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Susceptibility to bunch stem necrosis in grapes: A breeding screen

by

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Summary: A breeding screen has been developed with which it is possible to predict the resistance of newbred grapevine varieties to bunch stem necrosis. The screen is based on a 5-year study of 17 commercial varieties in which it was noted that in those which are sensitive to the disorder, xylem development is relatively reduced just distal to each branch point in the peduncle so as to form a short "bottleneck" (DÜRING and LANG 1993). The procedure advocated, offers a probabilistic assessment of susceptibility to the disorder, calculated from simple light microscope measurements on a relatively small amount of material.

Key words: bunch stem necrosis, disorder, resistance, xylem, model screening, variety of vine.

Introduction: A considerable proportion of commercial grape varieties is susceptible to the physiological disorder 'bunch stem necrosis' (Stiellähme), e.g. Riesling and Gutedel. On the other hand, significant numbers are resistant, e.g. Silvaner and the Pinot family (STELLWAAG-KITTLER 1975; KANNENBERG 1982). This clearly indicates a heritable factor and therefore the opportunity to reduce or eliminate the disorder from viticulture by selection for resistance in grape breeding programmes. Unfortunately, although clearly highly desireable, there is at present no way to predict susceptibility to bunch stem necrosis in a newbred.

In a preliminary study of xylem structure and function in the grape peduncle system (DÜRING and LANG 1993) it was noticed that xylem development in some varieties is rather reduced in a short region just distal to each branchpoint (node). Over a 5-year period an extensive investigation of this phenomenon was carried out in 17 grape varieties of different known susceptibilities to bunch stem necrosis. The investigation revealed a strong correlation between a feature of xylem development and susceptibility which was, moreover, reasonably stable from year to year.

The correlation, between a straightforwardly measured anatomical feature and a commercially important disorder, offers the prospect that a selection screen can at last be developed for use in grape breeding programmes. Accordingly, the results of the study (DÜRING and LANG 1993) are here summarised and analysed in such a way as to develop a model through which it should be possible to predict susceptibility to bunch stem necrosis amongst newbred grape varieties at an early stage of their evaluation.

Previous results: DÜRING and LANG (1993) measured a characteristic of the xylem which they quantified as the relative xylem development (D), scoring it on an arbitrary scale between 0 and 100. The classification of each variety for susceptibility to bunch stem necrosis they based on an extensive literature search. They found that the best correlation between D and susceptibility was for measurements made on peduncle transsections cut from lateral branches just distal to the nodes. For further details of the measurement of D and for the determination of susceptibility see DÜRING and LANG (1993).

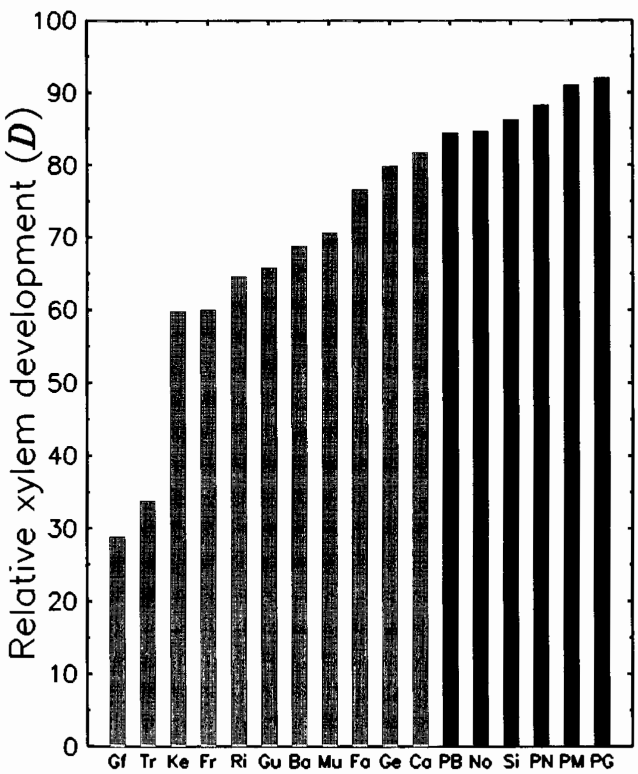

Fig. 1: Histogram of the mean values of xylem development (D) of 17 grape varieties. Shaded and black bars indicate varieties classified as susceptible and resistant, respectively. (The figure has been drawn from values presented in tabular form in DÜRING and LANG 1993.) Variety abbreviations are: Gf=Gf.Ga-51-13; Tr=Trollinger; Ke=Kerner; Fr=Freisamer; Ri=Riesling; Gu=Gutedel; Ba=Bacchus; Mu=Müller-Thurgau; Fa=Faber; Ge=Gewürztraminer; Ca=Cabernet Sauvignon; PB=Pinot blanc; No=Nobling; Si=Silvaner; PN=Pinot noir; PM=Pinot meunier; PG=Pinot gris.

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Analysis: For the present analysis, values were averaged over the 5-year period over which measurements were made enabling them to be presented here as a bar graph (Fig. 1). For convenience, the varieties are plotted in ascending order of D. Inspection of Fig. 1 reveals that the highest values of D are to be found amongst the resistant varieties (black bars) whilst the lower values are to be found amongst the more susceptible ones (shaded bars). The clear separation of susceptible and resistant cultivars in Fig. 1 on the basis of their D value invites the development of a prediction model based on this anatomical character.

To generate the model we first combine the 6 resistant and the 11 susceptible varieties into two groups and calculate the mean D and standard deviation σ_D for each. These work out at

D = 87.73 and σ_D = 6.13 for the resistant varieties and

D = 61.66 and σ_D = 18.61 for the susceptible ones.

Then for each group we evaluate the relationship

$$t = D_i\text{-}D/\sigma_D \qquad (1)$$

to find a series of values of t (the student t-statistic), for a range of values of D_i. Next, using the relationship

$$p = (1/\sigma\sqrt{2\pi})e^{-1/2t^2} \qquad (2),$$

where p is probability, we compute the two probability distributions presented in Fig. 2. From these we can estimate the probability that a newbred of known D, comes from each of the two susceptibility groupings.

Next, assuming that the population from which the newbred is taken is comprised of equal numbers of susceptible and resistant individuals[1]), we calculate the probability θ that a newbred is susceptible, where

$$\theta = p_s/(p_s+p_r) \qquad (3),$$

and where ps and pr are the probabilities that the newbred falls within each of the two susceptibility groupings (see Fig. 2). We can represent this as a single curve of θ *vs* D (Fig. 3).

Fig. 3 can be used to determine the probability that a newbred grape is susceptible to bunch stem necrosis on the basis of simple light microscope measurements of D.

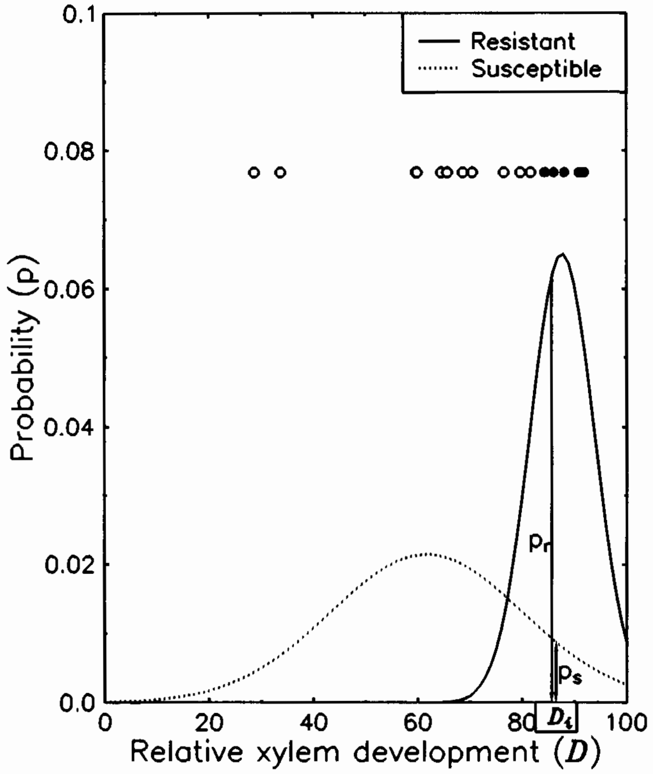

Fig. 2: Curves, based on the results of our study, showing the two probabilities that a newbred grape variety with xylem development D belongs within the susceptible and the resistant groupings of varieties. The values p_s and p_r are the two probability values for a hypothetical newbred with a measured relative xylem development D_i of 86. The open and filled circles are D values for the 11 susceptible and 6 resistant varieties, resp.

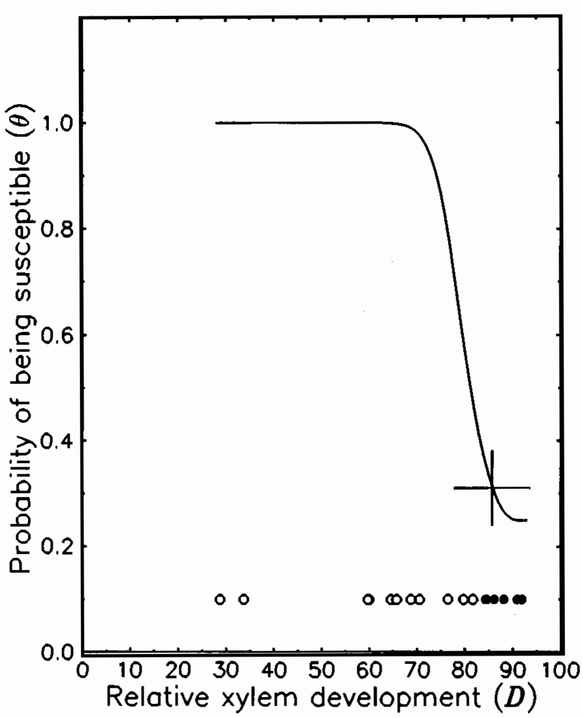

Fig. 3. The probability (θ) that a newbred grape is susceptible to bunch stem necrosis is expressed as a function of relative xylem development (D) measured at the base of the sidebranches of the peduncle. In our hypothetical example introduced in Fig. 2, the probability of its being susceptible to bunch stem necrosis is assessed as p=0.31 (this is marked as a cross-wires). The open and filled circles are the D values for the 11 susceptible and 6 resistant varieties, resp.

Application: If values of D for newbred grape varieties fall within about the same range as the 17 varieties tested (i.e. between about 30 and 100) predictions of their susceptibility will lie between 1 and 0.1 (Fig. 3).

The slight asymmetry means that we can be more certain that a low scoring newbred will be susceptible to bunch stem necrosis than that a high scoring one will be resistant. Commercial breeding places a somewhat opposite requirement on a probabilistic screen for it generally matters less for an early screen that a potentially valuable newbred is rejected in error, than that a defective one is retained in error. The proposed new screen nevertheless represents a considerable improvement on the existing situation in which we have had no screen at all. Previously, and again assuming equal representation in the population as a whole[1]), the chances of inadvertently releasing to the market a susceptible newbred were perhaps 0.5 (or more), whereas with the new screen they should improve to ca. 0.1.

Conclusion: Grape varieties exhibiting reduced xylem development in the peduncle just distal to the branch points tend to be those which are most susceptible to bunch stem necrosis. The correlation between susceptibility and relative xylem development allows the formulation of a probabilistic model from which the susceptibility to bunch stem necrosis of newbred grapes may be predicted.

The proposed scheme is practicable in that measurement of D in the laboratory is quick and straightforward and requires no special equipment. The result is, moreover, reasonably stable from season to season which makes the procedure we describe suitable for use by grape breeders as an early screen for resistance to bunch stem necrosis.

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[1]) The assumption that the population contains equal proportions of susceptible and resistant individuals is probably conservative to the extent that of the 17, more-or-less randomly chosen, varieties of our study, 11/17 (66 %) are susceptible and only 6/17 (34 %) are resistant.

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