Ecology and Epidemiology

Epidemiological Implications of the Spectrum of Resistance to Rice Blast

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Portion of the Ph.D. thesis of the senior author at the University of the Philippines at Los Baños, Laguna, Philippines.
Accepted for publication 29 May 1981.

ABSTRACT

Ahn, S.W., and Ou, S. H. 1982. Epidemiological implications of the spectrum of resistance to rice blast. Phytopathology 72: 282-284.

The infection efficiency and the infection rate of the spore population of *Pyricularia oryzae* was lower if the percentage of races to which each cultivar was resistant was high. It appears that cultivars with resistance to a high percentage of the races of the pathogen behaved as expected for "horizontal" or "general" resistance.

Additional key words: quantitative resistance.

We have shown earlier that rice cultivars differ greatly in the number of races of *Pyricularia oryzae* to which they are resistant, and the number of blast lesions are proportionately smaller on cultivars resistant to many races (1). This study examines the effect of the proportion of the pathogen races to which a cultivar is resistant on the infection efficiency and infection rate of nonoverlapping and overlapping secondary cycles of infection.

MATERIALS AND METHODS

Infection efficiency. Rice cultivars Tetep, Dular (or Kataktara), Peta (or Chokoto), and Khao-tah-haeng 17 (KTH), which differ in the percentage of 242 races to which they are resistant (1), were grown in the greenhouse in 10-cm-diameter clay pots, seven seedlings per pot. They were inoculated at the five-leaf stage with *P. oryzae* isolate 2017, pathogenic to all the four cultivars, at four different spore concentrations in three replications. The number of lesions on the fifth leaf of 15 seedlings of each cultivar was counted on the sixth day after inoculation. The number of lesions per leaf was converted to number of lesions per 20 cm^2 of leaf area. The experiment was conducted twice and average values were used for statistical analysis.

Infection rate. Ten greenhouse seedlings were grown in each of six 10-cm-diameter clay pots for each of the four cultivars. At the five-leaf stage they were divided into three groups (replications) of eight pots each for inoculation. The pots in each group were randomly arranged in an inoculation chamber. Plants were inoculated with isolate 2017, an isolate that was originally obtained from the cultivar Tetep, and which infected all the test cultivars. Each inoculated cultivar was incubated in separate compartments covered with a plastic sheet. At 6-day intervals, another batch of healthy seedlings of each cultivar was introduced, placed side by side, and allowed to remain for four days inside the compartment containing previously inoculated plants. This process of inoculating healthy plants with blast-infected ones was performed five times.

The infected plants were taken out from each compartment 10 days after inoculation and lesions counted. The average number of lesions per 10 seedlings of each cultivar was calculated for each of the nonoverlapping cycles of infection.

Continuous plantings with overlapping growth periods were done to simulate continuous planting of rice in the field. Seven cultivars were planted three times at 15-day intervals. Each microplot consisted of five 1-m rows, 10 cm between rows, 20 cm between plots, and with 2 m between cultivars.

The first planting was inoculated with isolate 2017 at the five-leaf stage. The plot was then covered with plastic film to insure conditions favorable for infection.

Leaf samples taken just before inoculation were incubated for four days to determine the number of lesions that were due to natural infection. Lesion count was done eight days after inoculation.

The increase of the disease in the third planting was measured by counting lesions on 20 seedlings of each cultivar at 2-day intervals.

All the data from lesion counts were converted to number of lesions per 100 cm^2 of leaf area. Percent of infection was obtained by defining 600 lesions (estimate highest possible) per 100 cm^2 of leaf area as 100% infection.

Infection efficiency. Infection efficiency here is defined as the ratio between the number of lesions per unit area of leaf and the spore concentration of the inoculum. It may be expressed as b in the equation

$$Y = bX$$

in which Y is the number of lesions per unit area of leaf and X is the spore concentration of the inoculum.

RESULTS AND DISCUSSION

Generally, an increase in spore concentration led to an increase in the number of lesions, within the range tested (Fig. 1). However, infection efficiency of a given spore population on the different cultivars varied greatly and was inversely proportional to the spectrum of resistance of the cultivars, being much higher for KTH

Fig. 2. Increment of the number of lesions through continuous cycles of nonoverlapping secondary infection on rice cultivars with different spectra of resistance to *Pyricularia oryzae*.

In Fig. 2 legend:
- ● KTH $Y = 66.0(1.87)^n$ (R=0.99)
- ○ Chokoto $Y = 49.7(1.52)^n$ (R=0.99)
- ▽ Kataktara $Y = 35.3(1.43)^n$ (R=0.99)
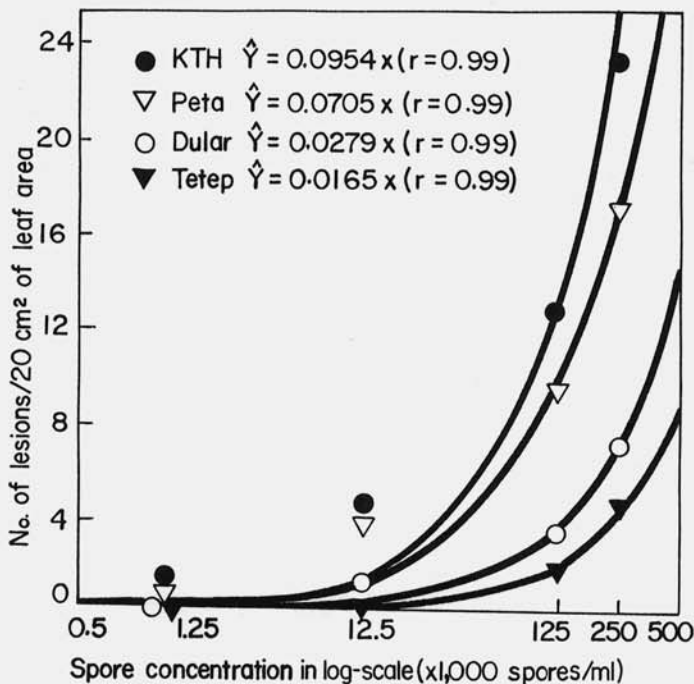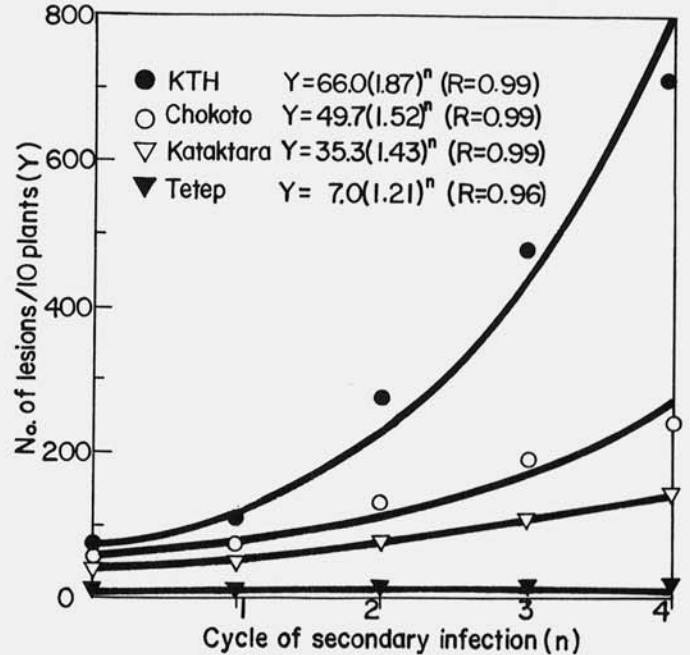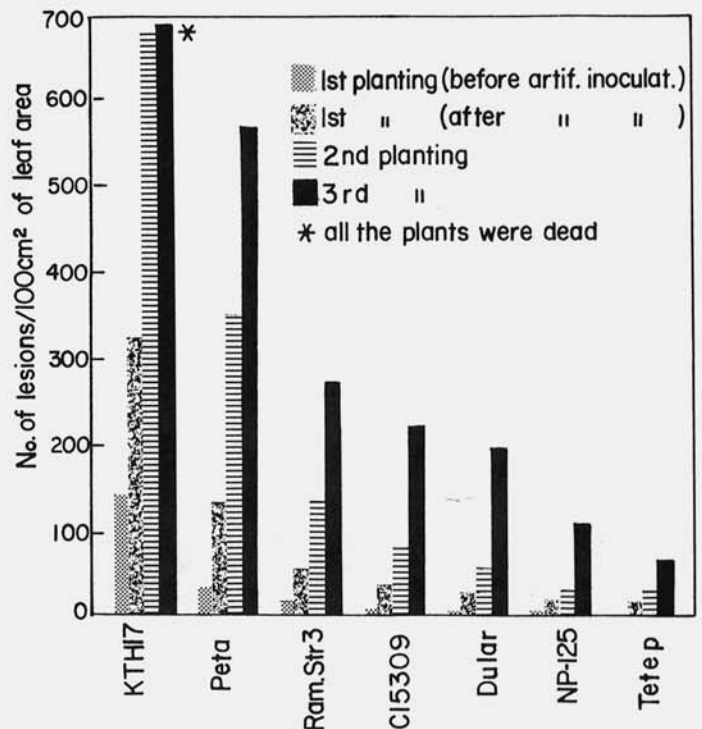- ▼ Tetep $Y = 7.0(1.21)^n$ (R=0.96)

Fig. 1. Relationship between number of lesions produced on leaves of four rice cultivars and spore concentration in *Pyricularia oryzae* suspensions used for inoculation.

In Fig. 1 legend:
- ● KTH $\hat{Y} = 0.0954x$ (r=0.99)
- ▽ Peta $\hat{Y} = 0.0705x$ (r=0.99)
- ○ Dular $\hat{Y} = 0.0279x$ (r=0.99)
- ▼ Tetep $\hat{Y} = 0.0165x$ (r=0.99)

Fig. 3. Blast development on rice cultivars with different spectra of resistance in three successive plantings at 15-day intervals.

In Fig. 3 legend:
- 1st planting (before artif. inoculat.)
- 1st " (after " ")
- 2nd planting
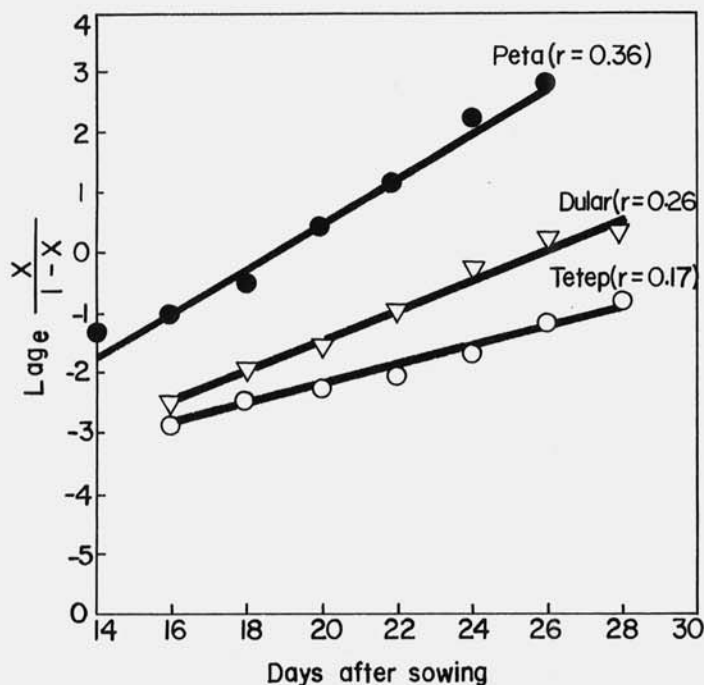- 3rd "
- * all the plants were dead

Fig. 4. Blast infection rate (*r*) on three rice cultivars in the third continuous overlapping planting (infection rate obtained by calculating regression coefficient of each line). X = proportion of disease.

than for Tetep. The differences in lesion numbers among cultivars could be due to the heterogeneous composition of the spore population of an isolate whereby only a small portion of the spore population could infect and colonize on cultivars with higher levels of resistance (1).

Infection rate. The number of lesions produced in the *n*th cycle of secondary infection was expressed as in the equation

$$Y = Y_o r^n$$

in which Y is the number of lesions produced in the *n*th cycle, Y_o is the number of lesions formed in initial infection, and *r* is the secondary infection rate.

The secondary infection rate was higher on cultivars with a narrow spectrum of resistance or lower percentage of resistance to races (1) than on cultivars with a higher percentage of resistance (Fig. 2).

In the overlapping cycles, there was a corresponding increase in lesion numbers in each succeeding planting of all cultivars (Fig. 3). The cultivars with a narrower spectrum of resistance (resistance to a lower percentage of races) showed higher rates of increase than those with a broader spectrum of resistance.

The daily increase rate (*r*) in the third planting was computed using Vanderplank's (4) equation. Cultivars with resistance to many races had lower rates of daily increase (Fig. 4) (not able to count lesions on KTH due to severe infection).

The low rate of infection among resistant cultivars may have been due also to reduced sporulation, longer incubation period, or slower lesion expansion, etc., but it is primarily due to the inability of most of the spores to infect these cultivars (low infection efficiency) because the pathogenicity of the fungus is extremely variable (2,3).

If measures of infection efficiency and infection rate are indicative of horizontal resistance, then cultivars resistant to many races can be considered to possess high horizontal resistance even though the reactions to individual races seem to be basically vertical (1).

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