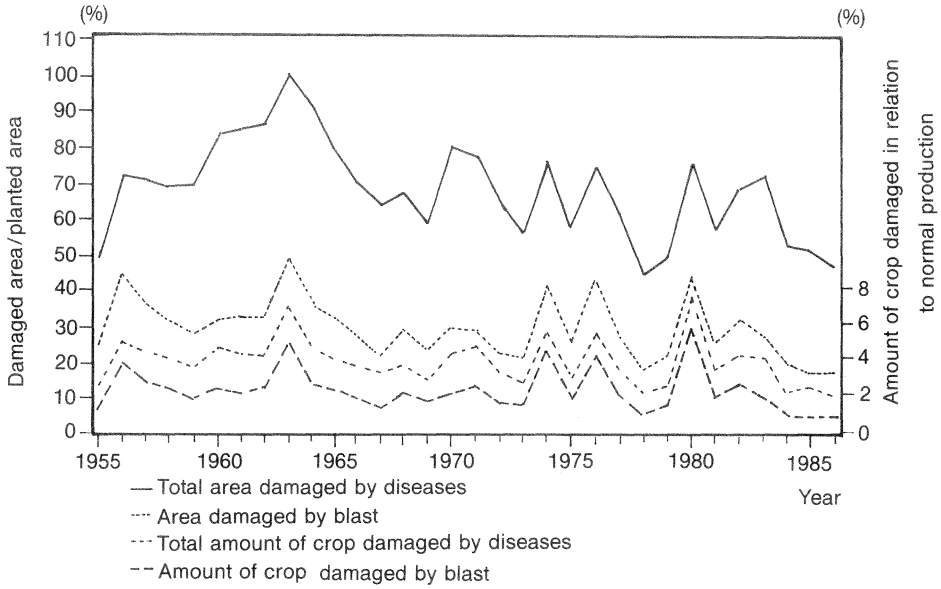


Fig. 4 Changes in the area and amount of crop damaged by blast.

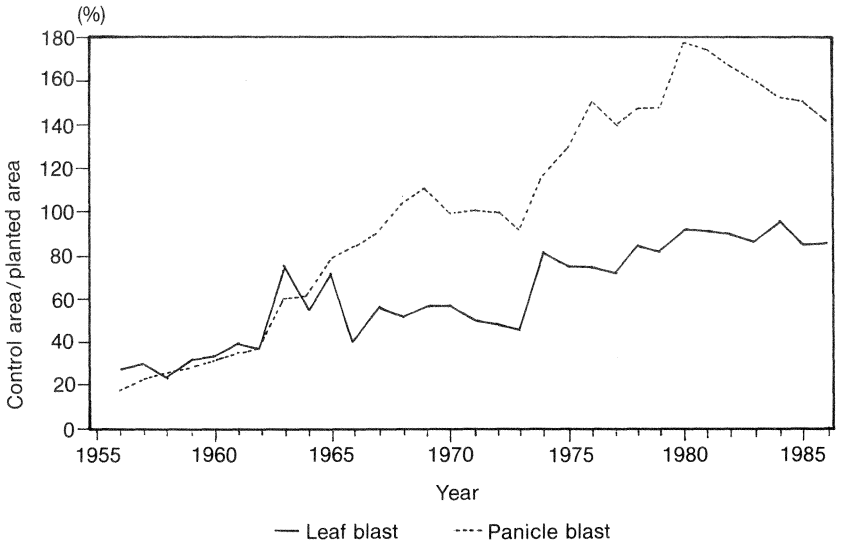


Fig. 5 Changes in the control area of blast.

density. Thereafter as the planting density remained stable the change in the ratio of the area with outbreaks, was almost the same as the change in the planting density (Y=8.899x-131.644 r^2=0.784) (Fig. 6,7).

On the other hand, the fluctuations of the area with outbreaks each year were mainly attributed to the weather.

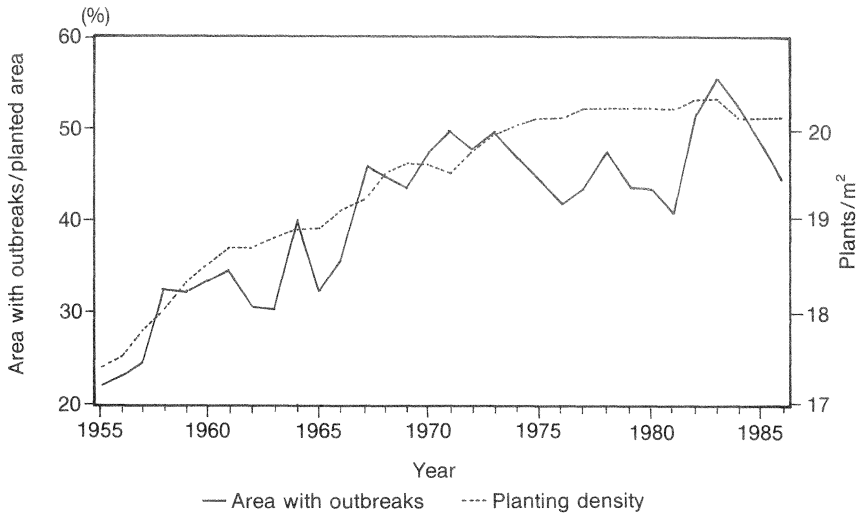


Fig. 6 Relationship between planting density and area with outbreaks of sheath blight.

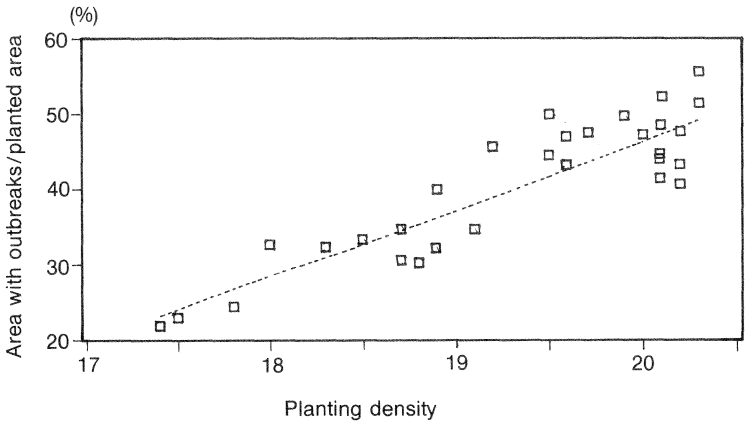


Fig. 7 Relationship between the area with outbreaks of sheath blight and the planting density.

The ratio of the damaged area was about 20% each year, and the ratio of the amount of damaged crop was 1% each year. In 1983 the disease occurred severely, with a damaged area of 27.5% and an amount of damaged crop of 1.3% (Fig. 8).

The ratio of the control area increased until 1984, especially in 1983 and in 1984 it increased rapidly, following the severe occurrence from 1982 to 1984. Fig.9 shows that sheath blight was controlled depending upon its occurrence. The stability of the ratio of the amount of damaged crop, despite the increase of the ratio of outbreaks, is attributed to the spread of chemical control.

Although blast was the most severe disease, the amount of damaged crop for sheath blight, was 0.9% in 1987 as in blast. Thus sheath blight is relatively more important.

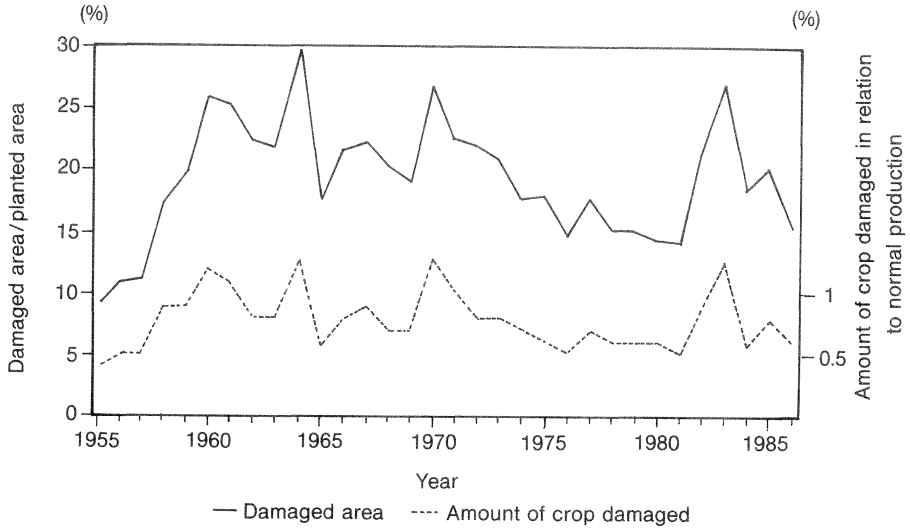


Fig. 8 Changes in the area and amount of crop damaged by sheath blight.

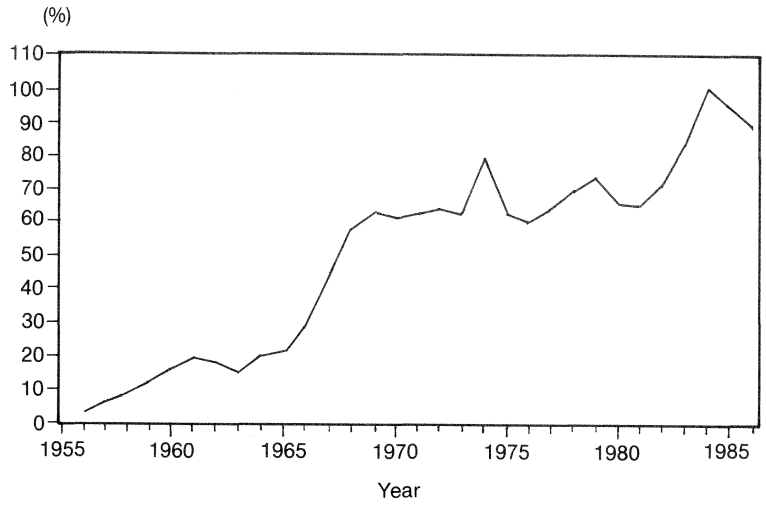


Fig. 9 Changes in the control area of sheath blight.

3) Disease control for rice

In the case of blast, the low occurrence in the past years was attributed to various factors except the weather, especially the chemical treatment.

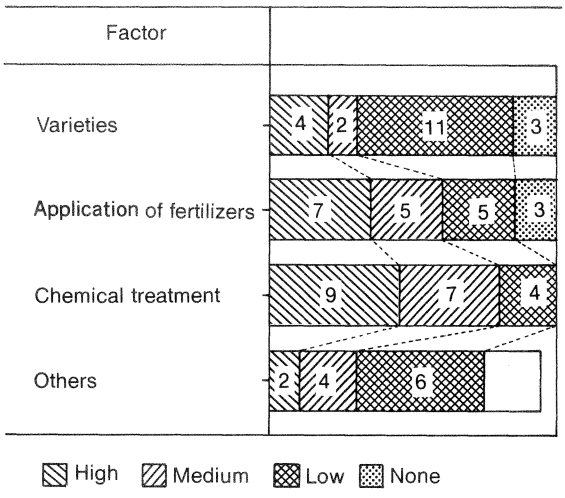
In the above-mentioned questionnaires, 20 prefectures out of 41 pointed out the factors (except for the weather) which were responsible for the low occurrence of this disease. Among the 20 prefectures, 16 prefectures indicated that the level of chemical treatment was a medium or high factor (Table 4). First the treatment with granular fungicides was found to be effective for the control of leaf blast and as a result also for the control of panicle blast (Fig. 10). Secondly,

Table 4 Questionnaire about factors responsible for the low occurrence of blast in recent years

1. Grading of the factors affecting blast (except weather)
(41 prefectures)

Influencing	:	20
Influencing but less than weather	:	15
Not influencing	:	6

2. Grading of factors affecting the low occurrence of blast (except weather)
(20 prefectures)



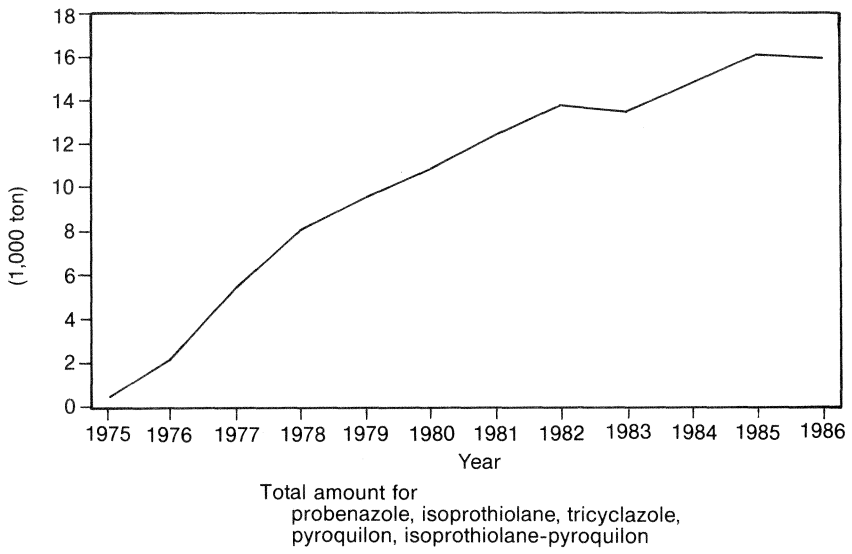


Fig. 10 Changes in the amount of granular fungicides sold for blast control.

aerial application using helicopter involved 1,730,000 ha and has been increasing. Aerial application that controls a broad area, at the same time is effective for the control of blast, and is a factor responsible for the decrease of the occurrence of this disease (Fig. 11). Thirdly the application of fungicides to nursery boxes was introduced in the southwestern part of the country because at the time of transplanting the temperature is high enough for the occurrence of blast. At first this technique was introduced for controlling the rice water weevil. But now it is considered that the application of fungicides to nursery boxes is very effective for leaf blast.

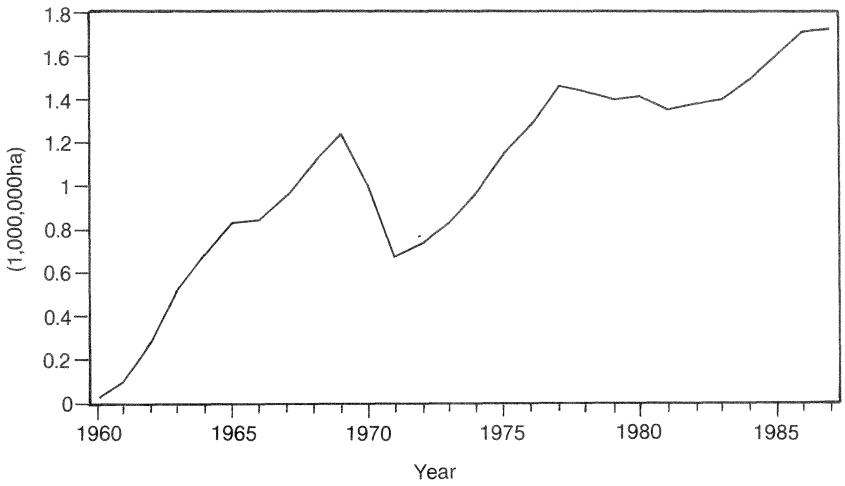


Fig. 11 Total paddy rice area with aerial application by helicopter.

2 Wheat and barley

The area planted to wheat and barley was about 1,500,000 ha until 1960. After 1960 the planted area decreased gradually to about 150,000 ha due to the increase in imports of wheat and barley. Since 1970 the Japanese government has taken measures to regulate rice production because of the excessive rice stock. Instead of rice the cultivation of wheat and barley has been encouraged through a comprehensive campaign to promote the conversion of paddy fields since 1976. Thus the area planted to wheat and barley was 350,000 ha in 1986.

1) Rusts

There are four kinds of rust diseases in wheat and barley, i.e. stripe rust (*Puccinia striiformis*), stem rust (*P. graminis*), leaf rust (*P. recondita*) and dwarf leaf rust (*P. hordei*).

Rusts were the major diseases until 1975. However their occurrence has decreased. In the past decade the ratio of the amount of damaged crop in relation to normal production was about 0.1%. The decrease in the occurrence is attributed to the fact that most of the varieties of wheat and barley which are now planted are highly resistant to rusts.

2) Powdery mildew

Powdery mildew is prevalent in spring when the weather is warm with a relative high humidity. Most of the varieties of wheat and barley now planted are resistant to this disease. The ratio of the amount of damaged crop has remained below 1% (Fig. 12).

3) Fusarium blight

Fusarium blight is a common disease in the warm regions of the western and southern parts of Japan. The occurrence of this disease depends on the presence of rain at heading time. Presently the varieties cultivated are not resistant to this disease. On the other hand since

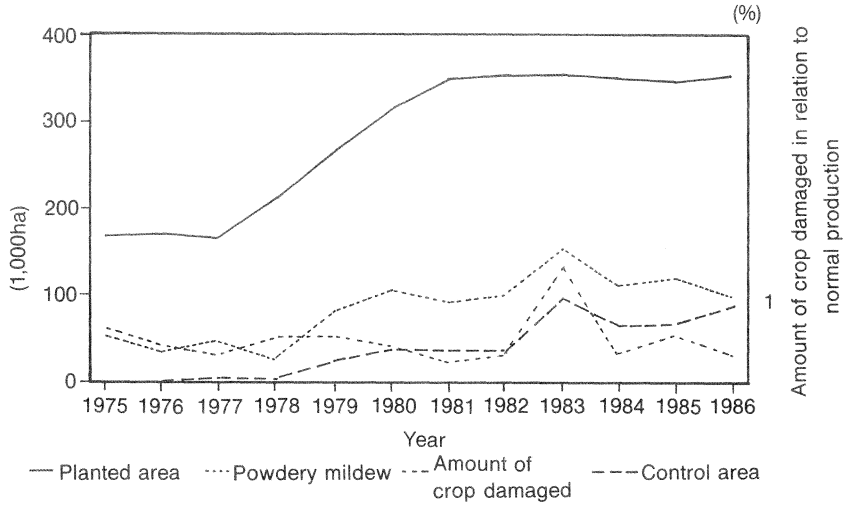


Fig. 12 Changes in the acreage affected by wheat and barley powdery mildew.

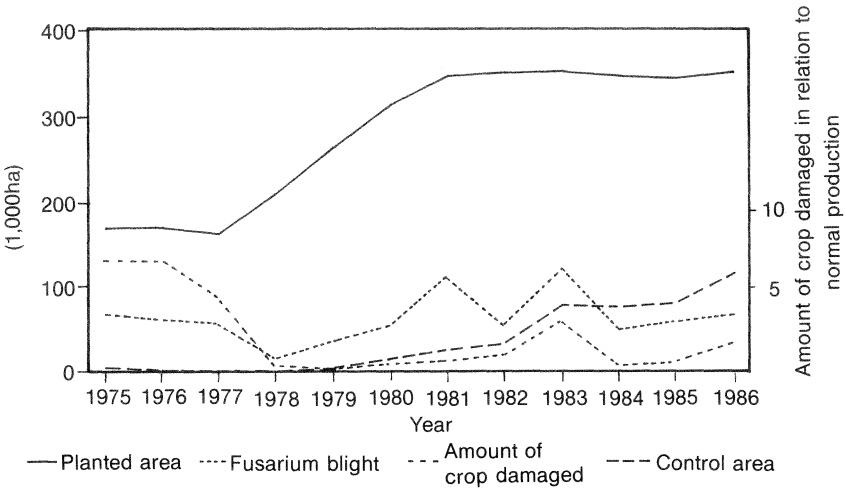


Fig. 13 Changes in the acreage affected by wheat and barley Fusarium blight.

fusarium blight produces mycotoxin the quality of wheat is poor. The administrative organizations concerned have recommended that the farmers use chemicals for the control of the disease. As a result the control area has increased (Fig. 13).

3 Citrus

In recent years due to the decrease in the demand of Unshu mandarin and the increase of imported citrus products the amount of production has decreased.

1) Melanose

This disease is one of the main diseases of citrus. With the increase in the demand for the improvement of the quality and appearance of the fruit, the disease is the best controlled one among all the citrus diseases.

2) Scab

Unshu mandarin is highly susceptible to this disease. Before the development of effective chemicals for the control of the disease, it was one of the most important diseases in terms of quality, taste and appearance of fruit. After the introduction of chemicals the disease has become less important.

3) Canker

Unshu mandarin is comparatively resistant to canker, unlike other citrus varieties. Strong wind and rain are favorable factors for the infection. Integrated control including the utilization of windbreaks, burning of infected branches, etc. must be implemented (Fig. 14).

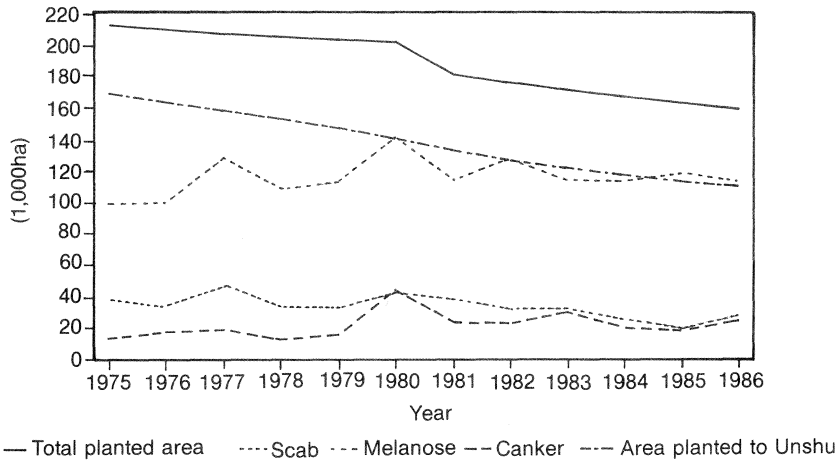


Fig. 14 Changes in the acreage affected by citrus diseases.

4 Apple

1) Blossom blight

This disease used to be most important in Hokkaido and the northeastern districts of Japan until 1960. The occurrence of the disease is related to snow. If snow lasts for more than 100 days, the incidence of the disease is severe. The occurrence of this disease, however, has decreased recently as a result of adequate control.

2) Alternaria leaf blotch

There are varietal differences in the susceptibility to the disease. Susceptible varieties include Mutsu and Delicious apple; intermediately resistant varieties, Golden, Delicious or Rolls Janet; resistant varieties, Jonathan.

The area with outbreaks of this disease is the largest of all the apple diseases and the control is difficult.

As it is necessary to reduce the frequence of application of chemicals, forecasting information is important (Fig. 15).

5 Vegetables

Since there are many different kinds of vegetables grown in Japan, many varieties and cropping

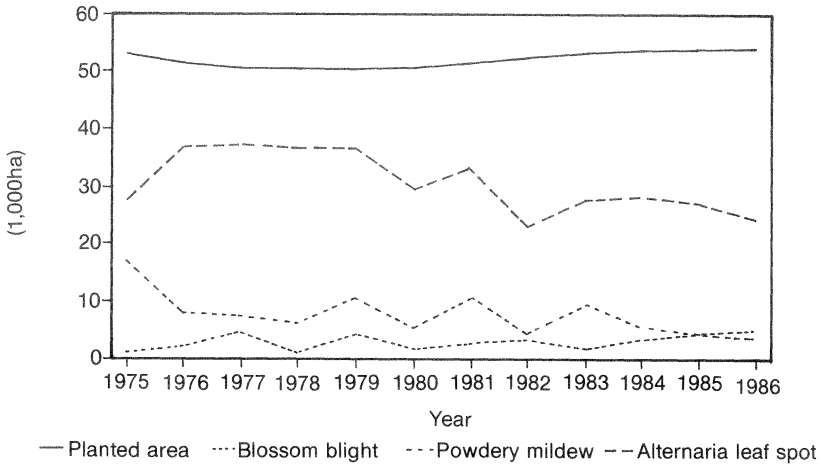


Fig. 15 Changes in the acreage affected by apple diseases.

types, a large number of diseases occur.

The production area of vegetables tends to increase for a particular crop and the scale of operation also increases. Cropping patterns consisting of continuous cropping or short rotation create conditions favorable for the outbreak of diseases.

Cropping facilities have increased and favorable conditions for diseases, for example high humidity, have contributed to enhance the damage to crops.

1) Fruit vegetables

Cucurbit vegetables

a. Downy mildew

The disease mainly affects cucumber. A temperature of 20–25°C and higher moisture are the optimum conditions for the occurrence of this disease, in particular in greenhouses.

b. Powdery mildew

Under dry conditions this disease propagates rapidly. Heavy occurrence of this disease results in yield decrease.

c. Bacterial spot

This bacterial disease occurs under high moisture conditions, and cucumber and melon in greenhouses experience the most severe injury. To control this disease it is necessary to adjust the moisture level through ventilation, use healthy and bacteria-free seeds, fumigate the soil, and apply chemical treatment (Fig. 16).

d. Virus diseases

The most important viruses affecting cucurbits are CMV, WMV and CGMMV.

2) Foliage vegetables

Vegetables of the rape family

a. Bacterial soft rot

Among the soil-borne diseases the most important disease is bacterial soft rot which attacks Chinese cabbage and cabbage. This disease causes severe damage. To control the disease, resistant varieties should be used or continuous cropping interrupted.

b. Clubroot

This disease is important among the soil-borne diseases, too. Control methods are almost the same as those for bacterial soft rot.

c. Virus diseases

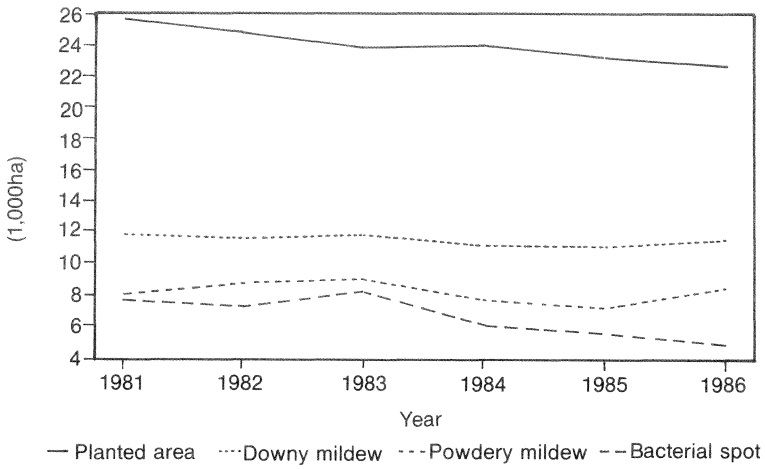


Fig. 16 Changes in the acreage affected by cucumber diseases.

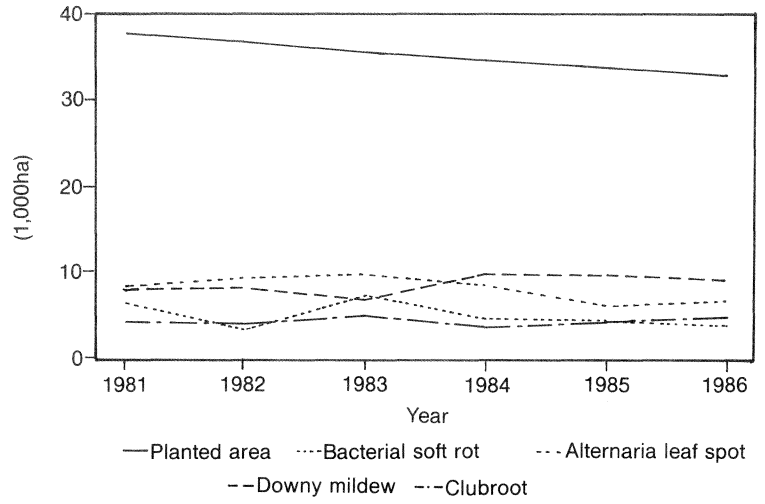


Fig. 17 Changes in the acreage affected by Chinese cabbage diseases.

Diseases caused by the TuMV, CMV viruses induce severe damage. These viruses are transmitted by various kinds of aphids. To control these diseases, it is necessary to remove plants of the Cruciferous family around the planted area, to plant resistant varieties and spray chemicals against the aphids.

d. Other diseases

Downy mildew, alternaria leaf spot occur most frequently (Fig. 17, 18).

3) Root vegetables

Japanese radish

Diseases which affect Japanese radish are the same as those which attack Chinese cabbage and cabbage. The control methods are similar to those taken for the latter crops.

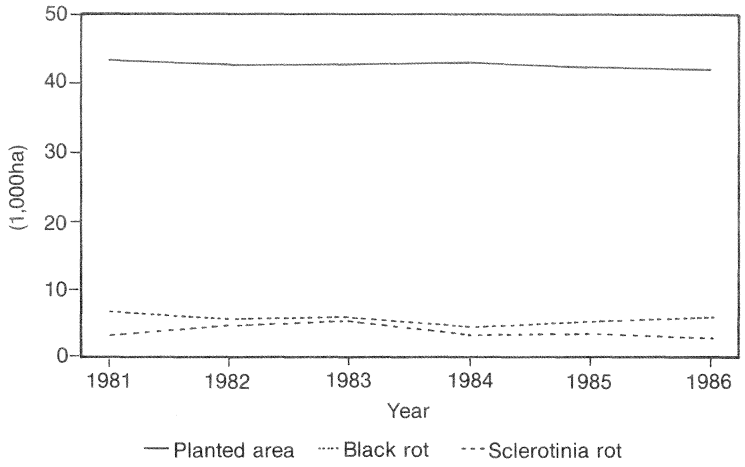


Fig. 18 Changes in the acreage affected by cabbage diseases.

Plant pest forecasting program

1 Background

The forecasting activities for the occurrence of diseases and insect pests in Japan started in 1941. At that time the forecasting program was focussed on blast, rice stemborers, planthoppers which attack rice plants and rusts on wheat mainly.

In 1950 the new Plant Protection Law was enacted without provisions concerning the forecasting program. Therefore, in 1951, the law was revised so as to include such provisions.

The law provided that the central government should be responsible for forecasting the occurrence of designated diseases and insect pests while the prefectural governments should be responsible for forecasting the non-designated ones.

The forecasting activities expanded to involve fruits and tea in 1970 and vegetables in 1980. Now the regulations of the law cover the following 41 diseases and insect pests in total:

Rice:	blast, sheath blight, bacterial leaf blight, planthoppers, leafhoppers, rice borers, black rice sting bug, rice leaf miner, rice leaf beetle
Wheat and barley:	rusts, powdery mildew, scab
Sugar cane:	oriental chinch bug
Citrus:	arrowhead scale, scab, melanose
Apple:	alternaria leaf spot, blossom blight
Pear:	black spot
Grape:	ripe rot
Japanese persimmon:	persimmon fruit moth
Pineapple:	pineapple mealybug
Fruits in general:	Comstock mealybug, citrus red mite, European red mite, oriental fruit moth smaller tea tortrix
Tomato:	late blight, gray mold
Cucumber:	bacterial spot, downy mildew, powdery mildew
Watermelon:	gummy stem blight
Chinese cabbage:	black rot
Lettuce:	sclerotinia rot

Vegetables in general: aphis, tobacco cutworm, cabbage army-worm, diamondback moth, common white (common cabbageworm)

The forecasting program for the occurrence of diseases and insect pests at the national level is under the supervision of the Pest Forecasting Group (2 officials) of the Pest Control Section in the Plant Protection Division of MAFF and nationwide forecast information is released.

The prefectural programs for forecasting are under the supervision of Plant Pest Control Stations.

Responsibility for the forecasting programs is assumed by fulltime forecasting officers of the Plant Pest Control Stations, numbering 487 in total nationwide or about 10 per prefecture on the average. In addition there are part-time investigators such as pest control advisers (8,680 in total nationwide or about 185 per prefecture on the average).

It is important to establish a network among the Plant Pest Control Stations and Plant Protection Division, MAFF for forecasting the programs.

Information on outbreaks and forecasts conveyed by mail and telephone, requires time and is insufficient. Therefore from 1986 to 1988 the on-line network of the Plant Pest Control Stations and Plant Protection Divisions using personal computers was constructed,being subsidized by the central government. This network is scheduled to be completed by April 1989.

The information for this network includes the data on plant pest outbreaks (output of data is

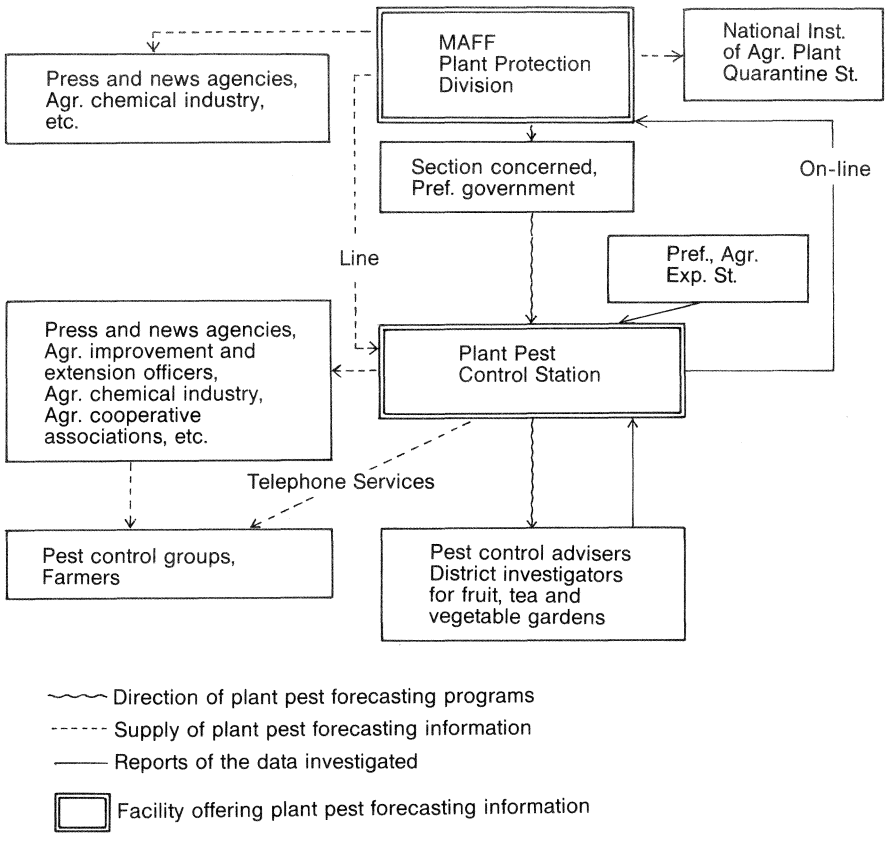


Fig. 19 Plant pest forecasting program in Japan.

arranged based on centralized data processing), the prefectural information on plant pest forecasts (forecasts, warning, caution, situation of specific pests), the nationwide information on plant pest forecasts and the number of trapped white-backed and brown planthoppers by the light traps (Fig. 19)

2 Surveys

The surveys for the forecasting program follow a method which can be roughly divided into fixed points of observation and circuit surveys. The former includes the observations on the occurrence of pests and meteorological conditions in a fixed plot, as well as laboratory investigations. The latter aims at collecting quantitative data on the occurrence of diseases and insect pests in ordinary crop fields including the general situation of occurrence and early detection of unusual outbreaks of diseases and insects pests. For example in Iwate prefecture, the number of fixed plots is 21, the number of areas of circuit surveys is 18 in 814 plots, the total number of crops is 11 and of diseases and insect pests 43. Fixed plots are surveyed every day and circuit plots twice a month as a rule (Table 5).

In order to carry out the surveys for the forecasting program according to uniform national criteria as much as possible, the regulations of the program targetted 32 crops and 276 diseases and insect pests.

Table 5 Surveys in Iwate Prefecture

Fixed point of observation

Crops	Agr. Exp. St.	Plant Pest Control St.	Mizusawa Pl. Pest Con. Subst.	Miyako pl. Pl. Pest Con. Subst.	Ninohe pl. Pl. Pest Con. Subst.	Hort. Exp. St.
Paddy rice	○	○	○	○	○	
Wheat and Barley	○					
Soybean	○					
Cultivation in upland fields		○				
Apple		○	○	○	○	○
Cabbage		○	○	○		○
Vegetables		○			○	○

Plots of circuit surveys

Crop	No.	Crop	No.
Paddy rice	300	Cucumber	64
Wheat and Barley	80	Bell pepper	40
Soybean	80	Lettuce	46
Hop	25	Cabbage	31
Apple	95	Chinese cabbage	23
Grape	30		

3 Information relating to pest occurrence forecasts

The information relating to occurrence forecasts is released by the national and Plant Pest Control offices. The information from the national offices is issued only as pest occurrence forecasts 8 times a year. It is prepared by the analysis of the results reported by the Plant Pest Control Stations and weather reports sent from the Meteorological Agency. The national information is delivered to the Regional Agricultural Administration Offices of MAFF, prefectural governments and agricultural chemical industries.

The information relating to pest forecasts consists of four reports on the following items: occurrence forecasting, warning, caution, situation of specific pests. The report on occurrence forecasting is regularly released once a month as a rule. The report for "warning" is released when an extensive outbreak of an important disease and/or insect pest is forecast but does not include warning and immediate control measures. The report on the "situation of specific pests" is released when a new disease and/or insect pest is detected or when the unusual occurrence of an important disease and/or insect pest is forecast.

The prefectural forecasting information is used by agricultural improvement and extension officers and administration offices of cities, towns and villages for securing control supplies and for providing guidance to the farmers to implement the control effectively and economically.

In 1987, information at the national level was released 10 times because it was anticipated that outbreaks of white backed, brown planthoppers would be severe. "Warning" information from the prefectural offices was released 18 times for the white-backed, brown planthopper and "caution" 209 times.

4 Computer-assisted pest forecasting programs

Recently it has become easy to utilize computers. Therefore computer-assisted pest forecasting programs have been developed. Simulation models of rice blast outbreak and citrus red mite were constructed and subsidized by the central government. Studies on the improvement of these simulation programs were carried out from 1983 to 1987.

For rice blast simulation, weather data are inputted because the main factor for the infection with the blast fungus is the time when the surface of rice leaves is wet. Weather data are also important to forecast the time of the initial occurrence of leaf blast and the time of the rapid increase of the 2nd and 3rd generation lesions.

For citrus red mites, the forecast is centered on the abundance of citrus red mites which depends on the interactions between the amount of natural enemies and mites, citrus and mites. Since 1988 a pilot program for determining whether the control should be applied in utilizing simulation models of rice blast and sheath blast, etc. has been initiated for rice.

In future, computer-assisted pest forecasting will be introduced for the control of various pests with a high level of accuracy.

Programs of pest control subsidized by the central government

The central government has granted subsidies for various control programs. The central government is currently subsidizing the following programs.

1) Program for the development and implementation of practical control measures including physical control, biological control and chemical control for the occurrence of new pests and pests that occur due to the change of cultivation methods.
2) Program for the development of methods excluding the application of pesticides, for example, biological control using attenuated viruses, antagonistic relations, natural enemies and communication disruption.

Discussion

Elphinstone, J.G. (CIP): Does the increase in the incidence of sheath blight reflect the rotation system employed? In other words, does the monoculture of rice result in the build-up of Rhizoctonia inoculum which leads to the increase of the disease level?

Answer: Continuing cultivation of rice led to the increase of the incidence of sheath blight. However the application of chemicals was able to prevent the damage caused by the disease.