Forecasting Techniques of Rice Blast

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Foreword

Rice blast is the rice plant disease which breaks out in most areas of Japan causing heavy damage. In the past few years, the average loss in harvest caused by rice blast has reached 300,000 tons a year. About 5 billion yen worth of fungicides are used to protect the disease annually. However not all of the fungicides have been effective since there have been considerable fluctuations in the process of disease outbreak and degree of disease occurrence by the year and region.

Therefore, it is necessary to determine whether or not spraying of fungicide is required or effective time of spraying, both from an economic point of view and from the view of lessening pollutions from agricultural chemicals.

There are such forecasting methods of rice blast as the one based on meteorological conditions, on inoculum intensity, or on predisposition of rice plant, etc. In this article, the latter two methods of forecasting will be explained.

Forecasting by inoculum intensity

The first occurrence of leaf blast is mainly brought about by the infection from the spores formed on the rice straw infected at last current season. After that time, the spores formed on the lesions become the source of infection and spread leaf blast and neck rot. Therefore, by estimating the amount of spores dispersing in the air, it is possible to forecast the leaf blast process of progress and degree of neck rot occurrence.

Kuribayashi et al (1952) proposed a forecastng method of neck rot based on the number of spores collected by the horizontal spore trap. This method has been utilized in the area where leaf blast increases before the heading occurs. However, the horizontal trap is not very effective in trapping spores so that it can not be used in the area where the number of dispersing spores decrease before the heading occurs as in western Japan.

Recently Suzuki (1969) devised a rotary spore trap as shown in Fig. 1. The trap consists of a supporting stand where the slide glass is fixed at the tip of a rotary axis, which is rotated by a motor at 1,500 rpm. drawing in the surrounding air, and the slide glass coated with glycerine jelly traps the spores.

The rotary spore trap is about 200 times as effective as the horizontal one. However, since it traps not only the spores but also the particles in the air, counting of spores becomes difficult after it has been in operation for a long time.

Therefore, it would suffice to operate the trap for only one hour between 1 and 2 a.m. when many blast fungus spores are floating about in the air to trap sufficient number of spores to enable forecasting.

Table 1 shows the relationship between the

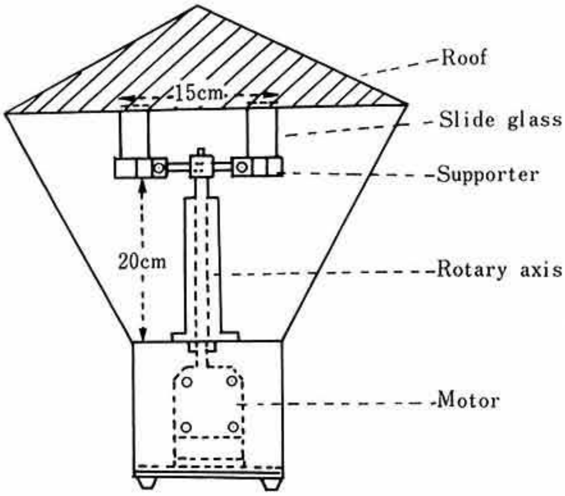

Fig. 1. Rotary spore trap.

Table 1. Relation between the degree of blast occurrence and the number of spores collected by rotary spore trap

Maximum number of spores per day at the periods more than 2 weeks before heading	Degree of leaf blast severity	Ratios of neck rot panicles
less than 30*	slight	less than 5%
from 30 to 100	moderate	20%
from 100 to 500	severe	60%
more than 500	very severe	100%

* The number of spores was counted in the areas 24×18mm under cover-glass by microscope (magnification×150)

number of spores trapped by this method and the degree of rice blast occurrence.

Although this standard can be applied to the plain region in Niigata Prefecture, another standard must be set up for the regions where meteorological conditions greatly differ. The velocity of wind especially affects the trapping of spores. In the regions where wind velocity is great, the spores in the plant canopy would disperse upward, but in the regions where the wind velocity is weak, the spores are apt to stay on in the plant canopy.

The trapping of spores is carried out at a height of 1.3 m on top of the plant canopy so that in the regions where wind velocity is weak, the number of spores trapped is likely to be less than the area where wind velocity is great. In other words, even though the number of the spores may be the same in the regions where wind velocity is weak, the number of spores in the plant canopy is more and the occurrence of disease tends to be severer than in the regions where wind velocity is great.

Therefore, forecasting can be made with a higher precision rate if the number of the trapped spores, just as it is not made the indicator for forecasting, but rather the number of spores divided by the average wind velocity at the time of trapping would serve as a better indicator.

Forecasting based on rice plant predisposition

Besides inoculum intensity, the resistance of rice plant influences the process of disease and degree of occurrence. There are two methods of determining the resistance, namely, one is to inoculate the rice plant with fungi directly to see its reaction and the other is to measure the plant's biological and ecological characteristics closely related with the resistance. This is called the Predisposition Examination Method.

1) Sheath inoculation test

This test is conducted about 10 days before the average date of leaf blast occurrence until the heading time in the area. The test is repeated every 7 days, clipping 5–6 cm long sheath of the longest stalk.

After the spore suspension is inoculated into the sheath, it is kept at 24°–25°C for 40 hours, then the epidermis of the back side of the sheath is scraped off, and grades of mycelial growth is measured under the microscope. The index of the grades of mycelia growth is shown in Fig. 2.

In northern Japan, there is high correlation between the grades of mycelial growth and the multiplication of the lesions so that the result can be utilized for forecasting. However in

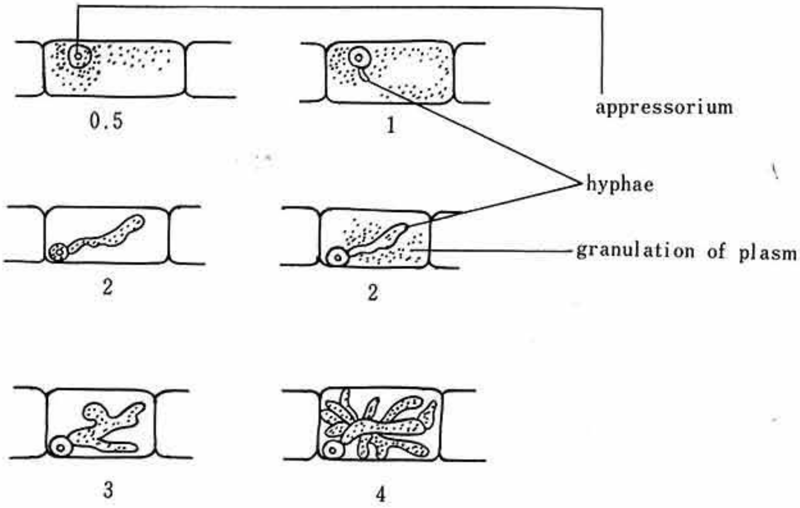

Fig. 2. The grades of mycelial growth in invaded cell of rice sheath.

western Japan, very often the grades of mycelial growth is less than 2, and there is no clear relationship with the outbreak of the disease.

2) Number of silicated cells in flag leaf

Hori (1963) clarified that there is high correlation between the degree of neck rot occurrence and the number of silicated cells of the flag leaf and that in the case of Asahi No. 1, middle ripening variety in Western Japan, the relationship between the two expressed by the following formula was noticed:

$$Y = 55.5 - 22.1 \log X$$

Y: degree of neck rot severity

X: number of silicated cells per

10 vision fields of microscope under the 150 times magnification.

This relationship varies depending upon the region and the rice varieties, so it would be necessary to establish this kind of formula for the representative variety in each region.

There is one demerit in this type of forecasting, however, as it does not leave much time before the forecasting of neck rot since the number of silicated cells does not stabilize unless more than 10 days would elapse after the flag leaf comes out.

3) Rate of starch accumulation in the sheath

This test was utilized by Hori (1965) in forecasting. Investigation is made on the representative varieties in the region a little before the first occurrence of leaf blast until the heading stage. Every 7 days, at about the same time, 10 of third sheaths from the top of the longest stalks are taken, fixed in alcohol, bleached and then dyed in the iodine and potassium iodide mixture.

The ratio between the part dyed into purplish black and the whole length of the sheath is calculated as the ratio of starch accumulation. The lower the accumulation rate is, the more incidence of blast disease is found.

However, since there are variations in the ratio depending upon the period, it is necessary to know exactly the development in an average year, and evaluation must be made comparing with these average figures.

Although this method is simple and there is high correlation between the degree of disease occurrence and the ratio of starch accumulation, its practical application needs further review since the method depends upon only one element, starch.

4) Leaf color

The leaf color has been used as an indicator for evaluation with the naked eyes but this allowed no quantitative evaluation. However, recently portable chlorophyll meter and color difference meter have been developed. Yamaguchi et al (1967) used these apparatuses and clarified that the rice plant with higher chlorophyll content and less luminosity, hue and chromaticity is apt to be susceptible to the blast disease.

5) *Breaking strength*

Yamaguchi et al (1968) clarified that in the same rice varieties there is high negative correlation between breaking strength and grades of mycelial growth and also high correlation with the difference in the number of lesions of leaf blast in the different years.

Breaking strength is tested by clipping the part of the stalk wrapped by sheath, from the top to the second sheath, then putting it on a hanger, and adding weight to its center, and the weight at which the stalk breaks is determined.

The rice plant with stronger breaking strength has a thick cell wall of epidermis, developed lignification of vascular bundle, many silicated cells, and is resistant to blast disease.

6) *Chemical components*

After investigating the relationship between soluble nitrogen content and disease occurrence in a specific variety in Fukushima Prefecture, Kobayashi (1963) reported that when there was more than 0.26% soluble nitrogen content before the occurrence of leaf blast, and more than 0.21% of the same at the initial stage of blast disease, there was the danger of severe occurrence of the disease in that year, and made it clear that there was high correlation between the degree of blast occurrence and the proportion of soluble nitrogen content and silicic acid content.

Ohata (1966) recognized that the ratio between flavonoids content and non-protein nitrogen content had high negative correlation with the grade of mycelial growth in the sheath.

He suggested also that since glutamine and asparagine promote the growth of blast fungi, while methionine and phenylalanine inhibit their growth, there was the possibility of utilizing amino acid content in the rice plant for the forecasting of rice blast.

Discussion

The first occurrence of blast disease is observed when the average temperature reaches 19–20°C so that the forecasting of the first occurrence period can be made by the change in the temperature, but the degree of the first occurrence and the subsequent development cannot be forecast unless the inoculum intensity is measured.

However, the inoculum intensity at this time is not so high and besides it is uneven in the fields so that even with the rotary spore trap with high effectiveness it is not easy to trap sufficient number of spores for forecasting. It would be necessary to develop a method of measurement with more effective trapping of inoculum density.

Another reason why the accurate forecasting of leaf blast progress cannot be made is perhaps that the method of examining predisposition of rice plant has not been perfected. As stated above, there have been many methods developed to determine it, but only specific parts of the rice plant as leaf, sheath or stalk, are taken for the test.

Consequently with these tests, the results of measurements varied greatly unless uniform samples were used and strict conditions for the measurement were established. As a result the predisposition test, which showed close relationship with the resistance under experimental condition, is difficult to use for practical purpose.

At present, although the system of forecasting of rice blast in Japan has been established, contributing to the prevention of the disease, there is still much to be desired in the degree of precision in forecasting. It is because these methods depend upon meteorological forecast and indirect forecasting method that the researchers visit the rice fields to observe the state of disease occurrence. It is urgently required to establish new forecasting methods laying more emphasis on inoculum intensity and the plant predisposition.

References

1) Hori, M.: Studies on the forecasting of rice blast.—with special reference to the experimental forecasting. Special Res. Rep. on disease and insect forecasting, Min. Agr. Forest. **14**, 1–76 (1963). [In Japanese.]
2) Hori, M.: Forecasting techniques on the basis of morphological and chemical characters of the host plant. *Ann. Phytopath. Soc. Japan* **31** (2), 301–306 (1965). [In Japanese.]
3) Kobayashi, Y.: Forecasting techniques of rice blast on the basis of chemical characters of the rice plant. Special res. rep. on disease and insect forecasting, Min. Agr. Forest. **15**, 1–105 (1963). [In Japanese.]
4) Kuribayashi, K. and Ichikawa, H.: Relation of the floating conidia of rice blast fungus to prediction of the disease. Bull. Nagano Agr. Exp. Sta., **13**, 1–229 (1952). [In Japanese.]
5) Ohata, K., Goto, K. and Kozaka, T.: Effects of low air temperature on the susceptibility of rice plants to blast disease, with special reference to some chemical components in the plant. *Bull. Nat. Inst. Agr. Sci. Ser. C.* **20**, 1–65 (1966). [In Japanese.]
6) Sakamoto, M.: On inoculation of the leaf sheath of rice with the blast fungus. *Bull. Inst. Agr. Sci. Tohoku Univ.*, **1**, 120–126 (1949). [In Japanese.]
7) Suzuki, H.: Studies on the behaviour of rice blast fungus spore and application to outbreak forecast of rice blast disease. *Bull. Hokuriku Agr. Exp. Sta.*, **10**, 1–118 (1969). [In Japanese.]
8) Takahashi, Y.: On the methods of sheaths inoculation test by rice blast fungus. *Plant Protection Japan*, **12** (8), 339-345 (1958). [In Japanese.]
9) Yamaguchi, T. and Yoshino, R.: Forecasting techniques of rice blast on the basis of leaf colour. *Ann. Rep. Hokuriku Agr. Exp. Sta.*, 68–73 (1967). [In Japanese.]
10) Yamaguchi, T. and Yoshino, R.: Forecasting techniques of rice blast on the basis of breaking strength of rice stems. Proc. Assoc. Pl. Prot. Hokuriku, **16**, 4–9 (1968). [In Japanese.]