The Rationale for the Horsfall-Barratt Plant Disease Assessment Scale

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The Horsfall-Barratt or logarithmic scale for estimating percentage of plant disease was introduced by Horsfall and Barratt (2,3) after they discovered by chance the Weber-Fechner law, which says that visual acuity is proportional to the logarithm of the intensity of the stimulus. This provided the rationale for their new system of grading in which the grades were placed logarithmically, not arithmetically. At the same time they began to realize that the eye actually reads diseased tissue below 50% and healthy tissue above 50%. They set the grades to go both ways from 50% with a ratio of two (eg, in a downward direction the grades were set at 50 to 25%, 25 to 12%, 12 to 6%, etc.).

It is not clear exactly how the Weber-Fechner law operates in the estimation of percentage of plant disease. Presumably the stimuli are the diseased areas and the healthy areas. However, it is not possible to obtain a valid estimate of percent disease by assessing only the diseased area or only the healthy area. Awareness of both areas must be involved in estimating percent disease. The estimation may be based on a perception either of the proportion of the total area that is diseased, or of the ratio of diseased areas to healthy areas. However, estimates of proportions do not necessarily obey the Weber-Fechner law (1,5,6).

The Horsfall-Barratt scale is based on the assumption that all estimates that depend on visual perception would obey the Weber-Fechner law. This assumption is false. There have been indications for many years that some stimulus-response curves do not obey this law (5,6), but it was also recognized that many factors may affect the stimulus-response curve besides the sensitivity of the observer to the stimulus. Philip (5) performed an experiment in which observers were asked to judge the proportion of blue dots to green dots on cards. With the exception of the terminal positions (which served as frames of reference for the series) correct judgments were made with nearly equal frequency at all points of the scale. Stevens and Galanter (6) found that the estimated length of rods was very nearly a linear function of their actual lengths. Estimates of the lightness of colors seemed to be a power function of the measured luminance. Stimulus-response curves based on the estimation of the actual magnitude of the stimulus were frequently different from those obtained by the category method in which observers were asked to classify the stimuli into several magnitude categories. They warned that "there are numerous pitfalls in this business" (6).

Baird and Noma (1) proposed that there are probably four types of stimulus-response curves: The first of these is the linear function in which the response increases linearly as the stimulus increases linearly. Curves in this group seem to deal mostly with estimation of proportions or positions. The second type is the logarithmic function in which the response increases linearly as the stimulus increases logarithmically. This is the Weber-Fechner law. The central portion of many stimulus-response curves fit this function although frequently there are deviations at the lower and upper ends of the curves. The third type is the exponential function in which the response increases logarithmically as the stimulus increases linearly. No example of this type was given. The fourth type is the power function in which the response increases logarithmically as the stimulus increases logarithmically. This function, also known as Steven's law, has been verified in hundreds of experiments for a wide variety of stimuli (including the visual estimation of area, sweet taste, coffee smell, loudness, brightness, weight of objects, and skin electrical impulses). It is common practice to plot the response against the stimulus on double-logarithmic paper (base 10) and to draw a straight line through the points, which allows the slope and y intercept to be found directly.

Although the rationale for the Horsfall-Barratt scale has been questioned, many investigators have used it and its popularity seems to be increasing (3). Other investigators use keys based on a percent scale (4) while still others assess disease directly without a scale. There appear to be no convincing experimental data showing that one scale is better than the other, or that using a scale is better than assessing disease directly without a scale.

Many investigators have claimed that disease can be estimated more accurately by using a scale, but have neglected to present data that support their conclusions. We need to know how much improvement in accuracy can be expected by using a scale. The logarithmic and percent scales should be compared in the same experiment to see if one performs better than the other. Furthermore, if we use a scale we should determine whether it is better to use it as an aid in estimating the actual percent disease, or merely as an aid in classifying diseased material into disease-intensity categories.

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LITERATURE CITED

1. Baird, J. C., and Noma, E. 1978. Fundamentals of Scaling and Psychophysics. John Wiley & Sons, New York. 287 pp.
2. Horsfall, J. G., and Barratt, R. W. 1945. An improved grading system for measuring plant diseases. (Abstr.) Phytopathology 35:655.
3. Horsfall, J. G., and Cowling, E. B. 1978. Pathometry: The measurement of plant disease. Pages 119–136 in: Plant Disease, An Advanced Treatise. Vol. II. J. G. Horsfall and E. B. Cowling, eds. Academic Press. New York.
4. James, W. C. 1971. An illustrated series of assessment keys for plant diseases, their preparation and usage. Can. Plant Dis. Surv. 51:39-65.
5. Philip, B. R. 1947. The relationship of speed and exposure time in a perceptual task. J. Exp. Psychol. 37:178-186.
6. Stevens, S. S., and Galanter, E. H. 1957. Ratio scales and category scales for a dozen perceptual continua. J. Exp. Psychol. 54:377-411.