Partitioning of injuries caused by winter, fungal diseases and viral infections in cereals

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The objective of this study was to clarify whether the critical levels of winter damage, viral infections and foliar diseases of cereals could be established by the Cate-Nelson procedure. This information would help the State Granary representatives and computer modelists, as well as farmers and consultants to understand the yearly variations in grain yields of cereals. Three winter rye, spring wheat and oat cultivars were used. The severity of leaf diseases and percentages of winter damage were observed visually. When winter damage exceeds 19%, a yield reduction of 44% (1804 kg ha^{-1}) in winter rye may be expected. The critical level of *Septoria nodorum* infection in spring wheat was 37%. Above this critical level a yield reduction of 33% (1393 kg ha^{-1}) was estimated. In oat canopy an area of ≥ 38% infected by barley yellow dwarf virus (BYDV) decreased the grain yield significantly by 30% (1718 kg ha^{-1}).

Key words: winter rye, spring wheat, oats, winter damage, foliar diseases

Introduction

At the State Granary, decisions regarding import/export ratios of cereals are made retrospectively. In the absence of timely and exact yield data the decisions are inaccurate. The observations on the cereal crop are made by the Finnish Natioal Board of Agriculture, which has 300 - 400 representatives in different parts of the country. Yield estimates are based on visual observation. The results obtained by this method have shown that estimations may be inaccurate due to the paucity of observations. In addition, if growing conditions are abnormal (e.g. due to foliar diseases), the State Granary representatives may be unwilling to make extreme prognoses.

Recently TEITTINEN et al. (1993) developed a simple dynamic model based on daily climatological data, enabling prediction of crop growth, change in crop yield and grain quality. However, foliar diseases like *Erysiphe graminis* f. sp. *tritici* had a deleterious effect on grain yield of spring wheat and the prognoses on yield with the dynamic model failed (TEITTINEN et al. 1993). Therefore, it is preferable to determine the critical levels of winter damage, viral infections and fungal diseases of cereals. This information would help the State Granary representatives to estimate the final yield losses caused by the above mentioned stress factors, or to improve the prognostic value of the dynamic model developed by TEITTINEN et al. (1993).

Material and methods

The field trials were conducted in 1982-1988 at the Anttila Plant Breeding Farm (Hankkijan kasvinja-

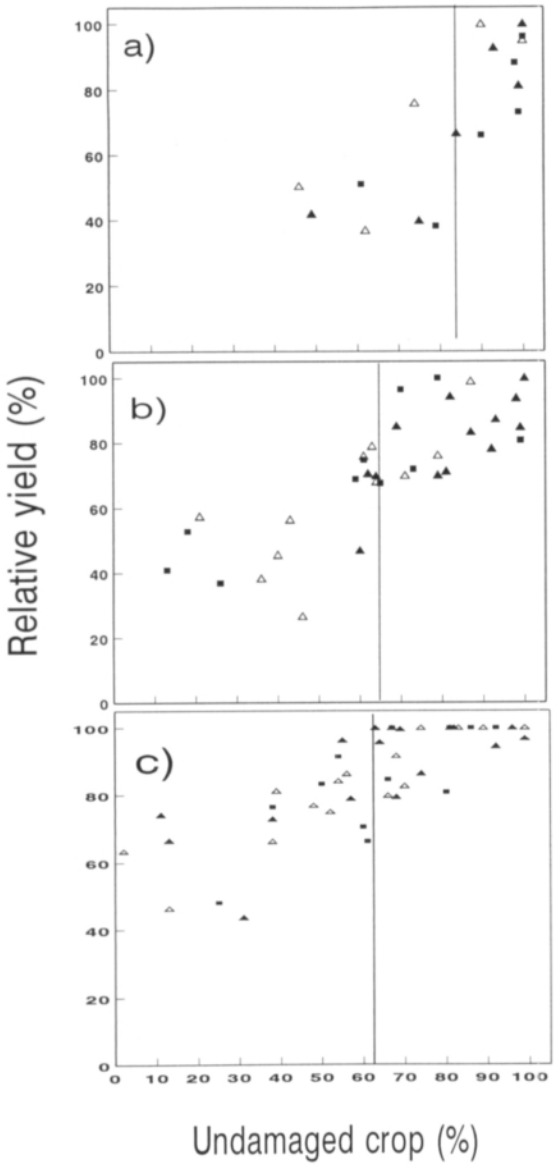

Fig. 1. Relative yields of three (a) winter rye cultivars as related to winter damage, (b) spring wheat cultivars as related to *Septoria nodorum* infection rate, and (c) oat cultivars as related to the barley yellow dwarf virus (BYDV) infection at the Anttila Plant Breeding Farm, 1982-1988. Cultivars: ■ = Hja Jussi winter rye, Ruso spring wheat, Caesar oats; ▲ = Sampo winter rye, Kadett spring wheat, Puhti oats; Δ = Voima winter rye, Ulla spring wheat, and Veli oats.

lostuslaitos 1982-1988). Winter rye cultivars Hja Jussi, Sampo and Voima, spring wheat cultivars Ulla, Ruso and Kadett, and oat cultivars Puhti, Veli and Caesar (naked Cv.) were used. The fertilization levels used were those commonly applied in cereal cultivation in southern Finland. The percentage area of winter injury per plot in rye, and canopy infected by *Septoria nodorum* Berk. in spring wheat, and by barley yellow dwarf virus (BYDV) in oats were observed visually according to REKUNEN (1990). The critical levels of different stress factors were established using the Cate-Nelson analysis (CATE and NELSON 1971, NELSON and ANDERSEN 1977), a procedure widely used by soil scientists in evaluation of soil fertility and nutrient requirements of crops. Grain yield of a cultivar was expressed as a yield percentage (Y_i/Y_{max} x 100) where Y_i stands for actual grain yields of a cultivar obtained in 1982-88 and Y_{max} is the highest grain yield of a cultivar obtained in 1982-1988. The graphical Cate-Nelson method (NELSON and ANDERSEN 1977) was used (Fig. 1).

Table 1. Cate-Nelson equations describing grain yield (Y) in relation to (1) overwintering in winter rye, (2) infected plant canopy of *Septoria nodorum* in spring wheat, and (3) disease development caused by barley yellow dwarf virus (BYDV) in oats.

Equation	R^2
(1) $Y = 2294 + 1804 \cdot x$	
where $x = 0$ if ≤ 81 and 1 if ≥ 81 (%)	0.68^{***}
(2) $Y = 2791 + 1393 \cdot x$	
where $x = 0$ if ≤ 63 and 1 if ≥ 63 (%)	0.48^{***}
(3) $Y = 3948 + 1718 \cdot x$	
where $x = 0$ if ≤ 62 and 1 if ≥ 62 (%)	0.51^{***}

*** Significant at 0.001 probability level.

The critical levels reducing the grain yields of cereals

The critical level of winter damage for rye observed in the present study was 19% (Fig. 1a). When winter damage exceeds 19%, a yield reduction of 1804 kg ha^{-1} (44%) may be expected (equation 1, Table 1). The critical level of *Septoria nodorum* infection in spring wheat was 37% (Fig. 1b). According to the present results, yield losses caused by *Septoria* in an infected canopy of a cultivar ranking

'low', as estimated by the Cate-Nelson procedure (equation 2, Table 1), average 2791 kg ha^{-1} of grain yield as compared with an average yield of 4184 kg ha^{-1} for the 'optimum' class. In other words, above the critical infection rate (≥ 37%) a yield reduction of 33% (1393 kg ha^{-1}) can be expected. This result is an agreement with the earlier results of KARJALAINEN (1985) who reported decreases of kernel weight of 10-35% due to leaf and glume blotch (*Septoria nodorum* Berk.). Inversely, if the *Septoria* level in the canopy is < 37 %, no significant yield reduction will occur. Regarding BYDV in the canopy of oats, an area of ≥ 38 % infected by BYDV decreased the grain yield significantly by 1718 kg ha^{-1} (Fig. 1c, Table 1). This corresponds to a yield reduction of about 30 %. Similarly, a severe out-break of BYDV has been observed by KURPPA (1989) and PELTONEN-SAINIO and KARJALAINEN (1990) to cause 30-50 % yield losses.

In conclusion, the Cate-Nelson model may provide useful information of yearly variations in grain yields of cereals to the State Granary representatives and computer modelists, as well as to farmers and consultants. However, this study was based on data collected by the Anttila Plant Breeding Farm. The data consisted of visual estimation of leaf diseases and winter damage only. Therefore, more detailed experiments are needed in future to determine the variation in critical levels in different locations and in different growth stages of cereals.

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SELOSTUS

Eräiden stressitekijöiden raja-arvoja viljojen sadonmuodostuksessa

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Tutkimuksessa määritettiin rukiin talvituhojen, kevätvehnän härmäsaastunnan ja kauran BYDV:n (ohran kääpiökasvuviruksen) rajaarvoja sadonmuodostuksen kannalta. Talvituhot rajoittivat rukiin sadonmuodostusta voimakkaasti, mikäli kylvetystä pinta-alasta oli tuhoutunut yli 19 %. Jos Septoriasaastunta oli voimakkaampi kuin 37 %, heikensi infektio satotasoa selvästi. BYDV:n aiheuttama satotappio oli merkittävä mikäli enemmän kuin 38 % lehdistöstä oli saastunut. Kyseisten sadonmuodostusta rajoittavien stressien aiheuttama sadon menetys oli mallin mukaan rukiilla keskimäärin 44 % (1804 kg/ha), kevätvehnällä 33 % (1393 kg/ha) ja kauralla 30 % (1718 kg/ha). Tutkimuksessa on pohdittu stressiraja-arvojen merkitystä arvioitaessa viljojen vuosittaisia satovaihteluita.