General and Detailed Rules for the Enforcement of Disease and Insect Outbreak Forecast Work for Ordinary Crops in Japan

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CONTENTS

I. General Rules for the Enforcement of Disease and Insect Outnreak Forecast Work for Ordinary Crops

1st. Objective

To increase agricultural production on sound and stable basis, it is necessary to establish, appropriate control measures based on precise forecast information on the occurrence of plant diseases and pests, which would otherwise cuase serious losses of crop yields.

Rational control measures should be taken to increase the yelds of rice, wheat, and other field crops. This Rules was issued in order to bring into operation the service business of forecast for the occurrence of plant diseases and pests, on the basis of Articles 23, 31, and 32 of the Plant Protection Law.

2nd. Business and Others

(1) In the State and in each Prefecture (regional administrative units called To, Dou, Fu, or Ken) distributions of plant diseases and pests propagation of plant pathogens and pests, meteorology, and growth conditions of crop plants should be surveyed and assessed, in order to forecasting the occurrence of plant diseases and pests. The forecast information will be transmitted to persons in concern, in time for appropriate control to be practised against the plant diseases and pests.

(2) Prefecture is requested to cooperate with the State to execute the service business in following the advice and suggestions, and business plans laid out by the State, in addition to the Rules described here.

3rd. Business Operation System

Prefectural governor will appoint staff for the business, those who are to forecast the occurrences of plant diseases and pests ("forecasters"), and those who are to control these diseases and pests (" control men").

4th. Survey

(1) Survey on the occurrences of plant diseases and pests, is carried out to prepare data for forecasting, and to obtain information for improving or devising the methods of forecasting.

(2) In the survey business, great care will be taken for the selection of the survey items, and preparation of practical application plans, to be operated in good communication on local and nation-wide scales.

(3) Survey will be made by the staff in both selected areas of the model-fields and general fields, by examining plant diseases and pests of rice, other cereals, sweet potato, potato and other crops. The survey comprises fixed spot observations and field trip observations.

(4) The Director General of the Agricultural Administration Bureau, Ministry of Agriculture and Forestry will decide the standard items for the survey practice.

5th. Information

(1) Prefectural governor will appoint a person resposible for distribution of information. He is to summarize and draft the survey results.

(2) The person in charge must distribute information which has been prepared on the basis of the survey results to the persons concerned quickly and with accuracy, and also report to the Director General of respective regional Agricultural Administration Bureau (in Hokkaido, the Director General of Agricultural Administration Bureau, the Ministry of Agriculture and Forestry who is responsible for this job).

6th. Report of the Business Results

Prefectural Governor must summarize the business results in an annual report every year, and submit it to the Minister of the Agriculture and Forestry through the Director General of the regional Agricultural Administration Bureau, by the end of June of the following year. (In Hokkaido, the Director General of Agricultural Administration Bureau, the Ministry of Agriculture and Forestry who is responsible for this job).

7th. Support by the Government

The Government will subsidize the total or a part of the expenditure necessary for the execution of this business, permitted under the Governmental Budget.

8th. Others

Any item necessary for the execution of the Rules may be decided by the Director General of Agricultural Administration Bureau, the Ministry of Agriculture and Forestry.

II Detailed Rules for the Enforcement of Disease and Insect Outbreak Forecast Work for Ordinary Crops

1. Objective

To execute the forecast business for plant diseases and pests, the rules provided in both the General Rules for the Enforcement of Disease and Insect Outbreak Forecast Work for Ordinary Crops (abbreviated as the Rules) and the Detailed Rules now to be described here are to be observed.

2. Execution of the Business

(1) Each prefecture may decide every year the schedule of the business, based on the Governmental plan of the business and directions of the Government, and execute the business.

(2) The forecasters described in the Rules, 3rd. may be named prefectural forecaster (one) and district forecasters (several).

a. Prefectural forecaster will belong to the Prefectural Agricultural Experiment Station and do the business as follows:

(a) plan the details of the schedule to practise the business based on the survey standards listed in the supplementary paper 1, and plan (1),
(b) instruct the district forecasters,
(c) do the survey listed in 3,
(d) analyze the records of observation and survey, prepare the plan for forecast information, and hand it to the person in charge of distribution of information.
(e) do special survey and investigation necessary for the execution of this business.

b. District forecasters may belong to the plant disease and pest control station of the assigned district, and do the business as follows:

(a) do the survey listed in 3,
(b) do the survey in the "model-field for determining timely application for plant disease and pest control", instruct the inspectors who are adopted based on this Detailed Rules (emended rule 492, 28th and 29th of April, 1954),
(c) give suggestions to the control men,
(d) if necessary, prepare the plan for obtaining forecast information in the district concerned under the direction of the prefectural forecaster.

(3) The control men may do the survey and observation under the direction of the respective district forecaster and report the results to the (same) district forecaster.

3. Survey

Survey and observation will be conducted in the model-fields with or without measuring equipment, by way of either fixed spot observation or field trip observation in the assigned area. The experimental plots will be set up in taking consideration the purpose and nature of the survey and based on the standard of the survey practice listed in the supplementary paper 1. These plots are the forecasting plots for analyzing and examining the characteristics of occurrence, transitional conditions of occurrence, for discovering incipient occurrence of plant diseases and pests, for determining the adequate time of plant disease and pest control. They may be provided equipment for trapping plant pathogens, for trapping pests, and for meteorological observation.

4. Information

The announcement of the forecast will constitute the technical basis for establishing timely, rational, and economic control methods for plant diseases and pests, and they must be fast and accurate.

(1) The forecast information and reports will be separated into forecast information, alarm notice, incidental notice, and monthly report.

a. The forecast information will be issued on the forecast of occurrence and transitional conditions of plant diseases and pests based on the survey and worked out by prescribed forecast methods. As a rule, the report will be issued once a month. The description items may cover the names of plant diseases and pests, the time of the occurrence, areas of the occurrence, the place of the occurrence, and comparison of the current occurrence with the occurrence in the ordinary year or in the previous year, the outline of the forecasting basis, suggestions for plant disease and pest control (necessity or unnecessity of the control, frequency and appropriate date for control, chemicals for the control, etc.) and other required items.

b. The alarm notice will be issued whenever there is a probability of severe outbreak of an important disease or pest, and it is necessary to take proper steps immediately to arrange control programs. There will be described the name of the disease or pest, the place (city, town, or village) and time of probable occurrence, estimated degree of occurrence, recommended control measures and time of application, etc. The upper edge of the form will be stained red.

c. The incidental notice may be issued whenever any peculiar plant disease or pest is discovered, or a sudden change in the condition of occurrence of economically important plant diseases or pests is noticed, such as incipient occurrence, marked variation in the peak occurrence of plant diseases or pests, and abnormal flight of pests toward the forecasting lamp. In the notices, the significance and the objective of the problem will

be commented, if necessary. The style of the form is free, but the upper edge of the form will be stained blue.

d. The monthly report will be periodically sent to the offices concerned, summarizing all the survey data every month. The descriptive items may cover the outline of the meterological observations, the conditions of crop growth, the conditions of occurrence of major plant diseases and pests such as the date of the incipient occurrence, of the incipient trapping of the plant pathogen in question, and of the incipient killing of the pest in question by light trap, abnormally abundant flight of the pests, the season, transitory conditions of the occurrence, the area of occurrence, the degree of occurrence, etc., which are the results of various kinds of survey and examination carried out every month.

(2) The forms for the forecast information, the alarm notice, and of the monthly report are given in the supplementary paper 2.

(3) The person in charge of distribution of information will, as a rule, be the chief of the Division concerned. The informations may be sent to the following offices which are resposible for planning control practices, instruction, and distribution of the information: Plant Disease and Pest Control Stations and the staff there, the Association for Plant Disease and Pest Control of the prefecture and of the district concerned, agricultural organizations of the prefecture, city or country, the Agricultural Extension Service offices, the Agriculture and Forestry Offices, the neighboring Prefectural Governments, the Agricultural Experiment Stations, Department of Plant Quarantine Offices, the Agricultural Administration Bureau, the Ministry of Agriculture and Forestry, the Office of Meteorology, press offices, broad casting companies etc.

Supplemental paper 1

Standard of Survey Practices

General Considerations

I. Objective of the Survey

The Survey constitutes the basis for forecasting the occurrence of plant diseases and pests. It is not too much to say that appropriate control practices are directly related to the success or failure of the forecast. Therefore, the survey items, date, frequency, and method must be determined for the respective plant disease or pest in problem to do accurate forecasting. Even when ideal surveys are difficult to do, it is essential not to miss important points of the survey from the point of forecasting.

II. Types and Contents of the Survey

1. Survey in the model-field for forecasting

The model-fields for forecasting are established in special spots for periodical surveys. The model-fields may ideally be classified into the fields for the analyses of characteristics of outbreak, for the survey of transitional conditions of outbreak, for the discovery of incipient occurrence, and for the determination of the date of timely control practices, which are different in position, schedules, area, etc., on the basis of the objective and the nature of the surveys. If it is difficult to do so from the points of labor for the survey, absence of spare areas, or expenditure, the model-fields for the analyses of characteristics of outbreak, and for the determination of the date of timely control practices are first of all to be set up, and other types of the model-fields may be combined into one, or any appropriate fields of the growers may be substituted for them.

(a) The model-fields for the analyses of outbreak

These model-fields should be selectively set up in positions where possibility of outbreak of the diseases or pests is high. In these fields, definite varieties of crops should be grown under the same cultural practices every year, to elucidate how the conditions of cultivation, of meteorology, and of other environmental factors are influential or related to the outbreak, and / or influencing or relating in the current year. The survey results obtained in these fields will be useful for the establishment of new forecasting methods, and also available for forecasting the occurrence of the plant diseases and pests in problem as made by the forecast methods currently used. Therefore, the varieties of the crop, cultural practices, etc., in these fields may be different according to the objective and the methods to be used. No changes related to cultural practices and varieties used are allowed in these model-fields until all analyses and surveys are through,

even if there occurred some changes in the varieties of crops and cultural practices in the adjacent fields of growers.

(b) The model-fields for the survey of fluctuation of occurrence

The model-fields should be set up in the area where occurrences of the plant diseases or pests are representative of the district concerned, and representative varieties of the crop in the district concerned should be grown by traditional cultivation practices in that district. Therefore, if there occurred a marked change in the variety of the crop used, and / or cultivation practices in the district concerned, the change may also be adopted in the model fields. The survey results are treated as representative of the fluctuation of occurrences in the current year, and become important data in learning the changes of the fluctuation as compared with those in the ordinary year.

(c) The model-fields for finding incipient occurrence

These fields should be set up to find incipient occurrences of any plant diseases or pests in the district concerned. The care should be taken for selecting the position where the plant disease or pest in problem occurs earlier and more frequently than at other positions. The positions of the model-fields, the varieties of the crops, cultural practices in these fields may be changed according to the plant disease or pest in problem or the schedules of the current year.

(d) The model-fields for determining the date of timely control practices

In order to obtain data on the timely control period, and the range of control, and on the necessity or unnecessity of control in the district concerned, the model-fields should be set up at a rate of one in an area of about 1000 to 1500 ha, where the time of occurrence of the plant diseases and pests in problem and fluctuation of the occurrence are almost uniform. The survey will be conducted by the assigned inspectors under the guidance of the district forecastors. These fields will be managed according to the "management practices of the model-fields for determining timely control periods of plant diseases and pests" (Act 492, April 28, 1954).

2. The survey in the experimental forecasting

The experimental forecasting is to forecast the occurrences of plant diseases and pests on the basis of the knowledge of ecology of plant pathogens and pests, and their transient conditions, from biological points of view, in the current season. Therefore, the effects of physiology and ecology of the plant pathogens and pests in problem on occurrences must be studied in order to establish this method. Occurrences of plant diseases and pests are under marked influences of cultivation practices in addition to environmental conditions. Artificial elements in the cultivation may

affect the physiology and ecology of plant pathogens and pests, as exemplified by the fact that utilization of rice blast-resistant variety of rice has changed the race distribution of the pathogen shift of crop season has changed the degree of dormancy of the rice stem borers. Starting from knowledges of physiology and ecology of the plant pathogens and pests in problem, it is necessary and it is considered possible to establish experimental forecasting methods.

As a practically established forecast method, the first emergence season of the rice stem borer can now be fairly accurately forecasted from the length of time required for pupation (and emergence) of overwintered nymphs when reared at 25°C. This will be described in detail later.

It is required to devise simpler and more practical methods for assessing susceptibility of rice varieties to the rice blast, and forecast method for the emergence season of the rice stem borers. In the former, rice sheath inoculation method and monoiodo-acetic acid reaction, and in the latter examination of spermatocytes of nymphs have so far been tried for these purposes.

3. The survey on the occurrences of plant diseases and pests by patrolling over grower's fields

The survey at fixed spots and also experimental forecasting will give accurate forecast for the occurrence of plant diseases and pests at the survey spots, but the results may not cover larger area. The objective of this survey is to obtain data covering actual aspects of local variations in occurrences of plant diseases and pests, so as to supplement forecasting data obtained by fixed point observations, and be generalized to cover the whole area of the district concerned.

In the field patrol inspection, there are two methods, qualitative and quantitative. In the former, occurrences of the diseases and pests may be roughly observed by field patrol inspection over the district concerned. In the latter, fields are randomly selected from each subdivision of the district showing similar degree and pattern of disease or pest occurrence; or fields are systematically selected without dividing the district. In either way, it is necessary to collect the data by making the observation within a short time in order to grasp the actual aspect of the occurrence of plant diseases and pests. For this, utilization of efficient transportation, establishment of quick method of observation, and the skill and experience are required. Indirect information obtained from the growers should be judged to be realiable or not. Furthermore, it is essential to obtain data on the occurrence of plant diseases and pests as well as cultural practices of the crop, growth conditions, and environmental factors, which are related to the occurrence of plant diseases and pests. The survey results will be utilized to attain the purpose previously described, by considering local variations in the natural and artificial conditions and applying knowledges on the mechanism of occurrences of plant diseases and pests.

By arranging the survey results and analyzing the data, local characteristics of the occurrences will be understood, and also new information may be obtained if the modes of occurrences in several districts are carefully compared.

(1) Selection of the model-fields and test plants

The model-fields may be selected by a systematic sampling method; or the fields may randomly selected from fields showing same degree of occurrence, when fields can be classified by a preliminary examination into several categories on the basis of degree of occurrence. The number of the model fields may be over 10 per district. Twenty five test plants per field are sampled as a rule, which may be selected from the whole area of the field by a systematic sampling method.

(2) Time of the survey

Time of the survey may be determined according to major plant diseases or pests in problem. As frequent surveying is laborious, major surveys will be conducted a few times a year by selecting the best time when occurrences of major plant diseases and pests may be observed. At the same time, however, observations of other plant diseases and pests as possible should be made.

4. Survey of the farming situation and the state of crop growth

The changes of varieties cultivated, types and patterns of cultivation, and annual fluctuations of crop growth affect the occurrences of diseases and insect pests. Then, it is very important not only for forecasting their occurrences in the current year but also for investigating mechanisms of their occurrences to grasp the general situation of farming and the state of crop growth in the district concerned.

The district is to be divided into several sections in consideration of the states of occurrences of major diseases and insect pests. The survey is made as to main varieties (early, medium, and late ones, respectively) cultivated, tolerances of varieties to diseases and insect pests, sowing time, types of nursery beds (how to raise seedlings), times of transplanting, maximum tillering stage, heading stage, and harvest, outline of fertilizer application (amount and time of application), types and patterns of cultivation (early-cultivating, early-transplanting, direct sowing, etc.), outline of pest control (times and numbers of application of pesticides, kinds and names of pesticides applied, range of control, etc.), etc. in each section.

The aimed crops for this survey are rice, wheat, and barley. However, the survey on the other crops should be made as well as possible at need according to the state of pest occurrences in each section.

When the items mentioned above agree to those examined by the Division of Statistics and Crops Survey, Ministry of Agriculture and Forestry, the results and data issued by the Division should be utilized as possible.

5. Survey of phenological phenomena

The occurrences of plant diseases and insect pests are phenological phenomena as similarly to the beginning or the end of chirping or singing, arrival, and departure of migratory birds, appearance and disappearance of various animals, sprouting, flowering, maturing, and defoliation of plants, etc. Such phenological phenomena sometimes have some certain orders through all seasons. There is a possibility then that the occurrences of diseases or insect pests can be forecasted from the observations of some phenological phenomena. There are some cases, in fact, that the occurrences of certain pests have been phenologically forecasted.

The survey is based on observations of various phenomena. Some phenological phenomena may differ among varieties in one species (e. g. cherry trees) or among several species in a certain group of animal (e. g. frogs). The observations should be made precisely in such points.

6. Meteorological observations

The changes of climatic conditions usually affect considerably the occurrences of plant diseases and insect pests. The observations on climatic conditions are useful not only as the basic data to establish forecasting methods by showing the effects of some climatic elements on the occurrences of pests but also for forecasting the occurrences of pests in the current year.

There are various kinds of meteorological observations. However, reliable observations for our purpose are two; first, observations at the meteorological field, showing the conditions of large air masses in an area, and secondly observations in crop fields, showing the climatic conditions in crop fields where diseases or insect pests occur.

(1) Meteorological observation field

The observations should be constantly and regularly made in an observation field as those in the observatory fields of the Meteorological Agency. An instrument shelter is set up in the field. The appoint personnel to make the observation regularly every day.

In places where a weather station or Local Meteorological Observatory is nearby, their data may be adopted. When the climatic conditions in the place for the observation of pest occurrences are apparently different from those at the station or Observatory, such data should not be adopted.

a. Items of observation: Dry-bulb and wet-bulb temperatures, maximum and minimum daily air temperatures, humidity, earth-surface temperature (earth temperatures at 5 and 10 cm in depth, if possible), wind direction, wind speed (maximum wind speed and its direction), duration of sunshine, amount of precipitation, depth of snow, weather, and other climatic elements (cloud amount, frost, fog, thunderstorm, etc.).

At least following climatic elements are examined at each Disease and Insect Pest Control Office; maximum and minimum daily air temperatures, amount of precipitation, weather (in the daytime and night-time, respectively), and other main climatic elements.

b. Notice as to observation: Observations are punctually made at 9.00 a.m., excepting those as to weather and other climatic elements in the morning and afternoon or before the sunrise and in the night-time at need.

All the instruments and apparatus used for the observation are to be officially calibrated and approved. They are inspected every day after use, and suitably cleaned and repaired, if necessary.

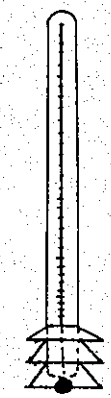
(2) *Crop fields*

As the occurrences of diseases and insect pests take place, some microclimatic conditions in the crop fields are to be examined at need. The climatic elements to be examined, sites and times of observation shall be reasonably decided according to kinds of diseases and insect pests and their ecological properties, as follows:

a. Items of observation: Temperature, humidity, wind speed (according to kinds of diseases and insect pests, and the purpose of observation, the sites for observation are decided such as 'above the vegetation', 'at the higher or middle part of the crop community, etc.), earth-surface temperature, temperature of irrigation water, wind speed, and other elements.

b. Notice as to observation: The time of observation may be decided appropriately. However, it is convenient for making comparison between the data obtained in crop fields and those in the observation fields to make observations in crop fields at 9.00 a.m.

Special care is required to use some instruments and apparatus in crop fields. For example, white shelters should be attached to the bulb of mercury thermometer in order to prevent the effect of direct sunshine, as illustrated below. At least three pieces of shelters of funnel shape made of waxed white paper are attached to the bulb of the thermometer. The lower margin of the lowest shelter is adjusted to be in horizontal level with the central part of the bulb.



7. Survey by using spore-trapping equipment

The purpose of spore trap is to examine the conditions of the dispersing spores in the air, and to obtain the data on the forecast of the occurrence. The relations of the dispersing spore conditions to the occurrence of the diseases are different in the kinds of the plant diseases in question, of the region concerned, or of the season. The quantities of the spores are different in different types of spore trap equipment, or set-up position of the equipment, and further research is required in order to utilize the dispersing spore conditions for the forecast of the occurrence of plant diseases. It is essential to accumulate the data for a long term, and even if the method may be revised from time to time, provisions should be taken to enable accurate comparison of the data obtained by different methods.

(Stationary type of spore trap)

A piece of slide glass coated with glycerin-glue * is placed on a wooden stand, and the spore-dispersing conditions is clarified by examining the spores of the plant pathogen in question sticked to this slide.

(1) Spore trap field

The spores may be trapped as a rule in the model-fields for the forecasting. Other fields may be used as substitute. The model-fields is at least over 5 a in area. As for the forecast of the rice blast occurrence, representative local varieties should be selected, and manuring should be rather heavy. The varieties to be grown and cultural practices should desirably be unchanged every year.

(2) Spore trap

Spore trap stand may be set up at the height of 30 to 90 cm from the soil surface in the footpaths between model rice fields or within general rice fields. On the stand, a piece of glass slide coated with glycerine-glue is placed to catch the spores by sticking to the slide glass. The slide glass should be changed at a definite time (in the morning or in the evening) every day.

* Preparation and utilization of the glycerine-glue.

Forty g of best quality gelatine is dipped in 100 cc of water, heat to dissolve, and 80 cc of glycerine is added to it. The quantity of gelatine may be increased if necessary temperatures. For a long term storage phenolic acid may be added to the final rate of 1%. To coat a piece of slide glass with this glue, it may be heated into dissolved condition, and painted evenly using a glass rod or spatula. After being solidified, the slide glass is set up on the spore trapping equipment.

(3) Microscopic observation of spores on the slide glass

One drop of water is placed at the center of the glass after being removed from the spore trapping equipment, and a cover glass slip, 18 X 18 mm is put on it. The total number of the spores present in the whole area covered with the cover glass may be counted without being duplicated. Suitable magnification may be 150 to 260 X.

(Revolving type of spore trap)

The stationary type of spore trapping equipment so far used has not been so efficient in catching the spores. It has often been complained that spores have not been trapped in enough quantity to obtain the data for forecasting, in a slight occurrence of the rice blast, notably in southern parts of Japan.

The revolving type of spore trapping equipment has a cross bar above a shaft connected with a motor, the bar supporting 2 pieces of glass slides. As the spores are trapped in the air current generated by rotating shaft at 1000 to 2000 rpm, the quantity of spores trapped by this equipment is larger than by the aforementioned stationary type of spore trapping equipment. The quantity of the spores trapped in 24 hrs by the use of the stationary type of spore trapping equipment may be trapped within 1 hr by the revolving type of spore trapping equipment.

The revolving type of spore trapping equipment may be set up at the height of rice plant in the case of the rice blast fungus. These spores may be trapped for 30 to 60 minutes at the definite time in the evening, or for 60 min. in early morning. The preparation method of glycerine-glue and microscopic examination method have already been explained. The revolving type of spore trapping equipment has become practical in use by the progress of recent research, but there is not enough experience for this equipment, and accumulation of the data is not yet sufficient. One should be cautious to change the stationary type of spore trapping equipment to the revolving type, because there may be some inconveniences for the comparison of the data. For the time being, both types of spore trapping equipments may be used together, and then the revolving type may be gradually increased in use. In the meantime, the data obtained by both types of apparatus can be compared.

8. Tests of virulency of leafhopper and planthopper vectors

(1) Methods using rice seedlings

This is a method in which a rice seed soon after germination or a healthy rice seedling younger than four-or five-leaf stage is put in a test tube or a cylindrical screen cage together with the insect to be tested, and the test plant is then examined for disease symptom expression, to detect whether the insect is viruliferous or not.

When germinated seed is used, a rice seed is put into a test tube with a drop of water and kept at a temperature of 20 - 30°C. Soon after germination, the seedling is exposed to a single insect for a certain period, and transplanted into a flat with soil to be examined for disease symptoms. At higher temperatures above 25°C symptoms develop in several days after inoculation feeding.

When young rice seedling is used, each plant is exposed to an insect in a glass or wire-net cylinder for a certain period and kept at a relatively high temperature before the observation of disease symptoms.

(2) Serological methods

When an animal is injected with a foreign protein, a substance which has the properties of eliminating the injected protein appears in its serum. This is called an antibody, and any substance which will stimulate the production of antibodies is called an antigen. Antibodies combine specifically with the corresponding antigen and form a precipitate but do not react with any proteins other than the antigen. As plant viruses are nucleoproteins and have the properties of acting as antigens, the properties are available for testing the virulency of an insect vector.

a. Precipitation: Virus suspension clarified by centrifuge, etc. and an equal volume of antiserum are mixed under an adequate condition. From observation on the amount of specific precipitate, it is possible to test whether the insect is viruliferous or not. This test is also known as the precipitation reaction test.

b. Hemagglutination with antibody-sensitized cells: Antibodies are contained in globulin fraction of the serum. As globulins are protein, these become attached to sheep red blood cells treated with a dilute solution of tannic acid. When these antibody-sensitized blood cells are mixed with virus suspension, the cells are agglutinated by the medium of virus. Hemagglutination test is an application of this principle.

An insect to be tested is macerated with a glass rod in the bottom of a small test tube. A volume of 0.5 ml of the sensitized cell suspension, diluted with tenfold diluents, is added and well mixed with the macerated insect. Observation on agglutination is made after 3 hrs to

one day. In a positive agglutination pattern, blood cells are spread over the bottom of the tube, whereas in a negative one, the cells form a small, flat and smooth circle at the center of the bottom.

9. Observation of the occurrences of insect pests

(1) Light trap method

The observation is intended to grasp the time of occurrence, abundance, and seasonal prevalence in the current generation of insect pests, by counting the light trap catches, and to obtain data for forecasting those in the following generations.

A standard light trap for the purpose of forecast is set up at a representative place in each section of the district, as divided in consideration of abundances and types of occurrence of insect pests. The spot to place the trap is desirably not to be influenced by harvested rice straw heaps, nursery beds, buildings, forests, etc., regarding the number of insect pests lured to the trap. The spot has to be outside of the range of influence by other illuminations. As a rule, a frosted bulb (60 watt, double-filament) is used as the light source of the box-type trap. A regulator for constant voltage is attached to the trap if necessary. The bulb shall be exchanged with a new one every 2—3 months, as the intensity of illumination deteriorates when it is used too long. The box-type trap is constructed of a large wooden or plastic box. Several cotton pouches, each containing 150—200 g potassium cyanide (KCN) or sodium cyanide (NaCN), are kept within the box to kill insects dropped into the box through a funnel attached to the top of the box. Such pouches are renewed when larger insects are not killed, usually every 7—10 days. The whole structure of the trap standardized for the purpose of forecast is illustrated elsewhere (IX, the structure of the light trap for forecast). The aimed insect pests are as follows: rice stem borer, paddy borer, white-backed planthopper, brown planthopper, smaller brown planthopper, green rice leafhopper (also tropical green rice leaf-hopper and oriental green rice leafhopper in the western part of Japan), zigzag-striped leafhopper, rice green caterpillar pink borer, armyworm, southern green stink bug, rice stink bug, black rice bug, grass leaf roller, rice leaf roller, rice crane fly, sweet-potato leaf worm, etc.

a. Time and items of examination

Light traps are illuminated every night from April 1 to October 31. The items are daily catches (separately, male and female), date of the first catch, date of peak catch, five-day period of peak catch, date of 50 % catch, date of the final catch, total catches in each generation, and sex ratio of catches in each generation.

b. Notice for the arrangements of data obtained

The date of the first catch means the date when one or more adults were captured by the light trap for the first time in the season. The date of peak catch is the middle date of the five consecutive days with the highest number of catches as a whole, and these five days are termed the period peak catch. The five-day period including the date of peak catch is termed as the five-day period of peak catch. The of 50% (moth, fly, etc) catch is the date when the daily accumulated number of catches exceeds a half of the total catches in the generation. The date of the final catch is the date when one or more adults are captured for the last time in the generation. However, there are often some cases in which the number of adults captured does not drop off between two successive generations, and distinction between the two periods of adult appearance is obscure. In such cases the middle date of the period of five successive days supposed to be the end of the period of adult appearance, having the lowest moving average value of the number of adults captured, is deemed to be the date of the final catch in the generation: one half of the number of adults captured on that date is deemed to be the number of adults belonging to the foregoing generation. When a half of the number of adults captured on that date yields the decimal 0.5, the decimal is added to the number of adults belonging to the foregoing generation.

When at the end of a generation there occur two or more bottoms in the curve showing the relative abundance of adults captured, the middle date with the smallest moving average value is deemed as the date of the final catch. If the judging of the date of the final catch is made by methods other than these described here, it shall be reported clearly with necessary explanations.

c. Notice as to the examination

° Identification and counting of insects captured are to be made desirably in the morning of the current day. The results are recorded in the column of the preceding date.

° When there is no examination, no counting, or the light trap was not illuminated on a certain date, estimated numbers of insects to be captured on that date are given by the values of average catches / day during the five-day period. The estimated numbers are to be put down with a mark of (missing).

° In the report form the following items should always be described; place where the light trap for forecast is set up, outline of the environment (situation of rice culture, topographic features, etc.), structure of the light trap (water-tray or box-type, size of the water tray, height of the light-source above the surface of the earth, etc.), etc.

° Low temperature, rainfall, wind, moonlight, etc. influence relative prevalences of light trap catches. Therefore, such meteorological events should be mentioned. Relative frequencies of catches should be used for estimating the abundances in the field in consideration of the effects of such events.

(2) Sweeping method

a. A silk net (37 cm in diameter) with a handle (1 m in length) is used on vegetation.

b. Insects are collected by sweeping with the net over vegetation in the field, and catches of each species are counted (separately, male and female, adult and larva or nymph, and different instars, if necessary). The collection by 25 double strokes or 50 sweeps of the net is equal to an area of about 33 m^2.

(3) Tap-and-count method and push-aside-and-count method

a. Both methods are applied for the survey of density in the field especially in planthoppers and leafhoppers on rice plants.

b. Tap-and-count method means that a rice plant or hill is tapped by hand or a stick to drop adjusts and nymphs down from the plant or hill to the surface of the irrigated water and counts them directly. Push-aside-and-count method means that adjacent plants are pushed aside quietly by hand and count the adults and nymphs on the target plant or hill directly. In both these methods the observer should be careful to count the adults and nymphs only from or on the target plant or hill, and not to confuse them with adults and nymphs from or on plants or hills nearby the target plant or hill.

c. As a rule, adults and nymphs on 25 hills of rice plants in each field are counted.

(4) Sticky trap method

a. A 25 x 80 cm piece of wire gauze (3 x 3 mm mesh) wooden- or iron-framed is used. An adhesive is spread over the gauze: e.g. 'lime' on sale or a resinous lime described below. The trap or wire gauze is set up just above the upper part of plants.

b. Preparation of the resinous lime

Materials: Castor-oil 200 cc, pine resin 100 g, and carnauba wax 10 g.

Procedure: Castor-oil is heated taking care not to boil, and add finely powdered pine resin and carnauba wax mixture little by little under stirring. A little portion of the solution is taken by a glass rod,

cooled, and tested for the viscosity. When the viscosity of the solution becomes suitable, the solution is poured into a large dish and immediately cooled to 0°C. The solution is ready for use after several hours. This solution or adhesive may be stored at room temperatures.

How to use: Spread the resinous lime on the wire gauze with a brush with strong hairs. Do not spread so much of the lime that meshes of the wire gauze are closed. The effectiveness of this lime on the trap is maintained for a long period when the weather is fine, but drops down rapidly after raining. Hence, count the insects on the trap and recoat the lime on the wire gauze whenever it rains. When the meshes of the wire gauze are closed or the trap becomes dirty, exchange it for new one.

c. Method of the examination

Each piece of the framed wire gauze is fixed between two parts of a bamboo or wooden stick vertically cut. The trap is oriented to a direction optionally decided for convenience of the counting of catches. A couple of traps are symmetrically settled in each field in consideration of the shape of the crop field and its vegetation, as possible. Insects are counted every three days to grasp their relative prevalences. The method is useful for planthoppers and leafhoppers.

(5) Suction-machine or suction-catcher method

a. The suction machine consists of an air cooled single cylinder 2-stroke engine with cylinder displacement of 50 cc., blower, collecting apparatus, anterior attachments, and flexible hose between the anterior attachments and the collecting apparatus, etc. The insects are collected with negative pressure on intake side.

b. Insects in a predetermined area in each sampling plot are collected, identified, and the catches counted.

c. The abundance and the time of appearances of insects are estimated from the data of catches.

10. Survey of acreage of crop fields in different degrees of occurrence of a pest

It is important for the establishment of forecasting methods in the district, for judging the fitness of forecast information in the current year, and for drafting control programmes, to grasp the degree of occurrences of pests and actual state of the damage in each district.

This survey is carried out by cruising inspection. The procedures for the selection of sampling fields, number of sample hills, etc. should be decided on the basis of statistics.

(1) Items and methods

The degrees of occurrence of each pest are classified into five: absent or none, light or rare, moderate, heavy or abundant, severe, by the percentages of lesion area, if hills infested, of stems infested, number of insects / plant, etc. Such a classification in each pest is used as the standard for the estimation of the area of crop fields in each degree of occurrence of the pest. The standard for the degree of occurrence and methods for survey of each pest are described in the respective articles. The calculation of the degree of occurrence should be made down to the tenths of percent and count 0.5 and fractions as units, cutting away the rest.

(2) Calculation of the acreage of crop fields in each degree of occurrence

When the fields for survey are selected by a systematic sampling, the percentages of crop fields belonging to each degree of occurrence (absent or none, light or rare, moderate, heavy or abundant, severe) are obtained. The total cultivated area of a crop in the district is multiplied by the percentage of crop fields belonging to each degree of occurrence to estimate the area of crop fields in each degree of occurrence.

When the fields for survey are selected from each district classified by the degree of occurrence, first it is judged which degree of occurrence the fields belong to. Secondly the areas of fields belonging to each degree of occurrence are summed up.

(3) Remarks

As to the fields for survey, sampling of hills, times of observation, etc. see 3 (survey of the occurrences of diseases and insect pests by cruising inspection).

III. Method for the forecasting of occurrence

Forecasting of the occurrence of plant diseases or pests may be conducted on the basis of the results of various surveys made according to the aforementioned rules, but it may be difficult to do accurate forecasting only based on the survey results of the items 1 and 2. One should try to forecast on the basis of overall judgement, in paying attention to the significance of various kinds of the survey results for the occurrence of plant diseases or pests, and the date of the survey. For forecasting, it is necessary to establish, in the first place, the objects for the forecasting, such as the time of occurrence, the amount of occurrence, the rate of injury etc. At the same time, bearing of growth and propagation of the respective plant pathogen or pest on these items should be studied in order to work out reliable forecast methods.

There are two kinds of forecast methods, i.e., statistical forecast method, and experimental forecast method. In the statistical forecasting method, the forecasting items in question, and the annual variations of the survey items in regard to meteorology, conditions of cultural practices and others may be statistically analysed. When there is a significant correlationship among these items, forecasting may be made on these basis. In the latter method, conditions of the respective crop pathogen, or pest in question will be clarified through experiments. The data, as possible, should be obtained quantitatively. Therefore, it is necessary to do various kinds of surveys accurate enough to be treated quantitatively, on the basis of definite programme.

IV. Usage of general terminology in the forecast practices

In the practices, it is hoped to have a definite agreement on the usage of the terminology to be used in expressing conditions of occurrence of plant pathogens and pests, growth conditions of the crop in concern, meteorological data, etc., to minimize misunderstanding or misinterpretation.

1. Mean value

(1) Data of the meteorological observations

In the Weather Agency, the mean value of meterological measurements obtained in the last 30 years is used. In this practice, this method will be adopted, but the mean value for any period of years, may be substituted when no data are available for the last 30 years.

(2) Occurrence season of the plant diseases or pests, the degree of occurrence, and the area of occurrence

The average of the 10 years data excluding the maximum, and the minimum year from the last 12 years should be used, and called the values of "the ordinary year."

2. Comparison with the ordinary year

(1) Season

Average; within 2 days plus or minus the mean
A little early; earlier than the near by 3 to 5 days
A little later; later than the mean by 3 to 5 days
Earlier; earlier than the mean by over 6 days
Later; later than the mean by over 6 days

(2) Quantitative data (the degree, and the area of occurrence, and the degree of injury)

Average; within 10% of the datum plus or minus the mean
A little larger; larger than the mean by 11 to 30% of the mean
A little smaller; smaller than the mean by 11 to 30% of the mean
Larger; larger than the mean by over 31% of the mean
Smaller; smaller than the mean by over 31% of the mean

(3) Meteorological conditions

As a rule, the data should be described precisely as by stating that it is higher (or lower) than the average by such and such degrees, or it has rained more (or less) than the average by such and such mm., but these data may be expressed in the following standard.

	Temperatures	Quantitative data* such as rainfall amount
Average	with 0.5°C ± the mean	within range including 40% of frequency distribution on both sides of the mean
A little higher (larger)	higher than the mean by 1.6 to 1.5°C	within range outside of the above, including 20% of frequency distribution
A little lower (smaller)	lower than the mean by .6 to 1.5°C	do.
Higher (larger)	higher than the mean by over 1.6°C	within range outside of the above, including 10% of frequency distribution
Lower (smaller)	lower than the mean by over 1.6°C	do.

*As the rainfall amount is quite variable according to year and locality, it is not appropriate to express the width of variation in terms of absolute values throughout the whole country. Therefore, frequency histogram is constructed using the data of the last 30 years in the respective locality, and "average" is defined as the range in which 40% of the members on both sides of the mean are included. Expressions "a little larger" or "a little smaller" are used for the range on both sides of the above including 20% of the members, and expressions "larger" or "smaller" used for the range further outside and including 10% of the members.

3. Standards to express the degree of occurrence

The expressions "severe", "heavy", "moderate", "light", and "none" to denote the degree of occurrence (or intensity) will be defined for individual cases in the respective chapters. When the words "larger" or "smaller" to express the degree of occurrence is used, it is recommended to spell out like "degree of occurrence larger" or smaller.

Details

I. Diseases of Rice

A. Blast

1. Objectives for forecasting

Control measures are somewhat different among leaf blast, panicle blast and node blast, where panicle blast consists of neck blast, panicle branch blast, and spikelet blast. Against leaf blast, eradicative spray of chemicals after infection gives satisfactory control as well as protective spray before infection. Therefore, detecting the initial lesions on leaves insofar as possible and spraying chemicals are very effective in controlling leaf blast. On the other hand, it is too late to apply chemicals against panicle and node blast after an appearance of lesions. These differences should be considered for making an appropriate forecast. Various types of blast outbreak can be observed even in a single prefecture according to several factors, such as altitude, cultivation methods, varieties of rice, race of the causal fungus, etc. In order to forecast the disease occurrence, it is also important to gain comprehension of these types of disease outbreak. For instance, yield losses from leaf blast and panicle branch blast offer more serious problem in southern Japan. Based on the inspection of a progress of leaf blast, a suitable date for chemical control against leaf blast must be forecasted in the first place. Forecasting the incidence of neck node blast and panicle branch blast, and informing whether the chemical control after booting stage is necessary or not are seriously demanded. Heavy losses from neck blast are more often inflicted in northern Japan. There needs suggestions as to whether leaf blast should be chemically controlled and how many times chemical control must be carried out against panicle blast.

2. Surveys

a. Surveys conducted during whole growing season of rice

Disease proneness of rice plant is greatly affected by climatic conditions, soil types, amount of fertilizer supplied, and cultivating manner. These factors provide valuable information for disease forecast. The following surveys are used not only for the forecast for the current year, but also for providing information to improve forecast methods.

(1) Measurement of rice growth

Methods

In nursery: Height of seedlings, number of leaves, the age of seedlings, number of tillers, fresh weight, and dry weight are measured in the middle and end of nursery stage on the basis of 20 plants.

In paddy field: Height of plants, number of tillers, and number of panicles are measured twice at 15 days interval from transplanting to the completion of heading, on the basis of 20 plants. These data are obtained from the model-field specially prepared for the disease forecast. Fresh and dry weight of 5 to 10 plants at each time are also examined.

(2) Estimation of predisposition of rice plant to the disease

Chemical and biological approaches for measuring predisposition of rice plants to the disease have been attempted. Estimation can be made to some extent from an analysis of nutritional components in plants; for example, contents of total nitrogen, soluble nitrogen, amino acids, phenolic compounds, silica, etc. The amount of starch preserved in the basal parts of leaf sheath and the number of slicified cells in flag leaf are other useful indices of disease proneness. The grade of predisposition is also distinguished by differences in the reaction of leaf to mono-iodoacetate solution, or in the level of mycelial growth in inner surface cells of leaf sheath. Spore inoculation on different plants at constant intervals by spray method is also valuable to estimate disease proneness directly.

Examination of predisposition of rice plants by the leaf sheath inoculation technique

Five leaf sheaths of the third leaf from the top on the highest stem are collected from the model-field for forecasting. The second leaf sheaths are used after booting stage. The detached sheaths are cut into 15 cm long cylinder. A conidial suspension at a concentration of 5 to 7 spores per loop is injected into the inside of a leaf sheath cylinder using a syringe. Fresh conidia, produced within 48 hr, of the most predominant race in the region concerned and also of a standard widespread race should be used. The leaf sheaths inoculated with conidial suspension are settled in petri dishes with moistened filter paper at 24 to 25°C for 40 hr. The degree of mycelial growth in the epidermal cells of inner side of sheaths is determined under microscope. The correlation previously examined between the degree of mycelial growth and the intensity of the disease occurrence provides a criterion for forecasting disease in a given period of the year.

By reaction of mono-iodoacetate

Mixed solution (1:1, v/v) of 2×10^{-3} M mono-iodoacetate and 10^{-2} M catechol is prepared. A second leaf from the top is detached, and pressed at three different points 2 mm in diameter with a special pressing pinchers A drop of the solution is placed on each pressed spot. Leaves thus treated are placed in humid petri dishes at 28 to 30°C for 10 hr. The degree of brownish discoloration is observed.

By the degree of silicification in flag leaf

Twenty flag leaves fully developed are collected and segments 5 x 10 mm from the middle part are used. The segments are decolored with alcohol and treated with phenol. The average number of silicified cells per unit area in 20 segments is determined.

(3) Measuring meteorological elements

Disease outbreak is considerably affected by weather conditions. Therefore, the correlation between disease intensity and various climatic conditions can afford reliable criteria for forecasting. Maximum and minimum temperatures, relative humidity, duration of sunshine, amount of precipitation, and wind velocity are to be measured throughout the whole period of crop growth.

b. Survey for forecast of leaf blast

(1) Survey in the model-field for forecasting

(a) Inspection of the degree of disease occurrence in nursery

The date of an initial appearance and the degree of disease occurrence must be carefully inspected in the nursery, because there is a correlation to outbreaks of the disease after transplanting. Sometimes diseased seedlings, especially plants in incubation period, become major source of inoculum after transplanting.

Methods

The date of initial disease occurrence, the type of lesions, the uppermost leaf-order of the diseased leaves, presence of infection in blade auricles, and the degree of disease occurrence should be inspected in the nursery under the same cultivation practices every year.

Date of surveys

These surveys are made three times: at a middle growing stage in the nursery, 7 to 10 days and immediately before transplanting.

(b) Surveys of leaf blast progress in paddy field

An initial incidence and peak of an outbreak of leaf blast must be identified by repeated inspections in the model-field for forecasting, under favorable cultural conditions for the disease. Susceptible and less field-resistant varieties are planted in this field. Much amount of nitrogenous fertilizer is supplied, and the chopped diseased straw harvested in the previous year are sometimes scattered over the field to provide

inoculum, if needed. The inspections should be made as many times as possible, at least three times, at the stage of tillering, ear-primordium formation, and booting.

Methods

Percentage of diseased hills, degree of disease occurrence or percentage lesion area, type of lesions, and the uppermost leaf-order of diseased leaf counted from newly developing leaf are assessed as follows.

(i) The degree of disease occurrence is rated on the basis of 50 plants from the model-field for forecasting. The following table indicates a key to each degree of disease occurrence. The percentage lesion area is evaluated by comparing samples with the figures, of the illustrated standard.

Index	I	II	III	IV	V
Degree of disease intensity	None	Light	Moderate	Heavy	Severe
Percentage of lession area	0	0.1 to 0.5	0.6 to 2.0	2.1 to 10.0	above 10.1

(ii) Type of lesions. This is a very useful measure for indicating the virulence of the causal fungus and susceptibility of the rice plant. Average lesion type in a given field is determined, on the basis of the following standard:

Symbols	A-type	B-type	C-type
Expression of lesion types	Brown fleck type	Developed type	Developing type
Color of lesions	Brown, sometimes surrounded with yellow zone	Gray center with brown margin surrounded with yellow zone	Dark purple or gray center sometimes surrounded with brown and yellow zone

Symbols	A-type	B-type	C-type
Shape of lesions	Small spindle, ellipsoid or circle (below 5 mm in length)	Spindle Medium to large lesion (ca. 5 to 15 mm in length)	Ellipsoid or spindle Small to medium lesion (ca. 5 to 10 mm in length)
Sporulation	none or few	intermediate	abundant

Amount of C-type-lesion should be recorded on the basis of the following table:

Zero
Few: A few C-type-lesions can be observed per hill
Medium: Several C-type-lesions can be observed per hill
Abundant: More than ten C-type-lesions can be observed per hill

(iii) The uppermost leaf-order of diseased leaves. Inoculum potential is recognized to be different, corresponding to the vertical distribution of lesions on the plant. Leaves from top to bottom are arbitrally classified into three groups; namely, upper, middle, and lower layers. The layer showing lesions is identified from 25 plants.

(2) Survey by patrolling over grower's fields

(a) Survey at nursery stage

Two or three representative nurseries of various types; that is, a lowland nursery filled with water, a mud nursery covered with paper or vinyl film, and an upland nursery covered with paper or vinyl film, should be selected for inspection. The date and items for surveys follow the case of surveys in the model-field for forecasting.

(b) Surveys on leaf blast progress in paddy fields

In the selected paddy fields, developmental process of the disease is inspected, in order to grasp the general pattern in the district concerned.

Methods

Percentage of diseased hills, intensity of the disease, the type of lesions, the uppermost leaf-order of diseased leaf counted from the newly developing leaf are detected in the same way as mentioned.

Date of surveys

Once or twice at the initial to maximum stage of tillering, and ear-formation stage. The frequency of surveys must be increased when a severe outbreak is noticed.

(c) Survey of acreage classified according to the degree of disease occurrence

Acreage classified according to the degree of disease occurrence is cumulatively calculated from 25 plants per plot systematically sampled from selected grower's fields, based on the table shown before. Stunted plants showing no recovery are identified as "severe", but separately classified.

Date of surveys

The observations are conducted a) at the nursery stage immediately before transplanting and b) at the stage of maximum leaf blast appearance.

c. Surveys for forecasting of panicle blast

(1) Surveys in the model-fields

(a) Inspection of leaf blast occurrence immediately before heading

There is a close correlation between leaf blast incidence immediately before heading and panicle blast occurrence. Lesion on the juncture of leaf sheath and blade becomes also a source of inoculum for panicle blast. The amount of lesions on nodes are to be examined, if the incidence of leaf blast is slight.

Methods

The amount and severity of leaf blast are inspected by the methods indicated before; especially, the percentage of diseased leaves and the type of lesions on the upper three leaves.

Date of surveys

The inspections are made every 5 to 7 days since 2 weeks before heading.

(b) Counting of disseminating conidia

The significance and technique have already been mentioned. The number of conidia deposited on a vaseline-coated slide is counted every day during the period from 3 to 4 weeks before heading to 3 weeks after heading.

(c) Survey of panicle blast outbreak

The nature of disease progress on some early-maturing varieties gives a reliable basis for forecasting blast occurrence on late-maturing varieties in the same year. The accumulated data serve also as the basis for making forecast formulae.

Methods

The diseased panicles are classified into three categories: (a) panicles that are whitish in color and have many unmatured grains on account of infection on neck nodes, (b) panicles that have unmatured grains by more than one-third of the total number of grains, and (c) panicles with light damage on panicle branches. The number of diseased panicles in each category is counted on the basis of 50 plants from the model-field for forecasting. The degree of panicle blast incidence is indicated by the following formula: { Number of panicles belonging to the class (a) + Number of panicles belonging to the class (b) } x 100 / (Total number of panicles examined)

The classification of the diseased node follows the same principle as the case of panicle blast. These are; (A) number of stems died, (B) number of stems dying on account of infection on nodes, and (C) number of stems visually healthy despite infection. The degree of node blast incidence is indicated by the following formula; Number of stems classified into the (A) group + Number of stems classified into the (B) group x 100/(Total number of stems examined)

The percentages of diseased panicles and nodes classified into (c) and (C) group are recorded separately.

Date of surveys

These inspections are conducted 3 to 5 weeks after the completion of heading.

(2) Survey by patrolling grower's fields

(a) Survey of leaf blast incidence immediately before heading

In fields selected in each district, the degree of leaf blast occurrence should be inspected once or twice by the method described in the preceding section, around two weeks before heading.

(b) Survey of acreage classified according to the degree of panicle blast incidence

For identifying the accuracy of forecast, making plans for protection, and for improving forecast techniques, the records of acreage classified according to the degree of panicle blast incidence will be useful.

Methods

The degree of panicle blast occurrence on 25 plants is inspected in each field, and acreage corresponding to each degree is calculated. The key for identifying the degree of panicle blast occurrence is shown in the following table.

Index	I	II	III	IV	V
Degree of disease intensity	None	Light	Moderate	Heavy	Severe
Percentage* of diseased panicles		below 5	6 to 20	21 to 50	above 51

*Based on calculation indicated in the section c.(c).

Percentage zero includes disease incidence of up to ten panicles per are in southern parts and twenty panicle per are in northern parts of Japan.

Date of surveys

The assessment should be made at the stage of milky and dough-ripe i.e., 4 to 5 weeks after heading, of main varieties in the given area.

3. Method for forecasting rice blast

The development of the disease depends on some particular factors, and especially combination of those factors.

a. Forecasting leaf blast occurrence in nursery

The incidence of leaf blast in a nursery would be severer under upland condition than under lowland condition, and in nursery covered with vinyl film than in one covered with oiled paper. Later and heavier sowing also causes severer disease. The conidium formation on over-wintered diseased tissues starts under humid condition at 15°C or more of mean daily temperature (5-day period). In years when mean temperature

of 19°C arrives earlier, on early initiation of the disease would be expected. The higher the temperature in seedling stage, the earlier and the severer the incidence of the disease. Such relationships may not hold in the cases of covered nurseries.

b. Forecasting leaf blast occurrence in paddy field

The disease development after transplanting often depends on the degree of disease occurrence in the seedlings and susceptibility of the host, when the disease appears at nursery stage. An early appearance of the disease in the field, however, does not always result in severer disease outbreak. Several factors, such as initial disease appearance in the model-field for forecasting, acreage and degree of initial outbreaks in farmer's fields in addition to climatic conditions, susceptibility of rice, etc. must be taken into account. The subsequent development of the disease is greatly influenced by weather conditions; i. e., successive humid or rainy days, long duration of dew deposition. Proneness of the host also causes rapid increase of the disease. Leaf blast appears when minimum air temperature rises above 15 to 17°C. The disease proneness is assessed by the following signs: dark greenish leaves, weeping leaves, a lower dry weight, a good number of developing lesions, and a high level of nitrogen applied. To forecast panicle blast outbreak, it is essential to make comparison of the data such as the number of conidia deposited, the curve of daily conidium collection, the degree of leaf blast, susceptibility of host, and meteorological factors. Severe damage will be caused in the following cases: delayed growth, a higher degree of leaf blast occurrence, a higher density of conidia immediately before heading, a lower temperature at the booting stage, less sunshine, and a humid or rainy condition during the period from booting to 3 weeks after heading. The necessity of chemical control can be decided on the basis of these information. Sometimes, panicle branch blast occurs heavily in hot autumn and or when a typhoon hit at the stage of heading.

B. Pellicularia sheath blight

1. Objectives for forecasting

The disease appears initially on a lower sheath at tillering stage. As the number of diseased tillers increases, the disease develops upwards. Severe damage is caused after heading. Since this disease can be protected with chemicals sprayed by the time of heading, estimation of final degree of occurrence at the harvest time and determination of the necessity of control or the date of control, should be made until the booting stage. Pattern of outbreak and degree of damage are influenced not only by meteorological factors, but also by cultural practices, particularly the time of transplanting and the time of maturity. A standard pattern of outbreak must be recognized provisionally, using some representative varieties under representative cultural methods. The pattern of disease progress in a given year, taking into consideration the climatic conditions, should be compared with such standard to forecast the following incidence.

2. Surveys

a. Surveys in the model-field for forecasting

(1) The date and degree of initial appearance of the disease

Overwintered sclerotia which constitute the primary source of inoculum float over the surface of irrigation water immediately after transplanting. They arrive to rice stems. Infection occurs usually at the maximum stage of tillering or a little later. The sclerotia distribute heterogeneously among and within fields, so that primary infections do not occur uniformly and simultaneously in a field. The time when certain degree e. g. 3 to 5%, of uniform occurrence can be observed seems to be more important than the time of first detached appearance of the disease. Several sclerotia sometimes stick to a plant and cause the disease on a few stems, when many sclerotia are floating. Therefore, assessment of disease occurrence should be made not only by percentage of diseased plants, but also by percentage of diseased stems.

Methods

By periodical counting of the diseased plants, the time of appearance of 3 to 5% diseased plants is designated as the initial occurrence. Inspection is made on the basis of 50 plants per variety in the model-field for forecasting. Percentage of diseased tillers also should be recorded.

Date of surveys

Surveys should be conducted every 10 days from the 20th day after transplanting until the initial occurrence of diseased plants.

(2) Surveys for detecting progress of the disease

Secondary infections are caused by mycelia from lesions. The rate of progress is greatly affected by climatic conditions as well as cultural practices. Even when initial outbreak is slight rapid and severe disease development sometimes occurs under favorable circumstances. Therefore, the process of disease progress must be periodically inspected after the initial occurrence. Judging from the rate of disease progress and environmental factors, necessity of chemical control or the date of control may be determined.

Reference

cf.) Degree of disease occurrence at which chemical control is necessary

Relationship between the degree of disease occurrence and economical protection by chemicals varies according to different conditions: locality, methods of cultivation, varieties, etc. For instance, application of chemicals economically protects the yeild loss

when diseased plants become more than 20% at the time of 2 to 10 days before heading in early-maturing varieties cultivated in ordinary season in Yamaguchi Prefecture.

Methods

Fifty plants are systematically sampled from each variety growing in the model-field for forecasting. The percentage of diseased plants, the number of diseased tillers, the leaf-order of the uppermost diseased leaf sheath counted from the newly developing leaf, and the degree of damage should be percidically determined. The degree of damage is calculated by the following formula on the 20th day after heading:

The degree of damage (%) = {Number of plants classified into (A) group x 4 + Number of plants classified into (B) x 3 + Number of plants classified into (C) x 2 + Number of plants classified into (D) group} x 100 / (Total number of counted plants x 4)

Where; A: More than 50% of stems are infected. Lesions have developed to flag leaves or neck nodes. Most flag leaves withered. B: lesions have developed to the sheath of flag leaves, but the leaves are still green. C: Lesions have developed to the 2nd leaf sheath. D: Lesions have developed to the 3rd - 4th leaf sheath. E: Lesions have developed to leaf shaths below the 5th; or no lesions.

Date of surveys

Every 10 days from the time of initial occurrence to 20th day after heading.

(3) Measuring the growth of rice plants

The survey should be made by the same method as in blast.

(4) Meteorological measurements

The records in the case of blast should be reserved.

b. Surveys by patrolling grower's fields

(1) The initial outbreak

Methods

In the fields systematically selected in each region, the percentage of diseased plants is determined on the basis of 50 plants at the maximum tillering stage.

(2) Process of disease progress

Methods

In the field, percentage of diseased plants is determined on the basis of 25 plants selected systematically. The degree of damage is also surveyed at the maturing stage.

Date of surveys

The surveys should be conducted twice, 20 days and 10 days before heading.

(3) Acreage classified according to the degree of disease outbreak

Methods

Acreage corresponding to each level of occurrence should be computed. For that purpose, the degree of occurrence evaluated by the following key should determined in each selected field.

Index	I	II	III	IV	V
Degree of sheath blight occurrence	None	Light	Moderate	Heavy	Severe
Percentage of damage	0	below 20	21 to 40	41 to 70	above 71

On the basis of 50 plants

Date of surveys

Once, 4 to 5 weeks after heading.

3. The method of forecasting sheath blight disease

a. Long term forecast

The technique must be separately established for each major variety of different maturity in representative seasonal cultivations. General outline of the forecast method is as follows:

(1) Best use of the correlation between the degree of damage at maturing stage and climatic factors should be made. Higher temperature and higher humidity during the growing season are favorable for the disease development. The temperature range for infection is 22 to

35°C with the optimum of 28 to 32°C. The favorable humidity for infection is above 96%. Especially, a spell of higher temperature with higher humidity after heading causes rapid upward progress of the disease, resulting in severe damage.

(2) A close positive correlation between the damage at maturing stage and the time and intensity of incipient occurrence, or the rate of disease development which is represented in increase of diseased tillers or plants is recognized. Primary infections of the disease ordinarily take place at the time when temperature rises to 22°C or more and the growth of rice exceeds the maximum tillering stage, provided that moisture is high enough for infection. Higher air temperature and higher humidity, cause earlier initial occurrence and successive rapid development of the disease.

(3) Early transplanting, application of much fertilizer, and planting many seedlings as a hill cause severe occurrence. Vigorous tillering with rich leaves helps contact infection and causes serious damage. Early varieties are usually more conducive to the disease. A higher degree of occurrence is observed when plants grow more rapidly and heading comes earlier than usual.

(4) Short term forecast

The rate of disease progress at a certain time is almost constant for successive 7 to 10 days, if there is no extreme change in climatic conditions. Periodical evaluation of the disease should be made. The percentage of diseased plants or stems should be converted into logit, and plotted against time. The obtained linear plot showing the disease progress will allow one to estimate the degree of subsequent occurrence.

C. Xanthomonas leaf blight

1. Objectives for forecasting

Flooding on paddy fields, typhoon, heavy rain with wind, and successive rains tend to cause severe outbreak of Xanthomonas leaf blight. Severity also depends to a large extent on varieties of rice. To obtain a higher degree of accuracy in forecasting, combinations of these factors should be always taken into account. Infections at earlier growth stage of rice cause severe damage. Therefore, inspection of the causal bacterium population at the early growth stage is emphasized. A long term weather report and the susceptibility of the varieties give supplemental information.

2. Surveys

Since the disease occurs locally and not uniformly over a large area, the topographical differences in disease outbreak and irrigation water systems should be understood by some detail for selecting model-fields or route for patrolling. The model-field for forecasting is selected at the center of the diseased area in each location.

a. Surveys in the model-field for forecasting

(1) Inspection of the bacterium population

The change of the bacterium population coincides with that of the bacteriophage. Therefore, the estimated amount of phages can take the place of estimation of bacterium population. Application of chemicals and meteorological conditions often affect the amount of phages. The surveys should be periodically carried out under prescribed conditions, such as before chemical spraying or after rainfall.

(a) Survey in nursery and during the period of early growing season in paddy field

Methods

The amount of phage in irrigation water is examined in the field for forecasting, in the nursery season and after transplanting. Fifty ml of water are sampled into a bottle with a cap made of polyethylene at the exit of irrigation flow of the field. Samples should be kept and carried in a container with some dry ice or ice cubes to protect the viability of phages. Two major strains of X. oryzae distributed in the area concerned, previously cultivated for the period of 96 to 120 hr, are suspended in sterilized water. The suspension with high density of bacteria is poured into a test tube. Four test tubes with 2 ml each of bacterial suspension are prepared for each water sample. One ml of the supernatant of the sampled water after 15-min centrifugation at 6,000 to 10,000 r.p.m is mixed with bacterial suspension of two tubes. One ml each of both ten parts and a hundred parts dilutions of the supernatant of the sampled water should be poured into the other two tubes with bacterial suspension. Then, 5 ml of warm PSA medium prepared at 50°C are added, and plate-cultured at 25°C for 10 - 15 hr. The resulted plaques are counted. These diluted samples are used when the original one is too dense to count the number of plaques. The medium to raise the bacterium, called PSA is as follows; 300 g potato, 0.5 g $Ca(NO_3)_2 . 4H_2O$, 2.0 g $Na_2HPO_4 . 12H_2O$, 5.0 g peptone, 15.0 g sucrose, 20.0 g agar, and 1 liter of water.

Date of surveys

The counting should be made; (i) twice weekly during the later season in the nursery, (ii) twice on more weekly after transplanting, and (iii) 2 to 3 times from the middle stage to the maximum stage of tillering.

(2) Survey of disease appearance

The relationship between the amount of phages and the disease incidence is to be made clear. The results of this survey will be utilized to correct or improve accuracy of forecasts made by the phage method.

(a) Survey in the tillering stage in a paddy field

Method

The percentage of diseased plants is computed from the data collected from 100 plants each at different 5 spots in the model-field for forecasting.

Date of surveys

The degree of the disease occurrence should be inspected at the middle stage and the maximum stage of tillering, when assessment of phage is concurrently conducted.

(b) Survey after booting stage

Accuracy of the forecast made by phage assessment in early growing season can be checked by this survey. The information will be useful in finding any factors which affect the accuracy of forecast.

Methods

The percentage of diseased plants at the end of booting stage is evaluated by the method mentioned before. The degree of disease occurrence at the maturing stage is determined on the basis of 100 plants from the model-field for forecasting.

Index	I	II	III	IV	V
Degree of bacterial leaf blight occurrence	None	Light	Moderate	Heavy	Severe
Percentage of disease occurrence	0	1 to 15	16 to 35	36 to 75	above 76

Percentage of disease occurrence is calculated by the following formula;

{Number of plants (a) + Number of plants (b) x 3 + Number of plants (c) x 5 + Number of plants (d) x 6 } x 100 / (Total number of plants counted x 6),

a: Plants with 1/3 or below of diseased area to the total inspected leaf area,
b: Plants with 1/3 to 2/3 of diseased area,
c: Plants with 2/3 or more of diseased area,
d: Plants with fully diseased area.

b. Survey of varieties concerned

The acreage of each major variety is computed, for higher accuracy of forecasting.

c. Measuring meteorological factors, such as wind speed, wind direction, amount of rainfall, the number of rainy days, typhoon, thunder shower, flooding, and mist. These would be conducive to cause epiphytotic, and are taken into consideration in the adjustment of forecast.

d. Surveys by patrolling grower's fields

(1) Survey of distribution of host grasses and disease occurrence on those in the nursery season

Distribution of Leersia sayanuka Ohwi, L. oryzoides Sw., and Zizania latifolia Turcz. as the primary inoculum sources should be surveyed. The date and the degree of disease appearance on these grasses are examined in the early stage of nursery season.

(2) Survey of overwintering of the causal bacterium in rice stubbles

The stubbles of rice overwintered in a warm district become an important primary source of inoculum. The percentage of alive overwintered stubbles should be determined on the basis of 100 plants in several locations. This information is helpful for forecasting occurrences

of the disease in nursery season and at tillering stage.

(3) Survey of bacterium population

(a) In nursery season and at tillering stage

Methods

The amount of phages in the irrigation system of a given area is examined by the method mentioned already. Fifty ml of irrigation water are collected from several locations.

Date of survey

Examinations are made once in the sowing season, twice weekly in nursery season, and twice weekly after transplanting, at the middle and maximum stage of tillering.

(4) Finding initial outbreak in paddy field

Field where an earlier initial oubreak occurs would supply the causal organism to a vast area. Therefore, inspecting the initial appearance of the disease is very important.

(5) Survey for disease progress

To identify the relationship between the amount of phages and the degree of disease occurrence, the survey of disease progress is to be made.

Methods

The degree of the disease incidence at the stage of maximum tillering and the end of booting is surveyed on the basis of 25 to 50 plants. The acreage corresponding to each degree of disease incidence should be computed at the milky-ripe stage. The degree of the disease incidence is represented by the key shown before.

Date of surveys

The surveys are made once each at the stage of maximum tillering, the end of booting, and the milky-ripe stage.

3. Methods for forecasting bacterial leaf blight

The following techniques for forecasting are tentatively adopted from the results obtained. The numerical relationship as such can not always be applied universally to different localities.

a. Forecasting in nursery season and in an early stage of paddy field

In the model-field: The number of phages is usually below 30 per ml of irrigation water of a nursery. Infection would occur when the number of phages becomes above 100. The more the number over the critical line, the severer is the infection. Outbreak of the disease after transplanting also would become severer and earlier. There are generally very small amounts of phages in irrigation water in paddy fields immediately after transplanting. Judging from the change in the phage amount, it is predicted when and where the primary appearance of the disease in paddy fields can be discovered. Generally, the initial occurrence of the disease would be observed when the phages are counted by 2,000 or more per ml of irrigation water.

The survey by patrolling: An initial outbreak on L. sayanuka may take place when the phage counts are about 50 per ml of irrigation water. In the rice plant the disease occurs 10 to 14 days later when the phage counts are about 100 per ml. In places where the disease occurs early in many fields, there is a possibility of severe outbreak at later growth stage.

b. Forecasting in later season in paddy field

The results of phage inspection in this season indicates the degree and the range of the primary occurrence. Many phages distributed in a vast area signifies probability of a heavy attack by X. oryzae. The distribution of rice varieties and climatic factors connected with infection and disease development are valuable data for adjusting forecast by phage inspection.

At the middle stage of tillering, the phage counts becomes a good index of disease severity at respective locations. Various levels of phage in irrigation water of observation fields, such as 50 or less, 100 or more, and 1000 or more correspond to the degree of disease occurrences, light, moderate to heavy, and severe, respectively. At the maximum stage of tillering, outbreak can be expected to be of various degree; light, moderate to heavy, and severe, corresponding to the various levels of phage counts, 100 or less, 500 or more, and 5,000 or more per ml of irrigation water, respectively. In patrolling surveys, an initial stage of disease occurrence in the area concerned can be recognized when the phage counts are 100 or above per ml of water, and the progressing stage of the disease corresponds to the time when the phage counts exceed 1,000 per ml. At the maximum stage of tillering, when there are many locations where the phage counts are 1,000 - 2,000 per ml or more, and the counts are rather uniform with different locations, it is interpreted that the primary infections have occurred over a rather wide range and the disease spread has not yet ceased. If susceptible varieties are widely grown, and there is a prospect of heavy rain or typhoon, a severe outbreak is expected. A light to moderate

occurrence is predicted when the phage counts fall below 500 per ml, and there are large variations in the phage counts among different locations, and no prospects of climatic conditions favorable for disease progress.

II. Diseases of wheat and barley

A. Rusts

1. Objectives for forecasting

The ecology of leaf rust and dwarf rust has been almost clarified, and some suggestions for forecasting have been published. The spring occurrence of the diseases may be forecasted by analyzing the occurrence conditions of the diseases in autumn. As for stem rusts and stripe rusts, the ecology of the overwintering pathogens has not been known and it is as yet not possible to forecast in far advance, judging from the present status. Therefore, attentions should be paid to statistical forecasting just before the disease occurrence that makes use of meteorological factors, and growth conditions of wheat or barley in spring, and also recognition of the incipient occurrence of the diseases.

2. Survey

(1) Survey on the fluctuation of the disease in the model-field for forecasting and the fields where early occurrence of the disease has been found.

The progress of the disease after the incipient occurrence should be accurately followed in the model-field for forecasting where wheat or barley is cultivated under favorable conditions for the disease occurrence, or in the fields where incipient occurrence has been found. The data obtained will be utilized for forecasting the occurrence of the current year. The data of the annual survey results should be accumulated, and the forecast method will be developed in relation to meteorology and growth conditions of wheat or barley.

Survey method and items

In the model-field for forecasting, two different plots i. e., the conventionally manured plot, and nitrogen rich plot will be set up, and rust-susceptible varieties of wheat or barley be sown 10 days ahead of the standard sowing time of the district concerned. The fields with incipient occurrence perceived may be selected at 2 or 3 spots from the fields of the growers within the district concerned. Therefore, the survey fields may be different in position in different years.

In these fields, 50 plants are selected from 50 cm long row at the site of the incipient occurrence of the diseases, and the following items are surveyed:

The number of the total leaves, of the diseases leaves, the degree of occurrence (determined on the basis of the illustration of the standard degree of the disease occurrence), the conditions of the incipient occurrence, and at the time of discovery, the transition of the disease occurrence in the spring time from the emergence time to March, every month, and the degree of the disease occurrence examined every 10 days from April to early ripening stage amy be included. In the snowfall regions, survey time may be modified to suit local conditions. When the disease occurrence is low, the number of pustules on diseased leaves may be counted. The observations should be made, as possible, on the same plants.

(2) Survey of the growth condition of wheat or barkey at the time of the vernal equinox, and the heading stage.

There is a rather significant relationship between the growth condition of wheat or barley at definite times, and the occurrence of the rusts in some regions. Therefore, the relationship of the growth condition of wheat or barley at definite times to the occurrence of the disease in the fields may be used for forecasting in the region concerned where there is a significant relationship between the growth condition of wheat or barkey in the past, and the occurrence of the rusts.

Examination method and items

Definite variety of wheat or barley grown at definite time with definite quantity of the seeds under definite amount of manuring will be examined in the model-field every year. As the survey items, the number of plants in 50 cm long row randomly selected every time, the individual heights of 50 plants, the degree of the growth as compared with the ordinary year crop will be examined.

Survey season

Examinations should be conducted at the time of vernal equinox, and at the heading stage. When there is a delay of growth after the time of vernal equinox, another examination should be conducted between this and the heading stage examination. In snowfall regions where the vernal equinox examination is impossible, the examination may be conducted at some definite time after snow melting every year.

Reference

Survey of the summer spores drifting in the air

The stationary type of spore trap equipment is actually useless in collecting spores because spores are collected only after the occurrence of the disease in the fields.

Usage of a revolving type of spore trap equipment may improve the method of spore trapping, and examination on the conditions of drifting spores may be conducted especially in regions of severe occurrence of rusts.

(3) Meteorological measurements in the spring season

The severity of occurrence is affected by meterological conditions such as temperature, frequency of rainfall, and duration of sunshine. Therefore, the relationship of meteorological conditions to the past occurrence of diseases should be analysed in the respective places. The most significant meteorological factors related to the disease occurrence consist of the maximum temperature in the respective day, the average temperature, the rainfall amount, duration of sunshine, and presence or absence of the yellow sands from the continent.

(4) Survey of acreage classified according to the degree of disease occurrence

Survey method and items

Twenty five sites are selected by a systematic selection method from each of more than 10 model-field and total of 100 plants consisting of 4 plants sampled at each-site are examined about the severity of the disease, in comparing with the examination standard. Areas with respective degree of disease occurrence are estimated.

Time of examination; Milky-ripe stage
Standard of disease occurrence based on disease severity

The degrees of leaf rust, of dwarf rust, and of stem rust are determined based on the figures A of the illustrated standard of the disease occurrence, and that of stripe rust on the figures B.

Index		I	II	III	IV	V
Degree of occurrence		None	Light	Moderate	Heavy	Severe
% based on	Fig. A	0	below 30	30 - 50	50 - 80	over 80
	Fig. B	0	below 25	25 - 50	50 - 75	over 75

2. Forecast method

a. Leaf rust, Dwarf rust

The disease occurrence in the current spring tends to be earlier and higher in the case where the occurrence in the autumn of the previous year was earlier and more widespread. The occurrence will be

high and widespread when temperatures were high in the previous winter, and rather high in the current spring, especially from April to May and afterwards in the northern parts of Kanto district, and the frequency of rainfall is low. Frequent rainfall and low temperatures in April to May are the limiting factors for the disease occurrence.

b. Stem rusts

A precaution should be taken for the occurrence in the current spring when the occurrence in the previous autumn was high and widespread in rather warm regions such as Chugoku, Shikoku, and Kyushu. An outbreak may occur in the late growing stage when there is a poor growth because of low temperatures and dry weather early in spring. In areas located north to the Kanto district, stem rust occurs very rarely in the spring, and there is no clear-cut relationship between the spring and the autumn occurrence. Therefore, statistical forecasting method may be applicable, using reliable data on the finding of incipient occurrences, meteorological factors, and growth conditions of wheat or barley.

The season, and the degree of occurrence of stem rust are generally positively related to temperatures, and duration of sunshine and negatively related to the frequency of rainfall in the current spring.

c. Stripe rusts

The occurrence of this disease in autumn is very rare in Japan, and any reliable forecast for the spring occurrence has not been established. The relationship between the frequency of yellow sand-fall (from the continent) and the severity of the disease occurrence may be said to be positive, but nowadays, forecast method of the disease is mostly concerned with the survey of distribution of most susceptible varieties to this disease and incipient finding of the disease.

B. Powdery mildew

1. Objectives for forecasting

In order to forecast the occurrence of powdery mildew, information on the disease occurrence in the previous autumn, whether it was widespread, ease or difficulty of overwintering by conidia, and the occurrence in the current spring whether it occurred early and widespread under suitable spring weather conditions, are most important. Therefore, data on meteorological factors during certain limited stages, and on the correlation between the growth condition of wheat and barley and the degree of disease occurrence may be used for the forecast. In addition, volunteer plants of wheat and barley, early sown wheat, and barley for green feed must also be examined as possible inoculum source of the disease, because the diseases on these plants tend to occur earlier in autumn.

2. Survey

(1) Survey of fluctuation of the disease in the model-field for forecasting and the fields where early occurrence of the disease has been found.

It is important for the forecast for the current year to follow transitional conditions of the disease after the incipient occurrence of the disease in the model-field for forecasting where wheat or barley is grown under most favorable conditions for the disease occurrence, or in fields where early occurrences of the disease have been recognized. The yearly data on transitional conditions of the disease occurrence, and analyses of these data in relation to other data such as meteorology, the growth condition of wheat and barley, etc., may be used for formulating forecast method.

Survey method and items

Susceptible varieties of barley, naked barley, and wheat to powdery mildews are grown as in the case of rust survey methods described above in the item (1), and the number of the total leaves, of the diseased leaves, the degree of disease occurrence, the first date of disease occurrence noticed, and changes in the number of lesions may be surveyed. The degree of disease occurrence should be determined by comparing with the accompanied figures of the illustrated standard of the degree of disease occurrence. The rate of lesion area may be added.

Index	Degree	Conditions of disease occurrence
I	None	No disease occurrence noticed.
II	Light	Only lower leaves diseased.
III	Moderate	Whole leaves excluding the uppermost and next developing leaves diseased.
IV	Heavy	Whole leaves including the uppermost and next developing leaves diseased.
V	Severe	Whole leaves including the uppermost developing leaves diseased severely.

Date of survey

The survey will be conducted once a month in the emergence stage to yellow-ripe stage, but the degree of the disease occurrence should be surveyed every 10 days from April. The plants to be examined should be constant every time.

(2) Meteorological measurements

The measurements may be conducted as in the section on rusts.

Reference

Survey on the overwintering conditions of conidia

When abundant conidia survive winter, it means an abundant initial source of inoculum in the following spring.

Examination method and items

A model-field with 3.3 m^2 area are set up at a suitable position in the agricultural experiment station or at some appropriate site in the area concerned. A variety of barley, naked barley, or wheat which is not high in liability for spring-sowing and highly susceptible to powdery mildew is selected, sown 10 days ahead of the general sowing time in early September, and cultivated by the conventional cultural practices in the area concerned.

Survey may cover the date of incipient occurrence, the degree of disease occurrence, and conditions of diseased leaves of 50 plants selected from 50 cm long row every time. The degree of occurrence should be determined according to the standard of the item 1.

Date of survey

The survey will be conducted once a month from the time of the incipient disease occurrence to the time of epidemics in the following spring, but twice a month in warm winter year.

Reference

Survey on overwintering conditions of perithecia

In addition to follow the dissemination of the disease by conidia, it is important to know the time of ascospore formation in perithecia and significance of ascospores as inoculum. To do this survey, wheat or barley straw with perithecia formed is kept indoors and outdoors, and formation of ascospores will be microscopically examined periodically. Infection of cereals by the ascospores may be examined on barley or wheat plants which are grown by sowing at standard time, with diseased straws of wheat or barley of the previous year being spread in the vicinity. These plants should be cultivated at a site away from the survey field for examination of overwintering conditions of conidia.

(3) Survey of acreage classified according to the degree of disease occurrence

Survey method and items

The test samples are obtained according to the method for rusts. The degree of disease occurrence should be determined following the survey standard, and the disease occurrence area be summarized on the basis of the degree of the disease occurrence.

The survey standard should be determined on the basis of the item (1) of the survey on the fluctuation of the disease.

Time of survey Milky-ripe stage

3. Forecast method

The disease occurrence in the spring tends to be early and high empirically when the occurrence in the previous autumn was early and widespread. The quantity of overwintering pathogens is high in warm winter. The occurrence is high under high temperatures and high amount of rainfall in April to May.

Powdery mildew generally occurs in endemic conditions, and area with these endemic occurrence should be pre-examined on the basis of the past conditions of the disease occurrence. The area are classified into several categories according to disease occurrence, and forecast will be made along this classification.

C. Scab Fusarium blight

1. Objectives for forecasting

Scab is a disease which affects ears of cereals. The occurrence time is influenced by earliness or lateness of the varieties of the cereal in question, and their growth conditions. The disease occurrence is closely related to meteorological conditions at heading stage, especially soon after the disease appearance.

Spread of the disease is very fast when weather conditions are abnormal soon after the disease occurrence, and in such cases the timing of appropriate control may be lost. It is important to pay attention to the meteorological conditions around heading.

2. Survey

(1) Survey of heading time and conditions of disease occurrence in the model-field for forecasting, or in the variety-preservation fields

Major local varieties of the cereal area grown in the model-field for forecasting, and the heading time and conditions of disease occurrence will be examined. This will serve for estimating general heading conditions in the area concerned. The variety-preservation field may be substituted for this work. The varieties of the cereal, growth conditions of the cultivated early, medium, and late varieties, and the time of heading, etc., should be pre-examined in the area in concern.

Survey method and items

The time of the start of heading, 50% completion of the heading, completion of the heading, and blooming of the respective major varieties are observed, and these growth conditions are compared with the growth conditions of these varieties in the ordinary year.

In order to survey the disease occurrence, 25 plants each of the major varieties are selected at random from 50 cm row, and data on the rate of diseased ears, and of damage are obtained. The rate of diseased ears and of the damage may be used to determine the degree of the disease occurrence.

The rate of damage is defined as the rate of diseased ears times the the rate of diseased spikelets (in wheat), or the rate of diseased grains (in barley). The degree of disease occurrence, and of damage should be determined based on the following table.

Index	I	II	III	IV	V
Degree of disease occurrence	None	Light	Moderate	Heavy	Severe
Rate of damage (%) Rate of diseased ear x rate of diseased spikelets (or rate of diseased grains)	0	below 5	6 - 15	16 - 30	over 31

Time of survey

The survey should be conducted every 5 days from the first week after blooming to the ripening stage.

Reference

Survey on ascospores and conidia drifting in the air

When it is high in temperature, and very humid because frequent rainfalls around the heading stage of barley, ascospores tend to float in the air abundantly. Therefore, the drifting of conidia and ascospores around the heading stage may be examined, and the data may be used for forecasting the disease occurrence together with meteorological data.

Survey method and items

Ten to 15 bundles of rice, wheat or barley straws are placed as the source of spores at the center of the model-field for forecasting, and spore trap equipment (stand) is set up at the crown height of wheat in leeward position 3m away from the spore source, 15 days ahead of heading. The source of spores is placed early in March (early to middle April in snow-fall regions).

The formation of perithecia, and their maturing conditions will be observed every other day from the setting of the straws to the milky-ripe stage, and the drifting conditions of conidia and ascospores be examined every day.

(2) Meteorological observations before and after heading stage

Survey method and items

The data may be obtained in field observations. Especially for the forecasting, temperatures, relative humidities, the amount of rainfall and the frequency of rainfall (the number of days) should be observed from 15 days ahead of heading to milky-ripe stage.

(3) Survey of acreage classified according to the disease occurrence

Survey method and items

The specimen for the examination may be collected following the method for rusts. The degree of disease occurrence should be determined by the survey standard of the item, 2-(1), and the area be summed up according to the degree of the disease occurrence.

Date of Survey Milky-ripe stage

3. Forecast method

There is an important relationship between the scab occurrence and meteorological conditions around the heading stage. When the average temperature exceeds 18 - 20°C, or day with 80% humidity may last over 3 days, or the frequency of heavy fog or rainfall is high (the time of sunshine is little) serious occurrence of the disease may occur.

(2) When the heading of wheat or barley is delayed, and is to meet the rainy season, the disease occurrence tends to be high.

(3) Perithecia which are the incipient inoculum source of the disease may be formed increasingly as the average air temperature become over 13°C, or soon after rainfall. The perithecium formation and spore drifting may almost show the same tendency. The examinations should be practised together with meteorological observations, and these results should be used for the forecast.

(4) Conditions of disease occurrence may be examined in early disease occurring areas in the district in concern, and the data may be adapted for other areas as reference.

III. Diseases of potato

A. Late blight

1. Objectives for forecasting

As later parts of the growing stage of potato plant gets into the rainy season, the late blight of potato may often occur very seriously, and decrease yield.

In general, in years of early incipient occurrence of the disease, the disease tend to be serious. Therefore, disease forecast must be made in relation to meteorology, growth conditions of potato plant, etc.

2. Survey

a. Survey in the model-field for forecasting, and in the fields where early occurrence of the disease has been found

(1) Survey of conditions of the disease occurrence

Conditions of the disease occurrence may be surveyed in the model-field for forecasting late blight of potatoes, where the plants are grown under favorable conditions for the disease occurrence. Occurrence in the general fields may be estimated from the tendency of the disease occurrence in this model-field.

Survey method and items

In the model-field for forecasting, early to medium potato varieties susceptible to late blight are selected, heavily manured with nitrogen fertilizer, and if possible, diseased tubers are planted at intervals of 10 plants. The field may be set up in an area where early incipient disease occurrence is usually recognized.

The survey items cover the date of incipient disease occurrence, the degree of disease occurrence, and fluctuations of the disease. In order to obtain data on the degree of disease occurrence, over 20 plants are examined in each survey, and the degree is determined on the basis of the following standard by rating individual plants and taking their average.

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	severe
Condition of occurrence	None	1/4 of the total leaves are diseased	About 1/4 -3/4 of the total leaves diseased, and a part of leaves died sometimes	Almost all leaves diseased and many leaves died	Almost all leaves died, and stems died sometimes

Date of survey

Survey should be conducted every 10 days after the incipient occurrence. The frequency of the survey must be increased during the time of disease spreading.

(2) Survey of disease occurrence in the fields with early occurrence

Considerable correlation can sometimes be found between the time of disease occurrence and occurrence conditions in fields with early disease occurrence either of the same district or of adjacent districts and that in other fields; also between fields in lowland (plain) areas and fields in high-land areas. Therefore, reciprocal equations based on past data should be worked out and used for the forecast.

Survey method

Characteristics of the local occurrence in relationships with occurrences in other localities should be analyzed.

Data include: ordinary time of incipient disease occurrence, ordinary spreading time, ordinary conditions of the occurrence, meteorological conditions of ordinary years, etc. In the area concerned, growth conditions of potatoes and other items in the incipient stages of the disease occurrence as well as in later stages of the occurrence in the current year should be observed as in the previous survey. These data in the fields of early occurrence will be used to forecast disease occurrences in fields of later occurrence.

b. Meterological measurements in the stage after floral-budding

As the occurrence of the late blight becomes heavy from the stage after floral-budding of potatoes, the meteorological conditions after this stage should be watched. The meteorological data will be useful for the disease forecast.

c. Survey by patrolling grower's fields

(1) Survey of time of incipient occurrence and progress of disease

In order to find incipient disease occurrence, and to grasp transitional conditions afterwards, the model-fields should be selected by a systematic sampling method in respective cultivation zones. In these model-fields, the degree of disease occurrence in 25 plants sampled from each field should be recorded. The degree of occurrence should be determined based on the item a (1).

Date of survey

Survey should be conducted 1 - 3 times from the time of the incipient disease occurrence to the spreading time.

(2) Survey of acreage classified according to the degree disease occurrence

Survey method and items

The degree of the disease occurrence may be determined in the model-fields selected in the aforementioned way, and the area of the occurrence is calculated on the basis of the severity. The survey method is the same as in the item (1). The degree of the disease occurrence is determined on the basis of the item a (1).

Date of survey

Survey is conducted at the peak time of disease occurrence and leaf yellowing stage, but the survey at the peak time may be substituted by the survey in the previous items c(1).

3. Forecast method

The late blight of potatoes is closely dependent on meteorological conditions, especially the weather after the floral-budding stage. Effect of various factors to the occurrence may be different in its significance in different areas, but as the common factors, in years of severe occurrence of the disease, the following items may be point out;

1) Days with average air temperature of 16°C come up early in the season,
2) The incipient occurrence comes early,
3) Period with daily average or 5-days-average air-temperatures of 18 - 23°C lasts for a considerable time, at least over 4 to 6 weeks,
4) The frequency of cloudy day with 90% humidity or with the amount of rainfall over 1 mm is high.

(2) There are big differences in the date of incipient disease occurrence, spreading season, and the degree of disease occurrence among different areas in the same prefecture or among different prefectures, but there are sometimes good correlation of these items among different localities. For example, if relationship between the date of incipient disease occurrence, and the degree of occurrence in plain areas and those in mountainous areas is established, information on the occurrence in plain areas may be useful for forecasting the time of incipient disease occurrence and the degree of disease severity, in mountainous and semi-mountainous areas.

(3) In initial growth stages the potato plant is very resistant to the late blight, but with the advance of growth, especially after floral-budding stage, the plant becomes increasingly susceptibile. The spreading of the disease is generally prevalent just before the harvest in plain areas west of Kanto region. Occurrence is usually more prevalent in years with early rainy season, or with retarded growth because of low temperature and dry condition in early growth stages of potato plants. In mountainous, semi-mountainous, or cool areas incipient occurrence may come earlier and the degree of occurrence may be high in years with fast growth, early floral-budding, and early flowering.

IV Insect pests of rice

A. Rice stem borer, Chilo suppressalis Walker

1. Objectives for forecasting

Rice plants are seriously damaged by larvae in the 1st generation when the duration of moth appearance in the overwintering generation is long-lasted or retarded, or moths are abundant in the later period of emergence. When the moth appearance continues for a long time after transplanting, insecticides should be applied more frequently than usual. Hence, it is important to forecast the variation of appearance type of moths in the overwintered generation.

Damages caused by larvae in the 2nd generation depend on the abundance of moths in the 1st generation. Application of insecticides should be timed according to the peak period of moth appearance. Therefore, it is important to forecast the peak period of moth appearance and the abundance of moths in the 1st generation.

2. Surveys

a. Investigation for forecasting the 1st brood* or overwintered generation moth appearance

(1) Survey of larval density at the time of harvest (survey before overwintering)

Most larvae overwinter in harvested straws or stubbles of rice plants, but some in the stems of such graminaceous grasses as Zizania latifolia Turcz. etc. As overwintering sites more or less differ in various regions, it is rather difficult to estimate the larval density accurately. However, it is important for forecasting the relative abundance of moths in the following year to estimate at least approximate density of larvae overwintering. The survey is made to know the larval density before overwintering and overwintering site.

Methods of survey

A survey field with a 3- or more-are area is to be selected randomly in each district according to different types of rice culture and occurrence of the rice stem borer, and the model-field for forecasting mentioned elsewhere should be added. The survey fields are preferably grown with

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* The term "brood" is used to denote the appearance of moth population, e. g. the 1st generation eggs are laid by the 1st brood moths which emerge from overwintered larvae.

representative varieties of rice plants by usual manners in each district, and cutting and after-treatments are also preferred to be usual.

Take out straws and stubbles of 100 hills sampled systematically, and examine the following items for estimating the number of living larvae / 10 are and mortality:

Rice straws of 100 hills;

Nos. of stems examined, of stems infested, of stems in which borers are found, of living larvae, of dead larvae, body weight / living larva, and no. of larvae cut at harvest, if possible.

Stubbles of 100 hills;

Nos. of hills injured, of hills in which borers are found, of living larvae, and of dead larvae.

In regions where larvae usually move from rice plants to other sites for overwintering, the survey mentioned above should be supplemented by an additional survey on the same items after December when larvae seem to have completed their migration. The number of larvae moved away may be estimated and the sites for overwintering should be looked for.

In regions where little difference of larval density is found before and after overwintering, particularly in western parts of Japan, this survey may be omitted and the survey after overwintering mentioned in the following paragraph is to be carried out preponderantly.

(2) Survey of larval density after overwintering (survey after overwintering)

Together with the survey in the preceding paragraph, this survey is intended to estimate the mortality during overwintering, number of overwintered larvae, etc. This survey may be omitted in Hokkaido and Tohoku districts.

Methods and items of survey

About two months prior to the peak period of moth appearance in the overwintering generation in normal years, examine the following items to estimate the number of living larvae / 10 are and mortality, similarly to the methods for the survey before overwintering:

Rice straws of 100 hills

Nos. of stems examined, of stems infested, of stems in which borers are found, of living larvae, of dead larvae, of living pupae, of dead pupae, and of empty pupae.

Stubbles of 100 hills

Nos. of hills infested, of hills in which borers are found, of living larvae, of dead larvae, of living pupae, of dead pupae, and of empty pupae.

This survey should be annually made at about the same date for a given site.

(3) Observation of development and vitality of overwintering larvae kept at 25°C (incubation method)

This observation is to be omitted in regions where the Shonai ecotype is distributed.

The purpose of this observation is to estimate the developmental state and vitality of overwintering larvae by means of examining the time of pupation, trend of pupation, daily rate of pupation, etc., keeping larvae collected from fields at a constant temperature of 25°C.

Methods of observation

Collect more than 300 larvae either from harvested straws in regions where most larvae overwinter in harvested rice straws or from stubbles where those overwinter in stubbles, two to three months prior to the peak period of moth appearance when overwintered larvae begin to be reactive to the fluctuation of outdoor temperatures in normal years. The larvae, sterilized in a 1 : 1000 solution of corrosive sublimate, are separately put into small glass-tubes with small pieces of dried leaf sheaths of rice plants. After larvae are put into the sheaths, glass-tubes are stoppered with brass wire gauze. Set the glass-tubes into a tin with lid and bottom made of wire gauze. A tin, ca. 8 cm in diameter and ca. 5 cm in depth, accommodates a bunch of about fifty glass-tubes. Put the tins into small desiccators at 95 % R. H. Controlled with a saturated solution of potassium nitrate (KNO_3), and keep the dessicators within incubators at 25°C.

Start placing overwintering larvae in incubators for this purpose at each site on the same date every year. For example, the middle in March seems to be suitable for Kanto region.

Items of investingation

Weigh 50 larvae individually in mg before they are put into small glass-tubes to obtain the frequency distribution and the average body weight. During incubation, count living and dead larvae and pupae every other day to obtain the average period before pupation, cumulative rate of pupation, cumulative rate of pupation, mortality, etc.:

Average period in days before pupation =

Σ ((days from the beginning of incubation to pupation) no. pupae obtained on a date)/total no. pupae obtained

Cumulative rate of pupation = cumulative no. pupae / (no. living larvae at each observation + cumulative no. pupae on a date)

Mortality = no. dead larvae / total no. larvae used

Reference — Investigation of the development and vitality of overwintering larvae kept indoors (indoor-keeping method)

Similarly to that mentioned in the preceding paragraph, this investigation is intended to estimate the developmental state and vitality of overwintering larvae. This is based on the fact that trends of moth emergence from larvae kept indoors approximately corresponds to that in the field.

Methods and items of observation

Collect more than 300 overwintering larvae in the field two to three months prior to the peak period of moth appearance in normal years. After the treatment mentioned in the preceding paragraph, keep them indoors without heathing or cooling. Examine time and rate of pupation:

The date of 50 % cumulative pupation . . . . the date when 50% of larvae (excluding dead ones) used pupate

Mortality . . . . . ratio of the cumulative no. dead larvae by the date of 50% cumulalive pupation : no. all larvae used

b. Observations for forecasting the 2nd brood or 1st generation moth appearance

(1) Observation of larval development in the 1st generation

This is to estimate larval development, pupation, and density in the last period of the 1st generation.

Methods and items of observation

About three weeks prior to the peak period of moth appearance in usual years, the following surveys are started in the model-field for forecating and other fields around it:

(a) Field observation by sampling: Collect randomly 30 to 40 larvae and pupae in each of two or three observation times and count living and dead larvae, pupae, and empty pupae to know the rate of pupation and moth emergence.

(b) Observation of sex cell development in male larvae ("cyst" method): Collect more than 30 male larvae in the field every other day and measure diameter and length of spermatocytes under a microscope. Otherwise, divide the spermatocytes into developed and undeveloped categories * based on shape, piliform as developed and round as undeveloped, and judge developmental state of each larva on the basis of percentage of developed spermatocytes.

(2) Survey by patrolling over grower's field

(a) Survey of larval density

Methods and items of the survey

Designate about ten fields for this survey. Count stems infested (dead hearts and resembling tillers), stems in which borers are found, living larvae (separately at each instar), dead larvae, pupae, and empty pupae found from all the stems of 25 hills in each field to estimate the density / 10 are

Time of survey

Twice; the peak and the last period of infestation with larvae.

(b) Survey of acreage of rice fields in each degree of occurrence in the 1st generation

Methods and items of survey

Calculate the percentage of infested stems from 25 hills altogether for each field, as surveyed in preceding paragraph, to classify the degree of occurrence according to the following standard. Sum the area of rice fields in each degree of occurrence.

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* Tentative categories of development:

1;	Developed spermatocytes in a microscope field	> 81 %.
2;	do.	= 61-80 %.
3;	do.	= 41-60 %.
4;	do.	= 21-40 %.
5;	do.	< 20 %.

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
% stems infested by the 1st-generation larvae	0	1 – 5	6 – 15	16 – 15	31 –

When the damages are very severe and areas belonging to the Index V are very large, divide the Index V into sub-categories of 10 % interval.

Time of Survey
Once; in the last period of infestation

(c) Survey of acreage of rice fields in each degree of occurrence in the 2nd generation

To grasp the actual state of occurrence in the 2nd generation, examine the area of rice fields in each degree of occurrence by patrolling inspection. The procedures are similar to those for the 1st generation.

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
% stems infested by the 2nd generation larvae	0	1 – 5	6 – 15	16 – 40	41 –

When the damages are very severe and the areas belonging to the Index V are very large, divide the Index V into sub-caregories of 10 % interval.

Time of survey
Once; at the time of harvest

3. Methods and procedures for forecast

a. Moth appearance in the overwintering generation (1st brood)

(1) Moth emergence curves from overwintering larvae kept indoors at room temperatures are considered to approximate those in the field.

(2) For earlier forecast, moth emergence curves from larvae kept in incubators are available. The curves are deemed to resemble in shape those of field population.

(3) When the larvae to be kept at room temperatures or in incubators are properly sampled in proportion to the actual density at each survey point,quantitative changes in moth appearance in the field will be forecasted to some extent by comparing the maximum and minimum densities with the mean density. Moreover, the percentage of moth emergence may be estimated to some extent from the body weight of the larvae.

(4) In adapting equations obtained from the light trap records, examine confidence range of correlation coefficients for each survey site, before issuing actual forecast.

(5) For the standard of moth appearance time, use either the date of peak moth appearance or the date of 50 % cumulative moth appearance. The differences between the two are usually one or two days. When the date of 50 % cumulative moth appearance comes later than the date of peak moth appearance, notice that many moths are often apt to appear in the later period of emergence.

b. Infestation with larvae in the 1st generation

(1) It is considered that infestations are often severe when many moths in the overwintering generation appear in the later period of emergence.

(2) For use of light trap records, see (4) in the preceding paragraph.

c. Moth appearance in the 1st generation (2nd brood)

(1) Estimate fluctuations in moth emergence or apperance by the examination of larval development and that of spermatocytes from field sampls.

(2) Estimate the fluctuating patterns of moth density from the results obtained by patrolling inspection and those mentioned in a (3).

(3) See a(4) to obtain forecasting equations from light trap records.

d. Infestation with larvae in the 2nd generation

The earlier and more abundantly the moths in the 1st generation appear, the more severely rice plants are damaged usually by the larvae of the next generation. Accordingly, grasp the amount of the moth appearance and estimate the degree of infestation by the larvae, by utilizing the forecast described in the preceding articles.

B. Paddy borer, Tryporyza incertulas Walker

1. Objectives for forecsting

The larva feeds only on rice plant, i. e., monophagous in Japan. The occurrence of this borer is considerably affected by whether or not rice plants are grown in the field when moths in the overwintering generation emerge, and whether the peak period of moth emergence comes before or after the time of transplanting. Accordingly, it is important for forecasting the occurrence to estimate the period of appearance and the abundance of moths in the overwintering generation. There are some regions where light trap records show clearly two generations or three generations a year. As the prevalence varies considerably by years, it is important to pay attention to the annual fluctuations in light trap records. The forecasts in the 1st and the 2nd generations aim mainly at earliness or lateness of peak period of moth appearance and abundance of moths. These will be used to estimate adequate time of insecticide application in each generation.

2. Observations and surveys

a. Surveys for forecasting the 1st brood or overwintering generation

(1) Survey of overwintering larvae

The survey is intended to estimate the overwintering rate and developmental state of larvae, as the source of the ensuing moths, and to know the influence of environmental conditions in winter on larvae.

Methods and items of survey

Designate several fields, taking into consideration, the occurrence and infestation in the preceding generation, dig up 100 stubbles from each field, and dissemble them. Count the hills infested, living larvae, dead larvae, living pupae, dead pupae, and empty pupae, and calculate the rates of overwintering and pupation. Then, estimate the density / 10 are:

Rate of overwintered borers = no. living borers (living larvae + living pupae + empty pupae) / (no. living borers + dead borers (dead larvae + dead pupae))

Rate of pupation = (no. empty pupae + no. living pupae + no. dead pupae) / (no. empty pupae + no. living pupae + no. dead pupae + no. living larvae)

Time of survey

Twice; before pupation or one month prior to the peak period of moth appearance in the overwintering generation and two weeks after the 1st survey.

b. Survey for forecasting larval density in the 1st generation

(1) Survey of egg-masses deposited

Count egg-masses deposited on rice seedlings in nursery beds and those on younger rice plants transplanted in paddy fields to estimate the larval density.

Methods and items of survey

Count egg-masses found / 10 m^2 in each nursery bed or field previously designated in different areas as to the occurrence of the borer. The survey should be made at a fixed site within each paddy field or nursery bed throughout the period of the survey. Take away all the egg-masses found with leaf blades after they are counted.

Time of survey

Every five days throughout the period of the moth appearance in the overwintering generation in nursery beds and paddy fields.

c. Surveys for forecasting the 2nd brood or 1st generation moth appearance

(1) Survey of larval development and density

It is sometimes difficult to forecast the number of moths in the 1st generation and the larval density in the 2nd generation only by means of the surveys of light trap catches of moths in the overwintering generation. Accordingly, it is necessary to examine larval development, pupation, and population density in the last period of the larval stage in the 1st generation in the field. When the development is delayed considerably in many larvae, there is a possibility that the paddy borer closes the annual cycle through only two generations.

Methods and items of survey

Designate several nursery beds and paddy fields in areas different as to the occurrence of the borer and pick up all the rice seedlings / m^2 in each nursery bed or all the rice plants of 25 hills in each paddy field. Count the number of stems or seedlings, hills or seedlings infested, stems injured, stems in which living borers are found, and all the borers (living larvae, dead larvae, living pupae, dead pupae, and empty pupae). As the result, estimate the density / 10 are

Time of survey

Twice; in the peak and the last period of infestation.

d. Surveys for forecasting the 3rd brood or 2nd generation moth appearance

(1) Survey of larval development and density

Methods and items of survey

Make the survey similarly to that described in c (1).

Time of survey

Twice; in the earlier and the last period of infestation.

(2) Survey of acreage of rice fields in each degree of occurrence in the 2nd generation

Pick out 25 hills of rice plants from each paddy field, and count all the stems and the stems infested to calculate the percentage of stems infested. The standard of the degree of occurrence is given in the following table to sum up the area of rice fields in each degree of occurrence.

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
% stems infested	0	1—2	3—5	6—10	11—

When the areas belonging to the Index V are very large, divide the intensity V into sub-categories of 10 % interval.

Time of survey

Once; late in August or three to four weeks after the peak period of moth appearance.

e. Survey of occurrence in the 3rd generation

(1) Survey of acreage of rice fields in each degree of occurrence

Methods and items of survey

Make the survey similarly to that described in d (2).

Standard of the degree of occurrence

Inex	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
% stems infested	0	1 – 5	6 – 10	11 – 20	21 –

When the areas belonging to the Index V are very large, divide the Index V into sub-categories of 10% interval.

Time of survey

Once; early in October or three to four weeks after the peak period of moth appearance.

3. Methods and procedures for forecast

a. Time of moth appearance in the overwintering generation (1st brood)

(1) Use the results of the survey of developmental state of overwintering larvae.

(2) Obtain regression equations between light trap records and various meteorological factors for each district, with due considerations of statistical probability.

b. Abundance of moths in the overwintering generation

(1) Consider the abundance of moths from the results of the survey on density of overwintering larvae; the density of moths is to be high when that of overwintering larvae is high.

(2) Obtain regression equations between light trap records and various meteorological factors and use them for forecast.

c. Infestation with larvae in the 1st generation

(1) Larvae may even bore into rice seedlings and damage them. Consider that infestation is to be severe when moth appearance is delayed, or when the growth of rice plants is more advanced than in usual years.

(2) Consider that infestation is to be serious when egg-masses are abundant.

d. Time of moth appearance in the 1st generation (2nd brood)

Forecast it from the results of the survey described in 2 c (1).

e. Abundance of moths in the 1st generation

(1) It is considered that the density of moths is to be high when the larval density in the last larval stage of the 1st generation is high. When the larvae show large variations in their developmental speed, it is a sign that the majority of the individuals in the 2nd (next) generation fail to emerge, and there is no appreciable moth appearance in this generation(3rd brood).

(2) Use light trap records, as described in b (2).

f. Infestation with larvae in the 2nd generation

Forecast it from the estimation of the abundance of moths in the 1st generation, as described in 3 e.

g. Time of moth appearance in the 2nd generation

Forecast it from the results of the survey of larval development described in 2 d (1).

h. Abundance of moths in the 2nd generation

(1) Forecast it by means of examining the larval and pupal densities in the last larval stage in the 2nd generation, as described in e (1).

(2) Use light trap records, as described in b (2).

i. Infestation with larvae in the 3rd generation

Forecast it from the estimation of the abundance of moths in the 2nd generation, as described in h.

C. White-backed planthopper, Sogatella furcifera Horváth

1. Objectives for forecasting

The planthopper attacks seriously rice plants especially from the tillering to milky-ripe and dough stages. The point of this survey is to forecast the densities of both nymphs and adults in those stages.

2. Surveys

a. Survey before adult invasion into paddy fields

The 2nd or 3rd brood* adults in the western part of Japan and the 1st-brood adults in the northern part fly from other habitats into rice fields in June to early July and in July, respectively. In order to grasp the actual state of occurrence in the foregoing generations, the following survey is to be made in parallel with that by light traps.

(1) Survey by sticky traps

Methods and items of survey

Set sticky traps in several places such as the model-field for forecasting and fields where adults usually appear early in summer annually. Count planthoppers captured by sticky traps every three days.

Time of survey

From April to the end of July.

Reference Survey of planthoppers around paddy fields

Methods and items of survey

Collect both adults and nymphs on gramineous grasses around paddy fields where the planthopper occurs every year, using a suction catcher or sweep net, from April to May. Estimate the density / 10 m^2. It is desirable to have sampling plots as many as possible.

b. Survey of seasonal fluctuations in population density in paddy fields

Make the survey in the model-field for forecasting and fields where the planthopper occurs every year, as follows:

(1) Survey of adult density

The survey is designed to estimate the densities of the 2nd-brood and the 3rd-brood adults flying into paddy fields.

Examine the number of adults on plants / m^2 in each of the nursery beds or on 25 hills of rice plants in each of tne paddy fields by either push-aside-and-count method or tap-and-count method to estimate the density / 10 m^2. In parallel, it is better to examine the density by sweeping method.

* For the relation between the brood and generation see the appendices II, on P. 200 - 201

Time of survey

Every five days since the catches by light traps increase rapidly.

(2) Survey of population density in paddy fields

This survey is intended to estimate population density in paddy fields.

Methods and items of survey

Count eggs deposited or egg-laying punctures, nymphs, and adults on plants / m^2 in each of the nursery beds or on 25 hills of rice plants in each of the paddy fields by means of either push-aside or tap-and-count method to estimate the density / 10 m^2. It is better to examine the density by sweeping method at the same time.

Time of survey

Twice; middle July and between late July and late August.

(3) Survey of acreage of rice fields in each degree of occurrence

Methods and items of survey

Count eggs or egg-laying punctures, nymphs, and adults on 25 hills of rice plants to estimate the densities of eggs, nymphs, and adults / hill. In addition, it is better to make survey by sweeping method to confirm the density of nymphs and adults.

According to the standard of the degree of occurrence given in the following table, sum up the area of rice fields in each degree of occurrence:

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Rare	Medium	Abundant	Severe
Density / hill (by push-aside or tap-and-count method)	0	1—10	11—50	51—100	101—
No. eggs / hill	0	1—10	11—50	51—100	101—

Density / m^2 (by sweeping method)	0	1 – 30	11 – 50	51 – 100	101 –
Time of survey					

Twice; middle July and between late July and late August.

3. Methods and procedures for forecast

The outbreaks of the white-backed planthopper ever recorded frequently occurred in years of warmer preceding winter and warmer May to June, with little rain and little rainfall in the rainy season (usually June to early July). In such years the planthopper appeared in certain places earlier than in usual years, and population density in paddy fields increased rapidly. Hence, it is necessary to notice the meteorological data of the current year and to collect the 1st, 2nd, and 3rd brood adults in the western part of Japan in order to estimate the densities of adults as flight sources before invasion into nursery beds and paddy fields.

Estimate the density of adults flying into nursery beds and paddy fields from both the light trap records in June to July and the data as to densities surveyed in nursery beds and paddy fields.

Forecast the time of appearance and density of nymphs in the following generation in paddy fields soon after transplanting from the time and density of adult invaders. Similarly, forecast the densities of the descendant generations that cause serious damages to rice plants from the results of the field survey made in late July to middle August. In this case, it is necessary to take in account the reduction of population density due to the application of insecticides for rice stem borer control.

D. Brown planthopper, Nilaparvate lugens Stål

1. Objectives for precasting

The infestation with nymphs and adults in the brown planthopper is serious mainly from the booting to the heading and dough stages, a little later than that in the white-backed planthopper. As the brown planthopper frequently occurs abundantly in years of warmer preceding winter and warmer May to June with little rain, similarly to the white-backed planthopper, it is possible to prospect the occurrence from that of the white-backed planthopper.

a. Survey before adult invasion into paddy field

The 2nd brood adults fly from other habitats into rice fields in middle June to late July. Make the survey to know the actual state of

occurrence of the preceding generation rearing on wild grasses, as follows:

(1) Survey by sticky traps

Methods and items of survey

Make the survey as described in 2 a (1) for the white-backed planthopper.

Reference

Survey of the planthoppers around paddy fields

Methods and items of survey

Make the survey, similarly to that described in 2 a (2) for the white-backed planthopper.

b. Survey of seasonal fluctuations in population density in paddy fields

Make the survey in the model-field for forecasting and paddy fields where the planthopper occurs about every year, as follows:

(1) Survey of adult density

The survey is intended to estimate the density of the adult invaders in paddy fields.

Methods and items of survey

Similar to those mentioned in 2 b (2) for the white-backed planthopper.

(2) Survey of population density in paddy fields

The survey is intended to estimate the growth of population in paddy fields.

Methods, items, and time of survey

Similary to those mentioned in 2 b (2) for the white-backed planthopper.

(3) Survey of acreage of rice fields in each degree of occurrence

Methods and items of the survey, and standard of the degree of occurrence

The same as with 2 b (4) of the white-backed planthopper.

Time of survey

Once; between the 3rd five-day period in September and the 3rd five-day period in October.

3. Methods and procedures for forecast

The outbreaks of the brown planthopper show almost similar characteristics to those of the white-backed planthopper. Accordingly, estimate the density of macropterous adults invading nursery beds and paddy fields from both light trap catches and survey in the field in June to July to forecast the time of appearance and the density of the following generation.

Forecast the nymphal density in September from the density of adults and their egg-laying estimated by the 2nd survey in the paddy fields.

E. Smaller brown planthopper, Laodelphax striatellus Fallén and rice stripe disease

1. Objectives for forecasting

Stripe disease is transmitted by the smaller brown planthopper. Empirically, it is known to occur abundantly under such climatic conditions as fine weather and early ripening of barley and wheat in May, cloudy weather and little rainfall in June, and little rainfall and cooler weather in July. As cultural situation such as early transplanting also affects the occurrence of this disease, it is necessary to pay regard to the susceptibility of rice plants.

Infection of the disease in nursery beds and paddy fields soon after transplanting is related with the period of occurrence and number of invading adults in the 1st generation and also with the density and percentage of viruliferous nymphs and adults in the 2nd generation. Accordingly, it is important to grasp and forecast the factors mentioned above.

2. Surveys

a. Survey before the invasion of adults into paddy fields

(1) Estimation of the time of termination of diapause in the overwintering generation

Annual fluctuation in the time of termination of diapause in nymphs is to be made clear for estimating advance or delay of the development and resulting variation in reproductivity.

Methods and items of observation

Twenty male nymphs are collected at each of several optional points and dissected to examine the developmental stage of their gonads*. The minor and the major axes of each testicular follicle are measured, and the value (minor axis)^2 × (major axis) is presented as an index for the state of development.

Time of survey

Once ; from January to middle in February.

(2) Survey of population density and time of adult emergence of the overwintering generation

Population densities of nymphs and adults and earliness of adult emergence are surveyed.

Methods and items of survey

At three common overwintering places in each district, adults and nymphs in each 10 m^2 are collected by a suction-catcher or an insect net, and the mean number of adults and nymphs and the mean percentage of adults are calculated.

Time of survey

Twice ; early and late in March.

(3) Survey of occurrence of nymphs in the 1st generation

Earliness or lateness of the hatching time and population density of nymphs in the 1st generation are surveyed in anticipation of invading period and amount of the 2nd brood adults invading nursery beds and paddy fields.

Methods and items of survey

Survey of the number of insects / 10 m^2 is made by a suction-catcher, an insect net, etc. in wheat or barley fields where the 1st generation nymphs are growing.

Time of survey

Three times at five-day intervals from the milky-ripe stage of wheat or barley.

* See Shokubutsu-boeki (Plant Protection) Tokyo, 12(9), 1958.

b. Survey of population density in nursery beds and paddy fields

Survey of adult and nymphal population densities is made after the invasion of the 2nd brood adults into nursery beds and paddy fields.

Methods and items of survey

Number of planthoppers/10 m^2 is estimated by tap-and-count method, or other method., on 25 hills in the model-field for forecasting, or in four plots of 1 m^2 in nursery beds. It is recommended to carry sweeping survey, also.

Time of survey

Four times ; in the last period of nursery bed and early period of paddy field (in both cases the 2nd brood adults are main objects of the survey), peak period of hatching in the 2nd generation, and period of occurrence of older nymphs in the 2nd generation. In areas where an aerial application of insecticides has been made, however, survey is made after several days from the end of application.

c. Survey of percentage of viruliferous planthoppers(to be conducted only in designated prefectures)

To forecast the infection of the stripe disease and to analyze the cause of occurrence of the disease, percentage of viruliferous planthoppers is surveyed for adults and nymphs in each generation, before and after their invasion of nursery beds and paddy fields, in the region of occurrence of the disease.

Methods and items of survey

Percentage of viruliferous planthoppers is surveyed by hemagglutination test for 300 samples in each lot.

Time of survey

Once in the peak period of adult and nymphal appearance in each generation.

d. Observation of the time of respective leaf-emergence

Plant-age is determined by the number of leaves on the main culm, to know changes in susceptibility of rice plant to virus.

Methods and items of survey

Count the number of leaves on the main culms in each of 25 hills of rice plants in the model-field for forecasting.

Time of observation

The observation is made at the same time as the survey of the state of development of rice plants.

e. Survey of area of rice fields in each degree of occurrence of the planthopper and the disease

Methods and items of survey

The survey is carried out in the districts where the stripe desease is serious. The number of smaller brown planthoppers on 25 hills is counted to estimate the density / hill by the tap-and-count method or the density / 10 m^2 by the sweeping method. The percentage of stripe diseased hills is calculated for 50 hills. Then the degree of occurrence in every field surveyed is estimated according to the standard given in the following tables, and the areas in each degree of occurrence are summed up.

Standard of the degree of occurrence

Smaller brown planthopper

Index	I	II	III	IV	V
Degree of occurrence	None	Rare	Medium	Abundant	Severe
Density / hill	0	1 - 2	3 - 5	6 - 10	11–
Density by sweeping/m^2	0	1 - 6	7 - 35	36 -180	181–

Rice stripe disease

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
% hills infected	0	1 - 20	21 - 40	41 - 80	81 - 100

Time of survey

Smaller brown planthopper : Once ; in the peak period of population density in July.

Rice stripe disease : Twice : between middle July and early August and between middle August and late September.

3. Methods and procedures for forecast

Transmission of the stripe disease begins with the invading of adults of the smaller brown planthopper into nursery beds and paddy fields, but transmission by descendant nymphs in the 2nd generation is often more important. As development of the smaller brown planthopper fluctuates annually and the state of development of rice plants relating to the susceptibility also changes from year to year, infection mechanism is rather complicated.

Since the smaller brown planthopper passes several stages from the nymphal stage of the overwintering generation to that of the 2nd generation before the stripe disease is transmitted or propagated, as mentioned above, the population density changes considerably during the course.

Although the objective is to forecast both the occurrences of adults in the 1st generation and of nymphs in the 2nd generation in nursery beds as well as in paddy fields soon after transplanting, it is necessary to use such a procedure as to ascertain the forecast at a certain time from the result of the next survey which is turned to account of the next forecast.

That is, the time and the abundance of adults in the overwintering generation are estimated by the surveys a 1, 2, and are confirmed by the survey a 3, thereby earliness or lateness of appearance and the abundance of the 1st generation adults which invade nursery beds and paddy fields soon after transplanting are forecasted. The trend in the number of catches by light trap is also to be taken into consideration. When the survey c has been made, the amount of infection in nursery beds and in paddy fields soon after transplanting can be forecasted.

The stripe disease causes such damages as decreased tillering, obstruction of heading and, fruiting, etc. when transmitted before the 10- to 11-leaf stage, even after transplanting. The survey b and d contribute to forecast this late infection, which is expected to be abundant when the nymphal density in the 2nd generation is high and the development of rice plants as expressed by leaf number is delayed. The survey e gives data for forecasting over wide areas.

F. Green rice leafhopper, Nephotettix cincticeps Uhler and virus diseases

The grren rice leafhopper and the rice dwarf disease

1. Objectives for forecasting

The rice dwarf disease which is transmitted by the green rice leafhopper is considered to occur, abundantly when the 2nd brood adults appear late and their population density is high, and consequently the amount of their invasion into nursery beds or paddy fields is large. Therefore, it

is one of the main aims to forecast this amount of invasion. As the dwarf infection sometimes occurs in later developmental stages of rice plants, it is necessary to follow fluctuation of the insect vector population in the paddy field.

2. Surveys

a. *Survey in the overwintering generation*

(1) Estimation of the time of termination of diapause

Earliness or lateness of the termination of diapause in over-wintering nymphs is discriminated, and the results obtained are utilized to forecast successive progress of development.

Methods and items of survey

Twenty male nymphs are collected at several optional places and dissected to examine the degree of development of their testes, similarly to those for the smaller brown planthopper.

Time of observation

Once; between January and middle in March.

(2) Survey of population density after overwintering and of the time of emergence

This survey is made to know the population densities of nymphs and adults and the earliness or lateness of the time of emergence.

Methods and items of survey

Collect adults and nymphs in 10 m^2 at each of three typical overwintering sites in each district by a suction-catcher, an insect net, etc., and then estimate the average densities of adults and nymphs/10 m^2 for three places and the percentage of emergence.

Time of survey

Twice; late in March and early in Apil.

b. Survey of the period of appearance of nymphs in the 1st generation

To know the period of emergence of adults invading nursery beds and paddy fields, the earliness or lateness of appearance of nymphs shall be made clear.

Methods and items of survey

Collect about 300 nymphs where host grasses such as foxtail, Alopecurus aequalis Sobol. var. amurensis Ohwi., etc. to which adults in the overwintering generation preferringly deposit their eggs are abundant, and examine the degree of their development.

Time of survey

Once; early in June.

c. Survey of population density in nursery beds and paddy fields

The survey is made to pursue the change of the population density of the vector in nursery beds and paddy fields.

Methods and items of survey

Count adults and nymphs on 25 hills in the model-field for forecasting or those on seedlings in four plots of 1 m^2 in each nursery bed, by tap-and-count method, etc. to estimate the density/10 m^2. Besides, it is desirable that survey by sweeping is made together.

Time of survey

Every five days from the time when catches by light trap begin to increase rapidly. In areas where aerial application of insecticides has been made, it is conducted after several days from the end of the application.

d. Survey of the occurrence of the disease

The degree of occurrence of the disease is surveyed as to representative varieties cultured in usual manners to obtain data for grasping the situation and establishing forecast method.

Methods and items of survey

Fifty hills to each of several representative varieties cultured in usual manners of the respective district are chosen, and examined for disease symptoms, and the percentage of infected hills is calculated.

Time of survey

Once in the last stage of tillering.

e. Survey of the percentage of viruliferous leafhoppers (to be conducted only in designated prefectures)

Adults and nymphs in each generation before and after invading nursery beds and paddy fields in the diseased region are tested for the percentage infectivity of leafhoppers, to forecast the infection of the dwarf disease and analyze the causal factors of the disease.

Methods and items of survey

Sample of 50 to 100 insects in each lot are tested for the percentage infectivity by the method using rice seedings or other methods.

Time of survey

Once in the peak period of adult and nymphal appearance in each generation.

f. Survey of acreage of rice fields in each degree of occurrence of the leafhopper and the disease

Methods, items and time of survey

The same as those of the survey 2 e for the smaller brown planthopper.

Standard of the degree of occureence

The same as described in the section of the smaller brown planthopper and the stripe disease.

3. Methods and procedures for forecast

Similarly to the smaller brown planthopper, the green rice leafhopper passes one to two generations from the appearance of the overwintering generation to the transmission of the dwarf disease in nursery beds and paddy fields. Accordingly, the change in the population density and the period of appearance during the course should be pursued.

It is useful for forecasting the time of emergence of the 1st brood adults in this generation to know by the survey a. (1) whether the period of termination of diapause is early or late. The earliness or lateness of the time of emergence and the population density are ascertained together by the survey a. (2) to estimate the time of appearance of the nymphs in the following generation.

The time of invasion of the 2nd brood adults into nursery beds and paddy fields is considered to have a close bearing on the initial infection of the dwarf disease, and this can be deduced from the earliness or lateness of appearance of the 1st generation nymphs. The trend of light-trap catches of the 2nd brood adults and the result of population estimation in nursery beds and paddy fields give a more accurate forecast.

Survey of the occurrence of the disease is made to judge the fitness of the forecasts for the invading of the 2nd brood adults and for the occureence of the disease deduced from the surveys carried out. Moreover, the survey is intended to furnish data for improving forecast methods.

The green rice leafhopper and the rice yellow dwarf disease

1. Objectives for forecasting

As the the yellow dwarf disease virus is not transmitted trans-ovarially and infected plant usually does not survive winter, the virus is considered to overwinter almost in overwintering individuals of the green rice leafhopper, a major, vector. Therefore, the population density and the percentage of viruliferous leafhoppers in the overwintering generation, and interrelationship between longevity of adults in this generation and starting period of rice cultivation are important to forecast the amount of infection in early stages of rice plants.

Although transmission by leafhoppers in the 1st and successive generations, after the individuals in the over wintering generation have died out are not known well, fluctuation of population density of the vector insects is considered to be an important factor in determining the amount of occurrence of the disease.

2. Surveys

a. Survey of the state of occurrence in the overwintering generation

(1) Survey before overwintering

This is to know the state of occurrence of nymphs before overwintering.

Methods and items of survey

Count nymphs on ratoons from 25 stubbles of rice plants by tap-and-count or by push-aside-and-count method at an early period of the appearance of nymphs in the overwintering generation in areas of occurrence of the yellow dwarf disease.

Time of survey

Three or four times at five-day intervals from about September 20th.

(2) Survey of the diapause-termination time of overwintering nymphs

Methods, items, and time of survey

The survey is made in the same manner as the survey 2 a (1) for the green rice leafhopper and the dwarf disease.

(3) Survey of population density after overwintering and the time of emergence

Methods, items, and time of survey

The survey is made in the same manner as the survey 2 a (2) for the green rice leafhopper and the dwarf disease.

b. Survey of the virulency of leafhoppers in the overwintering generation

(1) Survey of the percentage of infected hills in autumn

The survey is made to know the degree of occurrence of diseased rice plants as the source from which the green rice leafhopper in the overwintering generation acquires the virus.

Methods and items of survey

At the period of hatching of the overwintering generation ratoons from 50 hills of rice plants are examined for disease symptoms at each of several optional fields in areas of occurrence of the disease, and the percentage of infected hills is calculated.

Time of survey

Once from early October to late November.

(2) Survey of the percentage of viruliferous leafhoppers (put into practice in the designated prefectures)

Methods and items of survey

The percentage of viruliferous leafhoppers are surveyed by a serological reaction for 300 nymphs in areas of occurrence of the disease.

Time of survey

Once; middle in March.

c. Survey of the state of occurrence of leafhoppers in nursery beds and paddy fields

The survey is made to seize the population densities and the earliness or lateness of appearances in the descendant generations of the 1st-brood adults invading into nursery beds and paddy fields, and to serve for the forecasting the state of transmission in nursery beds and paddy fields.

Methods and items of survey

Count adults and nymphs on 25 hills at the model-field by tapping and counting to estimate the population density/10 m^2. Besides, it is desirable to make survey by sweeping.

Time of survey

Every five days from the time when catches by light trap begin to increase rapidly. In areas of aerial application of insecticides it is conducted after several days from the end of the application.

d. Survey of the occurrence of the disease

The degree of occurrence of the disease is surveyed as to several representative varieties cultivated in usual manners to make data for understanding the situation and establishing the method of prediction.

Methods and items of survey

Fifty hills as to each of several varieties cultivated in the usual manners in areas of occurrence of the disease are sampled and examined for disease symptoms to calculate the percentage of infected hills.

Time of survey

Twice; late in July for early infection and after September for including late infection.

e. Survey of acreage of rice fields in each degree of occurrence of the insect and the disease

Methods and items of survey

The survey is made in the same manner as in the survey 2e of the smaller brown planthopper.

Time of survey

Occurrence of the green rice leafhopper . . . . . Once; in July

Occurrence of the yellow dwarf disease . . . . . Twice; late in July

for early infection and after September for including late infection.

Standard of the degree of occurrence

The green rice leafhopper :

The survey is made in the same manner as in the survey 2e of the smaller brown planthopper.

The yellow dwarf disease :

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
% hills infected (late July)	0	1 - 5	6 - 10	11 - 20	21 - 100
% hills infected (after September)	0	1 - 10	11 - 20	21 - 50	51 - 100

Methods and procedures for forecast

The amount of overwintering virus can be estimated from the population density of leafhoppers in overwintering generation, especially from that after overwintering as a result of the survey 2 a (3), and from the survey of virulency in the item 2 b. As the aerial application of insecticides aiming at the eradication of leafhoppers in the overwintering generation is widely put in practice recently, the residual population density of them should be surveyed after the application.

The frequency of transmission of virus to rice plants by leafhoppers in the overwintering generation differs considerably with regions and years according to whether the period of occurrence of leafhoppers in overwintering generation and the time of the starting of rice culture are early or late. Accordingly, it is forecasted from the surveys 2 a (3) and c and the progress of work of rice-cultivation. The data obtained from the survey of the population density of insect vectors and of the early occurrence of the disease in July (see the items 2 c and d) and light trap catches are useful for forecasting the degree of late occurrence of the disease.

It is generally accepted that the higher the population density of leafhoppers is or the more the early occurrence of the disease is, the more is the late occurrence of the disease.

G. The green rice leafhopper, Nephotettix cincticeps Uhler

1. Objectives for forecasting

The green rice leafhopper which transmits the dwarf and the yellow dwarf disease, as described above, sometimes occurs abundantly from the flowering period to the ripening period especially in the flowering period and the milky-ripe stage and checks the fruiting. So it is important to estimate both the population density in nursery beds and paddy fields soon after transplanting and that in the fruiting stage.

2. Surveys

a. Survey of the nymphal density after overwintering

The survey is made to estimate the population density after overwintering, which influences that in nursery beds and paddy fields soon after transplanting.

Methods and items of survey

Collect adults and nymphs by suction catcher, insect net, etc. in an area of 10 m^2 at each of three appropriate points according to circumstances in each region, for example, dikes, fallows, fields of the chinese milk vetch Astragalus sinicus, etc. where overwintering nymphs conceal themselves. Calculate the density/10 m^2 and the percentage of emergence.

Time of survey

Once; between late in March and early in April.

b. Survey of the state of occurrence in paddy fields

Population density and its fluctuation in paddy fields are surveyed to serve the forecasting for the number of leafhoppers infesting in the fruiting stage.

Methods and items of survey

Count leafhoppers on 25 hills in the model-field for forecasting in the western part of Japan in the early period of occurrence of nymphs in the 3rd generation or in the eastern part in the period of appearance of the 2nd-brood adults by tapping and counting method or sweeping to estimate the density/10 m^2.

Time of survey

Once; between middle in July and early in August or in the peak period of appearance of nymphs or adults of the generation to be controlled.

c. Survey of acreage of rice fields in each degree of occurrence

Methods and items of survey

Survey is made in the same manner as the survey 2 a (4) of the white-backed planthopper.

Time of survey

Once in the peak period of appearance of the 4th-brood adults in the western part of Japan or in the peak period of the 3rd-brood adults in other districts.

3. Methods and procedures for forecast

Population density in nursery beds and paddy fields soon after transplanting seems to be proportionate to that in the overwintering generation. Heavy snow in snow regions and low temperatures in winter and spring are bad environmental conditions for overwintering leafhoppers and tend to reduce the density in nursery beds and paddy fields soon after transplanting.

Fluctuation in population density and earliness or lateness of the occurrence in nursery beds and paddy fields can be seized by the survey 2 a, b. However, the trend in this period of occurrence is affected by climatic conditions and recently by the application of various kinds of chemicals. Accordingly, attention needs to be paid to kinds of chemicals, and time and extent of chemical application. On the other hand, density of adults is in some degree proportionate to that of nymphs in the generation in which adults do damage to rice plants in the fruiting stage. Thus, the adult density is forecasted by the survey in b of the preceding paragraph and also confirmed by light trap catches.

H. Rice leaf miner, Agromyza oryzae Munakata

1. Objectives for forecasting

A great part of injury to rice plants is caused by feeding of the larvae in the 1st and the 2nd generation. Therefore, it is important to forecast the time of appearance and the density of adults in generations preceding those injurious larvae.

2. Surveys

a. Survey of the occurrence of adults by sweeping

This survey is made to know the time of adult appearance and their density in each generation for forecasting the peak period of adult appearance or the suitable time for control of the miner.

Methods and items of survey

Designate model-fields for forecasting at certain fixed sites of districts different in the occurrence of the miner. In each model-field are grown representative varieties of rice by usual manners as to cultivation, fertilizer application, etc. every year. Collect adults in each field by 50 double or 100 single strokes of an insect-net, at 11.00 a.m. The time of collection may be shifted within one to two hours earlier or later according to weather condition, but the best time for the sweeping is under sunny and calm conditions. At that time, sweep insects even among lower parts of rice plants along dikes in nursery beds and paddy fields by the net with such a strength as not to injure the plants. Count the adults captured to record the date of the first catch, period of peak catches, date of the final catch, and total catches in each generation.

It is desirable to make the survey on the vegetation of Zizania latifolia Turcz in parallel with that in paddy fields.

Time of survey

Every other day throughout the period of adult occurrence.

b. Survey of occurrences of larvae and pupae, and the infestation

The survey shall be made to know both the period of occurrences of larvae and pupae, and their densities, intensity of the infestation, and the relationships between those and the adult density and to obtain the data for forecasting the occurrence.

Methods and items of survey

The survey is made in the fields mentioned previously. Pull out 50 rice seedlings of each nursery bed, or select 25 hills of rice plants (the sampling number of hills may be increased approximately when tillers are a few in number soon after transplanting and when the miner hardly occurs) in each paddy field without pulling them out, in order to examine the following items :

Nursery bed ; approximately total no. of seedlings/m^2, no. of infested seedlings, total no. of leaves (including infested leaves), nos. of infested leaves, of living larvae, of dead larvae, and of pupae/50 seedlings examined.

Paddy field ; no. of hills/10 m^2, total no. of leaves of examined hills, nos. of infested leaves, of living larvae, of dead larvae, and of pupae (separately diapause and non-diapause pupae) /25 hills examined.

Notice : Infested leaf means a leaf marked by feeding of a or larvae and not that marked only by licking of an or adults.

The number of pupae shall be recorded after observing carefully for their presence before pulling out the seedlings, because the pupae easily fall down from the plants.

Time of survey

Every ten days throughout the period of occurrence.

c. Survey of acreage of rice fields in each degree of occurrence

Methods and items of survey

Count all the leaves and the infested leaves including even leaves slightly marked by a larva, from 50 rice seedlings in each nursery bed or 25 hills in each paddy field, and calculate the percentage of leaves infested. Estimate the intensity of infestation in every field and sum up the area of rice field in each degree of infestation in each district, according to the standard of the degree given as follows :

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
% leaves infested	0	1 - 15	16 - 30	31 - 50	50 - 100

When the areas belonging to the Index V are very large, divide the Index V into sub-categories of 10% interval.

Time of survey

Twice; at the period of the most intense infestation with larvae or about early period of pupation in each of the 1st and the 2nd generation

3. Methods and procedures for forecast

a. The peak period of adult appearance in the overwintering generation

It is not seldom observed that the weather condition before the adult appearance influences the earliness or lateness of the peak period

of occurrence in the current year. It can be considered that higher air or earth temperatures hasten the coming of the peak period and that the earliness of the initial adult appearance in the field is in parallel with that of the peak period of the adult appearance.

b. Density of adults in the overwintering generation

The density is estimated from the results of the survey made by sweeping. Besides, use the fact that there is a negative correlation between the air temperatures in the 2nd and 3rd generations in the preceding year, and the adult density in the overwintering generation in the current year.

c. Infestation with larvae in the 1st generation

The intensity of infestation with the larvae is related to the density of adults in overwintering generation. Consider that higher air or field temperatures act suppressively on the survival of larvae infesting.

d. Density of adults in the 1st generation

The density of the 1st generation adults is related with the that of the same generation larvae in older stage. In some districts and years, the pupae in the 1st generation enter diapause. Accordingly, pay attention to the percentage of such pupae in diapause.

e. Infestation with larvae in the 2nd generation

The intensity of the infestation with the 2nd generation larvae is related to the density of adults in the 1st generation. However, when it is warmer in the larval stage, it is considered that the infestation is decreased owing to reduction of survival rate of larvae.

I. Smaller rice leaf miner, Hydrellia griseola Fallén

1. Objectives for forecasting

The miner has several generations a year. However, the larvae only in both the 2nd and the 3rd generation do damages to rice plants. It is important to forecast both the adult density and their egg-laying activity from the begining of rice cultivation to around July when high temperatures initiate to suppress the activity of the miner.

2. Surveys

a. Survey of abundance of adults by sweeping

The survey is intended to know the adult density in and around paddy fields where the miner propagates.

Methods and items of survey

Sweep adults on graminaceous wild grasses around waterways, dikes, etc. and those on rice seedlings and rice plants in nursery beds or paddy fields by an insect net, as described in the articles of the rice leaf miner. Then, count the catches and estimate the peak period of adult appearance.

Time of survey

Every other day from two weeks prior to the sowing in nursery beds till the maximum tillering stage in paddy fields.

b. Survey of the state of oviposition

The survey is made to forecast the larval abundance from examining the state of oviposition in rice fields and their surroundings where the miner propagates.

Methods and items of survey

Examine 100 leaves of graminaceous wild grasses collected from waterways and dikes around paddy fields, 50 rice seedlings in each nursery beds, and 25 hills of rice plants in each paddy field regarding to the egg-laying of the adults. Count leaves with eggs laid and eggs laid to calculate both the percentage of leaves with eggs laid and the number of eggs laid/leaf.

Time of survey

Every five days from two weeks prior to the sowing in nursery beds till the maximum tillering stage in paddy fields.

c. Survey of the area of rice fields in each degree of infestation

Methods and items of survey

Count all the leaves and infested leaves as to 25 hills of rice plants in a paddy field in the area where the miner occurs, to calculate the percentage of leaves infested. Estimate the area of rice fields in each degree of occurrence according to the standard of the degree given below.

Standard of the degree of occurrence

The same that given in the article on the rice leaf miner.

Time of survey

Once at the period of the most intense infestation in paddy fields.

3. Methods and procedures for forecast

a. Density of adults

When it has been warmer from December of the previous year to April, the adult density is higher on graminaceous wild grasses around paddy fields at the period prior to the beginning of the rice cultivation. Accordingly, abundant adults invade paddy fields. Forecast the of density of adults in the field from the temperatures during the above om period and from the number of adults in the field captured by sweeping.

b. Infestation

Injuries are, generally, serious when the adult density is high and when the peak period of adult appearance corresponds to the period of transplanting. Also, when it is cooler in May to July or egg-laying period and the irrigated water is kept so deep fields that rooting delays, eggs deposited are apt to increase in number. Forecast the degree of infestation from all those considerations.

J. Rice stem maggot, Chloropus oryzae Matsumura

I. Prediction in the regions of two generations a year

1. Objectives for forecasting

The rice stem maggot has two generations in Hokkaido and Tohoku annually, and in parts of Hokuriku district in some years. In those districts leaves and ears of rice plants are injured by feeding of larvae in the 1st generation. Therefore, it is important to survey the states of occurrence and oviposition of the 1st brood or overwintering generation adults for forecasting infestation with the larvae.

2. Surveys

a. Survey of the emergence of adults

The survey is made to obtain the data for forecasting the suitable time to control the species from examining the initial, the peak, and the end of emergence of the 1st brood adults.

Notice : The peak period of oviposition comes approximately 15 days after the time of peak emergence from overwintered pupae in these districts.

Methods and items of survey

Select from different places 100 hills of such winter grasses as Alopecurus aequalis Sobol. var. amurensis Ohwi, Agrostis clavata Trin.

var. nukabo Ohwi. etc. with many leaves injured by larvae late in May. Keep them in rearing boxes and then observe adults emerging.

Time of survey

Every other day throughout the period of adult emergence.

b. Survey of the occurrence of adults by sweeping

It is excuted to grasp the period of occurrence and the abundance of the 1st brood adults.

Methods and items of survey

First, select several nursery beds and paddy fields where rice plants have been transplanted at different times respectively. Secondly, designate a certain plot for the sweeping survey in each nursery bed or paddy field. Then count adults captured by 50 double strokes of an insect net as done in the rice leaf miner. Finally, sum up all the adults captured during the period of survey, and grasp the early and the peak period of appearance and the date of the final catch.

Time of survey

Every other day throughout the period of the 1st brood adult occurrence or usually untill early in July.

c. Survey of the state of oviposition of the 1st brood adults

The state of oviposition of the 1st brood adults is surveyed to obtain data for forecasting the intensity of infestation.

Methods and items of survey

Designate four plots in each nursery bed. Select 25 seedlings in each plot or 100 seedlings in total in each bed and 25 hills in each paddy field without pulling them up. The number of eggs laid and total number of stems are examined by picking eggs off rice plants with forceps.

Time of survey

Every other day throughout the period when eggs are found.

d. Survey of the infestation to rice plant in the forecasting model-field

It is executed to examine the annual fluctuation in intensity of infestation.

Methods and items of survey

Several rice varieties representative of the district are used. Select 25 hills of each variety. Examine the number of ears infested and the total number of stems / 25 hills of each variety to evaluate the percentage of stems infested and that of ears infested.

Time of survey

Once in the ear-bending stage.

e. Survey of acreage of rice fields in each degree of occurrence

Designate some rice fields in consideration of the resistances of rice varieties to the maggot and the relative area of fields cultivated with each variety. Count ears infested and all the ears examined. Calculate areas of rice fields in each degree of occurrence according to the standard given as follows :

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
% leaves infested	0	1 - 5	6 - 10	11 - 20	21 - 100

When the areas belonging to the Index V are very large, divide the Index V into subcategories of 20 % interval

3. Methods and procedures for forecast

a. Earliness or lateness of the period of the occurrence is forecasted from the results of the survey on state of adult emergence in the overwintering generation and of the survey by sweeping method in the field. It is considered that the higher the temperature is in spring, the earlier the period of occurrence comes.

Abundance is forecasted from the number of adults obtained by sweeping in paddy fields. It is considered that when the time of initial catch of the adult comes earlier, the abundance of the adults are higher in general.

b. Infestation

The damage tends to be larger after the period of higher abundances of adults and eggs deposited by them in the field.

For the prediction, however, consider that the degree of infestation are also variable to the differences of rice varieties for the resistance to the maggot.

II. Forecasting in areas of three generations a year

1. Objectives for forecasting

The maggot has three generations in Kanto, Hokuriku and westwards from them a year. In these districts, damages to leaves by larvae in the 1st generation are found late in nursery beds and in paddy fields soon after transplanting. Moreover, damages to ears by the 2nd generation larvae appear at the ripening stage. The latter is usually more serious than the former. Therefore, it is important to forecast the time of occurrence and the density of the 2nd brood adults as prodecessors to injurious larvae in the 2nd generation.

2. Surveys

a. Survey of the occurrence of adults by sweeping

The survey is made to grasp the periods of occurrence and the abundance of the 2nd brood adults in the field.

Methods and items of survey

Select several nursery beds and graminaceous vegetations around them as survey points in the period of appearance of the 1st brood adults. Similarly, designate several paddy fields in that of the 2nd brood adult appearance. In the latter case, it is desirable that designated paddy fields are cultivated with susceptible varieties to the maggot. Sweep the adults by 50 double strokes of an insect net in the daytime to count them.

Time of survey

Every other days throughout the period of occurrence:

1st-brood adults ; early May to middle June.

2nd-brood adults ; late June to middle July.

b. Survey of the emergence of the 2nd brood adults

The survey is made to grasp the period of the 2nd brood adults

Methods and items of survey

When more than 50 % of larvae in the 1st generation seem to become pupae, collect larvae, pupae, and empty pupae in each of several paddy

fields representative of all the district till the number of living pupae collected reachs approximately 200. Then, record the number of them separately.

Pupae collected in each field are placed on a wet piece of filter paper in a petri-dish at room temperatures. Record the number of adult emerging every day. And calculated the rate of emergence as fllows:

$$\text{Daily rate of emergence} = \frac{A + B}{A + B + C} \times \frac{A + D}{A + D + E} \times \frac{}{100}$$

A ; no. of empty pupae at collection

B ; acumulated no. of adults emerged

C ; no. of living pupae in the petri-dish

D ; no. of pupae living at collection

E ; no. of larvae at collection

c. Survey of the state of oviposition

The survey is made to obtain the data for forecasting both the change of population density and the intensity of infestation from examining the density of eggs deposited and time of egg-laying.

Methods and items of survey

Designate four plots in each nursery bed. Select 25 seedlings in each plot or 100 seedlings in total in each bed and 25 hills in each paddy field without pulling them up. The number of eggs laid and total number of stems are examined by picking eggs off rice plants with forceps.

Time of survey

Every other day throughout the periods of occurrences of the 1st and the 2nd brood adults.

d. Survey of the infestation in the forecasting model-field

The survey is made to grasp the degrees of infestations with the 1st and the 2nd generation larvae to some representative varieties and to obtain the data for forecasting the density of larvae in the 2nd generation from the result of the survey for density of larvae in the 1st generation.

Methods and time of survey

The survey is made as to several rice varieties representative of the district. The number of stems injured by 1st generation larvae and the

total number of stems are counted as to 25 hills in each of those varieties about early in July. Number of ears injured by 2nd generation larvae are examined in the ear-bending stage as similarly to the number of stems injured by the 1st generation larvae. Then, evaluate the percentages of stems infested and of ears infested.

e. Survey of acreage of rice fields in each degree of occurrence

The survey is made similarly to that made in the regions of two generation a year.

3. Methods and procedures for forecast

a. Occurrence of the 1st brood adults

The state of occurrence is judged by the results of sweeping survey on wild grasses and nursery beds. The abundance is considered to be low when the first discovery of adults is late. In some districts the facts are known as follows : The time of occurrence tends to come earlier in the year of warmer foregoing December to March. The abundance of the 1st brood adults in the current year is positively correlated to that of the 3rd brood adults in the preceding year, and negatively correlated to the precipitation in the preceding autumn. In previous paragraph, a survey of density of the 3rd brood adults in the preceding year was not described. However, percentage of ears infested with the 2nd generation larvae in the previous year may be used as an indicator for estimation of abundance of the 1st brood adults in the current year.

b. Occurrence of the 2nd brood adults

The prediction for the period of the occurrence is carried out by examining the rate of adult emergence from pupae collected in the field, and confirmed from the field survey by sweeping.

The abundance is estimated from the number of the 1st brood adults swept in nursery beds and on wild grasses around them, the number of eggs found in nursery beds, and the intensity of infestation with 1st generation larvae in paddy field soon after transplanting.

c. Infestation with larvae in the 2nd generation

The abundance of larvae in the 2nd generation is positively correlated to that of the 2nd brood adults. The former is considered to be correlated to the intensity of infestation with larvae in the 2nd generation. These facts may be useful for forecasting the intensity of infestation.

K. Rice leaf beetle, Oulema oryzae Kuwayama

1. Objectives for forecasting

Damage to the rice plants tends to be larger when the 1st brood or the overwintered adults occur earlier and more abundantly and when it is cooler in air temperatures at the period of infestation with the 1st generation larvae. Therefore, it is important to know the density of the adults, the time of the adult appearance, weather conditions after the adult appearance, etc., for forecasting the density of the 1st generation larvae and the infestation with them to the rice plants.

2. Surveys

a. Survey of the appearance of the overwintered adults

This survey is made to know the period and the abundance of the adults for forecasting the suitable time to control the beetle.

Methods and items of survey

The same as those given in 2 a of the rice leaf miner.

Time of survey

Every five days from early period of appearance of the 1st brood or overwintered adults to the period of disappearance of the newly emerged or 2nd brood adults.

b. Survey of the occurrence of the beetle in each developmental stage and of the intensity of infestation

This survey is made to know the densities of eggs laid, larvae, and pupae in the fields and the intensity of infestation for forecasting damages.

Methods and items of survey

The survey is made in the forecasting model-fields mentioned previously. Select 50 seedlings in each of nursery bed and 25 hills in each of paddy field for the survey. Count egg-masses, larvae, cocoons, adults, all the leaves examined, stems infested (including the stem with even a injured leaf), and leaves infested (including the leaf with a small part fed lightly). And then, calculate the number of living larvae/m^2.

Time of survey

Every ten days from early period of appearance of the 1st brood or overwintered adults to the period of emergence of the 2nd brood adults.

c. Survey of acreage of rice fields in each degree of occurrence

Methods of survey and standard of the degree of occurrence

The same as those given in articles on the rice leaf miner.

Time of survey

Once in the period of the most intense infestation in paddy fields or approximately early period of pupation.

3. Methods and procedures for forecast

a. The period of appearance of the 1st brood or overwintered adults

The time of appearance of the adults is closely related to weather conditions in winter to spring, especially to the air temperatures and the amount of snow-fall. It can be considered that the time of appearance is hastened in the case of higher temperatures in December to April and is delayed in years of late thaw or of late snow covering in spring.

b. Densities of adults and larvae in paddy fields

(1) The density of the overwintered adults tends to be high when the adults appear in paddy fields earlier than in usual years.

(2) Consider the density of the larvae in paddy fields from the abundance of the overwintered adults invaing into the fields.

c. Infestation

(1) Infestation to the rice plant is increased and the period of infestation is delayed at lower temperatures in May to July.

(2) It can be considered that damages become light under warmer conditions at the larval stage.

L. Black rice bug, Scotinophara lurida Burmeister

1. Objectives for forecasting

The abundance of the 1st-brood adults invading into paddy fields is closely related to that of adults in their overwintering sites. The sites where adults overwinter in masses seem to be fixed in some districts but are changeable in others yearly. However, adults overwinter mainly

under wild grasses and weeds, beneath fallen leaves in forests, in crevices of stone walls, etc. Then, first the survey of the abundance in several main overwintering sites should be made. Secondly, the survey should be carried out in and around paddy fields soon after transplanting. Finally, the abundance and the intensity of infestation in later season are forecasted from the abundance of adults found in paddy fields soon after transplanting.

2. Surveys

a. Survey of adults in overwintering sites

The abundance of adults that will invade into paddy fields is forecasted from that of adults found in their main overwintering sites.

Methods and items of survey

Count both living and dead adults in the area of 1 m^2 in each of such overwintering sites as around roots of wild grasses and weeds, beneath fallen leaves and stones, on soil surface, etc. Then, evaluate the density/ 10 m^2. Also, mortality due to parasitic fungi and others should be recorded on survey.

Time of survey

At least once; early in spring when adults are still in quiescence in their overwintering sites.

b. Survey of the occurrence on dikes and in paddy fields

Invading adults are investigated in and around paddy fields. Timing of controlling the pest is determined by this survey. The population growth after invasion of the 1st brood adults is also investigated to forecast the intensity of infestation with nymphs and adults in the following generation.

Methods and items of survey

Select several paddy fields as the regular survey plots around the overwintering sites where the survey of the density of overwintering adults was made (see a). The survey plots selected should be the paddy fields that stand for varieties and cultural practices in the district. The survey is conducted as shown below;

Dikes: Count invading adults within several blocks (each block is 1 m^2 in area) to evaluate the density of adults / 10 m^2.

Rice nursery: Count adults within four blocks (each block is 1 m^2 in area) In the nursery to evaluate the density of adults/ 10 m^2.

Paddy field: Count hills on which adults or nymphs are found, adults, nymphs (younger, middle, and older instars separately), egg-masses, eggs hatched, and eggs not hatched yet for 25 hills of rice plants to evaluate the densities of the 1st brood invading adults and nymphs in the 1st generation. At the same time, examine the numbers of stems, leaves, dead hearts, white head, and plant heights.

Time of survey

Dikes: From the early time of invasion of the 1st brood adults to the end of invasion.

Rice nursery: During the whole period of the seedling growth.

Paddy field: From the time of transplanting to the time when the newly emerged adults in the 1st generation leave the field for overwintering.

The above survey should be made every 10 days.

Reference

Early discovery of adult invasion by means of alluring paddy fields and other alluring plants

Overwintered adults have a tendency to fly earlier into fields of thicker grown rice plants. In some districts, the adults are likely to be found earlier on such grasses as Juncus effusus L. var. decipiens Buch., Zizania latifolia Turcz., etc. than on rice plants. Therefore, the survey of adults on such host plants mentioned above is available for the early forecast of adult invasion into ordinary paddy fields.

Methods and items of survey

For the early discovery of adult invasion, prepare an alluring paddy field for overwintered adults. Well grown seedlings of rice are densely transplanted in the field earlier than the usual time of transplanting in the district, i. e. a month prior to the initiation of adult invasion in an ordinary year. The basal fertilizer is given more than customly. Observation of the adults on other alluring plants than rice as mentioned above should be made at the districts where this insect usually occur in abundance. On survey, count adults in the area of 1 m^2 to evaluate the density / 10 m^2.

Time of survey

Every five days from 20 days prior to the initiation of the 1st-brood adult invasion in an ordinary year until the peak of invasion, and every

10 days from the peak until the end of invasion.

c. Survey of acreage of rice fields in each degree of occurrence

Methods and items of survey

Count insects on 25 hills of rice plants in each survey plot and calculate the density / hill. At the same time, examine the numbers of healthy ears and the white heads to evaluate the percentage of infested ears where white heads are seen. Based on these data, sum up the area of rice fields in each degree of occurrence according to the standard given below:

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Rare	Medium	Abundant	Severe
No. insect / hill	0	1—5	6—10	11—20	21—
% white heads	0	1—5	6—10	11—20	21—

Time of survey

Once; at the time of appearance of older nymphs in the 1st generation.

3. Methods and procedures for forecast

a. Abundance of the 1st-brood adults invading paddy fields

The abundance of the 1st brood adults that invade paddy fields is closely related to that of adults in their overwintering sites. The abundance of invading adults is at first forcasted on the basis of the densities of adults in several overwintering sites. This early forecast is later corrected by taking into account the results obtained from the surveys described both in 2b and in "reference".

b. Abundance of nymphs in the 1st generation

The abundance of nymphs is forecasted, based on the abundance of invading adults and eggs laid by them in survey fields.

c. Infestation

As there is a high correlation between the density of invading adults and the intensity of infestation, a long term forecast can be made based on the density of invading adults. The intensity of infestation is later corrected by taking into account the abundance of this insect having invaded the paddy fields.

M. Southern green stink bug, Nezara viridula Linne

1. Objectives for forecasting

The southern green stink bug occurs mainly in warm regions of south-western parts of Japan and repeats three or partly four generations a year. This insect, a polyphagous species, has become a serious pest of rice since 1956 with the spread of early cultivation of rice in these parts. It is considered that coexistence of the paddy fields under early, middle, and late cultivations afford suitable habitats for a rapid multiplication of this species. The 2nd brood or 1st generation adults and the nymphs in the 2nd generation onwards infest the ears of rice plants.

Forecast of the numerical abundance of the adult bugs invading paddy fields under early cultivation is made on the basis of adult densities in the overwintering generation. Thereafter, the densities of invading adults into paddy fields under different cultivations in time are investigated in order to forecast a suitable time for controlling the pest.

2. Surveys

a. Survey of adults before invasion into paddy fields

(1) Survey of the density of the overwintering adults

The abundance in the current year is forecasted on the basis of the adult densities in their overwintering sites.

Methods and items of survey

Overwintering adults are found mainly among dry grasses on a southern slope of a hill, in the hedges of Juniperus chinensis L., Sciadopitys verticillata Sieb. et Zucc., etc. Therefore, select several plots from the main overwintering sites and count living adults within the area of 1 m^2 in each plot. Then, evaluate the density / 10 m^2. At the same time, dead adults due to parasitic fungi or other mortality factors should be investigated to evaluate the mortality during overwintering period.

Time of survey

Once; late in March just before the adult bugs begin to leave their overwintering sites.

(2) Survey of the adult density after leaving overwintering sites

This survey is conducted to forecast the abundance of adult bugs which will invade into paddy fields and infest rice plants.

Methods and items of survey

Select several plots for this survey from the fields of barley, wheat, chinese milk vetch, raddish, potato, and rape. Such fields are desirable to be situated around the survey plots selected for the population census of overwintering adults (see the survey in (1)). Count nymphs and adults in four blocks (each block is 1 m^2 in area) of each plot and evaluate the density / 10 m^2.

Time of survey

Twice; during the period from late May to early July.

b. Survey of the occurrence in paddy fields under early cultivation

This survey is available for forecasting a suitable time for control from counting both adults invading paddy fields and nymphs in the following generation.

Methods and items of survey

Designate several paddy fields for the survey in the main area where the bug occurs. Count adults coming from other host plants, total eggs laid, eggs hatched, eggs not hatched yet, eggs parasitized, and nymphs in the following generation on 25 hills of rice plants in each field to estimate their densities / 10 are.

Time of survey

Every ten days from late June or early period of the heading stage to middle July or milky-ripe stage.

c. Survey of occurrence in paddy fields under middle-season cultivation

Methods and items of survey

Do as same as with b.

Time of survey

Every ten days from middle July to middle August.

d. Survey of occurrence in the paddy fields under late cultivation

Methods and items of survey

Every ten days from late August to late September.

e. Survey of acreage of rice fields in each degree of occurrence

Methods and items of survey

Count adults, nymphs, all the ears, and ears infested for 25 hills of rice plants in each of the fields. Then, calculate the percentage of ears infested in each field, and sum up the area of rice fields in each degree of occurrence according to the standard of the degree of occurrence given below.

Standard of the degree of occurrence

Adopt that given in the black rice bug. However, notice that the percentages of ears infested in the case of southern green stink bug correspond to those of white heads in the case of black rice bug.

Time of survey

Early cultivated rice; 20 days after heading.

Middle-season cultivated rice; 20 days after heading.

Late cultivated rice; 25 days after heading.

3. Methods and procedures for forecast

a. Abundance and infestation in paddy fields under early cultivation

Invasion of adult bugs to rice plants occurs in accordance with the time of heading. Therefore, the survey of occurrence before adult invasion should be made on the vegetations of other host plants around paddy fields. As a result of survey, forecast both the abundance of invasive adults and the intensity of infestation in paddy fields. Thereafter, the early forecast is corrected by the results obtained from subsequent surveys conducted in the field.

b. Abundance and infestation in paddy fields under middle-season cultivation

Invasion of adult bugs to rice plants occurs synchronizing with the time of heading. Such adult bugs come from other host plants around paddy fields and rice plants under early cultivation. Then, early forecast of the abundance of invasive adults and intensity of infestation in paddy fields under middle-season cultivation is made by examining the abundance of adults both on other host plants and on rice plants under early cultivation. Thereafter, the early forecast is corrected by the abundance of adults found in the fields under middle-season cultivation.

c. Abundance and infestation in paddy fields under late cultivation

Forecast the abundance of invasive adults into paddy fields under late cultivation by examining the abundance in paddy fields under early and middle-season cultivation. Thereafter, the earlier forecast is corrected by the abundance of adults found in fields under late cultivation.

N. Rice plant skipper, Parnara guttata Bremer et Grey

1. Objectives for forecasting

Main damage to rice plants is usually due to the infestation with the larvae in the 2nd generation, though larvae in the 1st and the 3rd generation occasionally infest rice plants. Hence, the forecast of the abundance of the larvae in the 2nd generation is most important.

2. Surveys

a. Survey of the abundance of the 2nd-brood adults by means of alluring flower plants

The adult has a habit of flying to flowers for sucking nectar. Therefore, the forecast of the abundance of larvae in the 2nd generation is made, based on the abundance of the 1st generation adults that visit flowering plants.

Methods and items of survey

Settle a field of red clover, Trifolium pratense Linn. (or rag guard, Luffa cylindrica Roem.) and garden zinnia, Zinnia elegans Linn., in places where the skipper occurs abundantly. The field is desirable to have an area of 50 m^2. Count adults flying to flowers of both kinds of plants in the field at 10 a.m.* every day. Sum up the daily number of adults observed in the field at the end of the survey.

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* The feeding activity of the adult begins at a temperature of about 17°C and decreases at high temperatures above 35°C. Generally, the feeding activity is high on a cloudy day and a peak number of adults on flowers appears during day time, showing a unimodal curve. A bimodal curve is shown in the number of adults on flowers in the morning and in the afternoon on a clear day of high temperatures.

Time of survey

Every day throughout the period of occurrence of the 2nd brood adults, i. e. from June to August.

b. Survey of the abundance of larvae in the 2nd generation

Fitness of the forecast based on the survey described in 2a is tested by counting larvae and pupae in paddy fields and examining the intensity of infestation with them in the 2nd generation.

Methods and items of survey

Select a paddy field larger than 3 ares around the survey field settled for attraction of the adult (see 2a). Count folds, larvae, pupae, and empty pupae for the hills of rice plants / 10 m^2.

Time of survey

Once; at the last period of infestation with larvae in the 2nd generation, i. e. late in August.

c. Survey of acreage of rice fields in each degree of occurrence

Methods and items of survey

Count folds for 25 hills of rice plants to estimate the degree of occurrence in a field, and calculate the area of rice fields in each degree of occurrence by referring to the standard below.

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Rare	Medium	Abundant	Severe
No. folds / 25 hills	0	1 - 5	6 - 10	11 - 25	26 -

Time of survey

Once; at the peak period of appearance of folds, i. e. the early period of pupation

3. Methods and procedures for forecast

a. Abundance of larvae in the 2nd generation

(1) The abundance is positively correlated with climatic conditions, specially with the air temperatures during the period of over-wintering. In general, the larvae occur in abundance when the mean air temperatures from December to March were high.

(2) The higher the air temperatures is during July, or the egg-laying period of the 2nd brood adults, the more abundantly larvae in the 2nd generation are considerd to occur.

(3) It is known that there is usually a positive correlation between the abundance of the 2nd brood adults that visit flowering plants and that of larvae in the 2nd generation.

b. Infestation

Due to 3 a, the infestation is apprehended to become serious when the larvae in the 2nd generation occur in abundance.

O. Green rice caterpillar, Naranga aenescens Moore

1. Objectives for forecasting

The green rice caterpillar repeats several generations a year and occasionally occurs in a great abundance. Severe occurrences in August are frequently known to cause the delay of heading of rice plants, shortness of culms in length, reductions of grains in number / ear, of rate of perfect grains, and more than 30 % decrease of ears in weight in Tohoku district.

The damage to rice plants is considered to increase when the moths caught by light trap are abundant. In such a case the prediction of the larval abundance is made, based on the density of eggs found on rice plants. The necessity of controlling the caterpillar is judged by the larval abundance estimated.

2. Surveys

a. Survey of the abundance of eggs

The survey is made both to forecast the abundance of larvae and the damage from counting the eggs laid on rice plants and to obtain the data for the judgement of the necessity of the control.

Methods and items of survey

After moths caught by light trap increased, count eggs laid on 25 hills of rice plants in each of several paddy fields approriately selected in the district.

Time of survey

Twice or three times; every five days after light trap catches began to increase in number.

b. Survey of acreage of rice fields in each degree of occurrence

Methods and items of survey

Count the larvae on 25 hills of rice plants and calculate the density / hill. Sum up the area of rice fields in each degree of occurrence in the district, according to the standard given in the table as follows:

Standard of the degree of occurrence

Intensity	I	II	III	IV	V
Degree of occurrence	None	Rare	Medium	Abundant	Severe
No. larvae / hill	0	1	2 - 4	5 - 10	11-

Time of survey

Once; at the period of the most intense infestation

3. Methods and procedures of forecast

a. Abundance of larvae

(1) The moth occurs abundantly when the air temperatures during April and May have been high. In Tohoku district there is a tendency that outbreaks are sometimes seen when the air temperatures during July and August are in the range of 25—27°C.

(2) Forecast the abundance from the survey of the eggs laid in paddy fields.

b. Infestation

Forecast the infestation from the result obtained by the survey described in 2 a.

P. Pink borer (purplish stem borer), Sesamia inferens Walker

1. Objectives for forecasting

The pink borer has three or four generations a year and injures paddy and upland rice plants, maize, other graminaceous fodder crops, etc. Serious damages to crops are usually caused by the larvae in both the 1st and the 3rd generation. The point of the surveys is to forecast the times of the 1st and 3rd brood adult appearances and their abundances.

2. Surveys

a. Survey of larval development in the overwintering generation

The survey is intended to examine the larval development for forecasting the time of the 1st brood moth appearance.

Methods and items of survey

Collect 50 individuals from the infested stubbles of rice plants or Coix lacryma-jobi Linn. gathered at random and kept outdoors and count larvae, pupae, and empty pupae. Weigh the larvae individually.

Time of survey

Every four days between March and April

b. Survey of the seasonal occurrence in the field

This survey is intended to examine the seasonal occurrence for the purpose of forecasting the larval density in each generation and the times and the abundances of the 2nd- and the 3rd-brood moth appearance.

Methods and it ns of survey

Draw 50 sample hills of rice plants from each of the forecasting model-field or paddy field around them. Count hills infested, stems infested, larvae at younger, middle, and older stadia separately, pupae, and empty pupae, and then estimate density / 10 are and percentage of pupation.

Time of survey

Every ten days between the earlier period of infestation with larvae in the 1st generation and the earlier period of the 3rd brood moth appearance.

c. Survey of acreage of rice fields to each degree of occurrence

Methods and items of survey

Pick up 25 hills of rice plants and count all the stems examined and stems infested to calculate the percentage of stems infested.

Sum up acreage of rice fields in each degree of occurrence in the jurisdiction, according to the standard of the degree of occurrence given in the table as follows:

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of Occurrence	None	Light	Medium	Heavy	Severe
% stems infested by the 1st generation larvae	0	1 - 2	3 - 5	6 - 10	11 - 100
% stems infested by the 2nd & the 3rd generation larvae	0	1 - 2	3 - 8	9 - 15	16 - 100

Time of survey

Once in the period of the most intense infestation by larvae in each generation.

3. Methods and procedures for forecast

a. Time of the 1st brood moth appearance

(1) Judge it by the results of the field survey of larval development in the overwintering generation. The time of the 1st brood moth appearance tends to be early when few larvae are in earlier stadia and larval development in general is more advanced than in usual years.

(2) The time of moth emergence tends to be early in years of warm March and April as the larval development is accelerated.

b. Abundance of the 1st brood moths

Forecast the abundance of the 1st brood moths from the abundance of the final-brood moths in the preceding year, abundance of overwintered larvae, mortality in winter, larval body weight, etc. The mortality of overwintered larvae which do not reach the final stadium yet is known to be usually high.

C. Time of appearance and abundance of the 2nd and 3rd brood moths

Forecast them from the seasonal occurrences estimated by the field surveys and light trap.

Q Armyworm, Leucania separata Walker

1. Objectives for forecasting

The armyworm occurs sometimes everywhere and attacks rice plants seriously, especially in paddy fields that have been flooded. However, outbreaks are not necessarily confined in such paddy fields. It is important to grasp the occurrence early in the season.

2. Surveys

a. Survey of the densities in wheat, barley, or maize fields in spring

The armyworm sometimes occurs on wheat, barley, maize, forage crops, and wild grasses and weeds, in spring. The survey is intended to estimate the abundance of the armyworm on such crops and wild plants as the source of occurrence on rice plants.

Methods and items of survey

Designate some wheat, barley, maize, and other crop fields for this survey in consideration of the survey described in b. Such fields are desirable to be situated near places where the armyworm usually occurs every year. The size of a sampling unit is 10 m^2. Collect and count the larvae (at younger, middle, and older stadia separately) in several sampling units in each field.

Time of survey

Twice; late May and early June

Reference Survey of the number of adults flying to flowers of wild weeds

The survey is intended to forecast the abundance of larvae in the following generation from the number of moths flying to wild flowers.

Methods and items of survey

Find the flowers of Oenothera odorata Jacq. around the fields where the survey described in a is made. Count directly the moths sucking nectar from the flowers at night, using an electric torch, and estimate

the density / 10 m^2.

Time of survey

Every five days between June and September

b. Survey of the larval density in paddy fields

The purposes of this survey are to compare the abundance estimated by the surveys described in both a and reference and the actual density of larvae found in the fields by this survey, to obtain some useful data for forecasting the occurrence of the armyworm, and to judge whether control of the armyworm is necessary or not.

Methods and items of survey

Designate some paddy fields situated near the fields used for the survey described in a and reference and those in flooded areas. Count larvae (at younger, middle, and older stadia, respectively), living pupae, dead pupae, and empty pupae collected from hills of rice plants corresponding to an area of 10 m^2 in each field.

Time of survey

Four times; late June, late July, early August, and early September

c. Survey of acreage of rice fields in each degree of occurrence

Methods and items of survey

Count the larvae collected from 25 hills of rice plants in each place where the armyworm occurs. Sum up the area of rice fields in each degree of occurrence, according to the standard of the degree of occurrence given in the table as follows:

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Rare	Medium	Abundant	Severe
No. larvae / 25 hills	0	1—5	6—10	11—25	26—

Time of survey

Twice; late July and late September

3. Methods and procedures for forecast

a. Abundance of larvae in paddy fields

(1) .Forecast it from the larval density estimated in wheat, barley, and other crop fileds.

(2) Notice that outbreaks are sometimes seen in some paddy fields that have been flooded.

b. Infestation

Forecast severe damages when larvae are abundant.

R. Other insect pests

Forecast the times of adult appearances and the abundances of larvae and adults of the grass leaf roller (Cnaphalocrocis medinalis Guenée), rice leaf roller (Susumia exigua Butler), rice crane fly (Tipula aino Alexander), etc. from light trap catches and others.

V. Insect pests of sweet potato and potato

A. Sweetpotato leaf worm, Aedia leucomelas Linné

1. Objectives for forecasting

The sweetpotato leaf worm has three or four generations a year, occurring most abundantly in autumn (September to October) and more in the period of planting (June). The influence of injuries to the aerial part (leaves and bines) on the yield of potatoes is variable with the developmental stages of potatoes, but the injuries in autumn affects considereably the yield. It is important to forecast the abundance of larvae in autumn.

2. Surveys

a. Survey of the seasonal occurrence in the field

The survey is intended to follow the prevalences of larvae and the damages for forecasting the time of occurrence and abundance in the following generation.

Methods and items of survey

Settle four square-frames, each with one m^2, at random in the model-field. Count younger (smaller than 1 cm in body length), middle

(1—5 cm), and older larvae* (larger than 5 cm) within each frame. At the same time count all the leaves and the leaves infested** within a quarter area of each frame. Then, calculate the larval density / 10 m^2 and the percentage of leaves infested.

Time of survey

Every ten days from late June to October.

b. Survey of acreage of potato fields in each degree of occurrence

Methods and items of survey

Designate some fields in main districts cultivated with sweet potato. Settle four sampling plots at random in each field. Count all the leaves and the leaves infested / 50 m^2 in each plot and calculate the percentage of leaves infested. Sum up the area of potato fields in each degree of occurrence, according to the standard given in the table as follows:

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
% leaves infested	0—5	6—15	16—30	31—50	51—100

Time of survey

Three times; early to middle August, early September, and middle October

3. Methods and procedures for forecast

In some regions the sweetpotato leaf worm is known to occur abundantly when it was hotter in June to August of the preceding year and the rainfall is more plentiful in June to July especially in June of the current year. Examine whether these relations exist in the district or not, as well as some other relationship between the abundance of the insect and some meteorological factors.

* Release the larvae into each frame after counting them.

** The leaves injured by the larvae of the sweetpotato leaf worm are similar in appearance to those injured by the larvae of the tobacco cutworm. Do not confuse them.

B. 28-spotted lady beetle, Epilachna vigintioctopunctata Fabricius

1. Objectives for forecasting

The survey is intended to examine the occurrence of the beetle and then to forecast the suitable period for the control.

2. Surveys

a. Survey of the seasonal occurrence in the field

The times of appearances and the abundances of adults, eggs, larvae, and pupae in Irish potato fields are to be examined for forecasting the most suitable period for the control.

Methods and items of the survey

Designate some representative fields in each district. Each field is desirable to have an area of more than one are. Count the adults, larvae (at younger, middle, and older stadia, separately), pupae, and egg-masses on potato plants / m^2 between 10 and 12 a. m.

Time of survey

Every ten days from the sprouting stage to harvest.

b. Survey of acreage of potato fields in each degree of occurrence

Methods and its of survey

Pick out ten hills of potato plants from each field systematically and estimate the degree of infestation, by examining all the leaves according to the standard given in the following table. Then, sum up the area of potato fields in each degree of occurrence.

Standard of the degree of occurrence

Index	I	II	III	IV	V
Degree of occurrence	None	Light	Moderate	Heavy	Severe
Average area of leaves fed	$0-\frac{1}{8}$	$\frac{1}{8}-\frac{1}{4}$	$\frac{1}{4}-\frac{2}{4}$	$\frac{2}{4}-\frac{3}{4}$	$\frac{3}{4}-\frac{4}{4}$

Time of survey

Twice; in the period of infestation with the 1st brood adults on sprouts and in the period of the most intense infestation with larvae in the 1st generation on leaves.

3. Methods and procedures for forecast

a. Abundance

(1) The beetle is apt to occur earlier and abundantly in spring when it has been warmer in December to April. It is known that there is usually some negative correlation between the abundance of adults in the current year and the precipitation at the larval stage in the preceding year.

(2) Estimate the abundance from the results of the field survey of seasonal occurrence.

b. Infestation

Forecast the degree of infestation from results obtained in a.

VI. Insect pests of other crops

There are many important insect pests causing on other crops. Some of them are distributed over wide areas causing severe damages. However, the states of occurrences of some insect pests often vary considerably and in complicated manner, not only in different areas but also in connection with various crops and methods of their cultivation. Studies even on the bionomics are insufficient, and few methods for their forecasting have been established. No nation-wide survey is intended for these pests, but it is advisable that important insect pests should be listed up in each prefecture, and methods and items of observations and surveys should be appropriately selected and prescribed.