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Prediction of eyespot infection risks

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Summary

The objective of the study was to design a prediction model for eyespot (*Tapesia yallundae*) infection based on climatic factors (temperature, precipitation, air humidity). Data from experiment years 1994-2002 were used to study correlations between the eyespot infection index and individual weather characteristics. The model of prediction was constructed using multiple regression when a separate parameter is assigned to each factor, i.e. the frequency of days with optimum temperatures, humidity, and precipitation. The correlation between relative air humidity and precipitation and the infection index is significant.

Key words: *Tapesia yallundae, T. acuformis,* winter wheat

INTRODUCTION

The causal agents of eyespot are two fungal species, *Tapesia yallundae* Wallwork & Spooner, [anamorph] *Pseudocercosporella herpotrichoides* (Fron) Deighton, and *T. acuformis* (Boerema, Pieters & Hamers) Crous, [anamorph] *Pseudocercosporella herpotrichoides* var. *acuformis* Nirenberg (Wiese, 2000). Eyespot occurs in Europe, USA, Australia, New Zealand, Japan, and Africa (Anonymous, 1981, Furuya and Matsumoto, 1996). Eyespot is also often found in the Czech Republic (Váňová et al., 2000).

The fungus infects winter wheat *(Triticum aestiwm* L.), winter barley *(Hordeum yulgare* L.), rye *(Secale cereale* L.) and as well as grasses that could be a source of infection. Oval spots form on stem bases and at high disease severity, cotton-like mycelium is visible on the cross-section of the stem. Due to joint effects with other pathogens, called stem-base diseases, cereals become more susceptible to lodging or water translocation is interrupted, which results in head whitening.

The fungus survives on post-harvest residues for all the year round. The peak of conidia production is in autumn (October and November) and in early spring (March and April). The optimum temperature for this development stage is around 5°C. Spores are formed under wet conditions only and are splashed by rain in the surroundings. The stem is infected by gradual growing of the mycelium through leaf sheaths that circie the stem base. Critical for this process are probabty weather conditions during May and June and as well as intensity ofthe host growth (Fitt et al., 1988) the growing tissue is resistant. In spite of a high level of infection of leaf sheaths, the plants with rapid growth are able to produce good yields.

The economic importance of cereal eyespot is difficult to determine due to the problem of accurate diagnosis of the disease in the presence of other stem-base pathogens. There is no doubt, however, that it is potentially one of the most damaging diseases of winter cereals, especially wheat (Polley and Thomas, 1991). High harmfulness of eyespot is conditioned by high infection already in April and sufficient rainfall during May (Benada, 1995). Besides weather conditions, the disease development is influenced by other factors, such as varietal sensitivity, sowing date and forecrop.

Efficiency of fungicide control is reduced for resistant to MBC fungicides which previously gave effective control (King and Griffin, 1985, Yarham, 1986). To be effective control, fungicides must be applied before lesions become severe and there have been numerous attempts to predict the occurrence of severe epidemics (Fehrmann and Schrödter, 1973). Many forecasting schemes for other crop diseases use meteorological data from synoptic weather stations to predict the occurrence of conditions favourable for sporulation, dispersal and infection; when the weather data suggest that infection has occurred, growers are recommended to spray their crops (Royle and Butler, 1986). Such a weather-based forecasting scheme has been developed for eyespot on wheat e.g. by Fehrmann and Schrödter (1973), Siebrasse and Fehrmann (1987), and Gindrat and Frei (1999).

MATERIALS AND METHODS

Samples of plants were collected at the late milky growth stage (DC 75). Infection of stem bases was evaluated and transformed using the infection index (Benada et al., 1981).

$$i = [(n_1+2n_2+3n_3).100]/[3.(n_0+n_1+n_2+n_3)]$$

Where: n is a number of plants in appropriate degree of infection (0 stems without lesions, 1 lesion on $^1/_4$ of stem circumference, 2 lesions on $^1/_4$ to $^3/_4$ of stem circumference, 3 lesions on whole stem circumference).

Data from experiment years 1994-2002 were used to study correlations between the eyespot infection index and individual weather characteristics. Conditions facilitating the infection were selected for this calculation, i.e. a preceding crop was always winter wheat one susceptible and one resistant variety for each growing season. The susceptible variety was in most cases Samanta, the resistant ones were most often Siria and Ebi. The growing season 1998 was excluded from evaluations due to excessive incidence of *Fusarium* and *Rhizoctonia* genera on stem bases that masked symptoms *of P. herpotrichoides* infection. Foreign models according to Siebrasse and Fehrmann (1987) and Gindrat and Frei (1999) were verified first.

These models predict an infection level based on the five-score scale of EPPO and use parameters of average temperatures after sowing, a number of days in November with the temperature above 4°C, sums of average daily temperature in November, and precipitation sums from sowing to the end of February. The correlation analysis of the predicted and actual infection level showed that such models were not suitable for our conditions since correlation coefficients were very low and insignificant in all cases. Then, weather parameters and the infection index were correlated. The correlations were calculated for the period from October to the end of April, which is the deadline for efficient treatments against eyespot. The model was tested in field experiments at locations Zabćice, Ivanovice, Branisovice, and Troubsko.

RESULTS AND DISCUSSION

The correlation between the frequency of days during the defined period with optimum values of these climatic characteristics for disease development and the infection index are illustrated in Figs 1 3. If average values or sums of data are used for correlations, the correlation coefficients are mostly insignificant. The exception is a precipitation sum and sunlight duration when correlation coefficients are close to significant values. The model would not provide a reliable prediction of infection for these parameters, and therefore optimum periods for disease development and frequency were defined.

Based on literature data and empirical experience, these optimum conditions were defined as follows: temperature of 4-10°C (average daily temperature), relative air humidity above 80% (relative air humidity at 2 p.m.), and daily precipitation above 3 mm.

The correlations of frequencies of days with such conditions show that reliability of predictions increases in all parameters, and the correlation between relative air humidity, temperature, precipitation and the infection index is significant (Table 1).

Table 1. Correlation coefficients of the infection index for *Tapesia yallundae* and the most important meteorological data

Meteorological data	Correlation coefficient	
	Susceptible variety	Resistant variety
Precipitation sum	0.69	0.67
Sunlight duration	0.65	0.56
Number of days with temperatures of 4 10°C	0.4	0.53
Number of days with relative air humidity above 80%	0.75*	0.75*
Frequency of days with both favorable temperatures and humidity	0.73*	0.83**
Number of days with precipitation above 3 mm	0.72*	0.68
Frequency of days with both favourable temperarures and precipitation	0.65	0.76*

(* significant at p=0.01 0.05; ** p<0.01)

Fig. 1. Infection index for eyespot *(Tapesia yallundae)* on winter wheat in dependence on a day number with precipitation above 3 mm

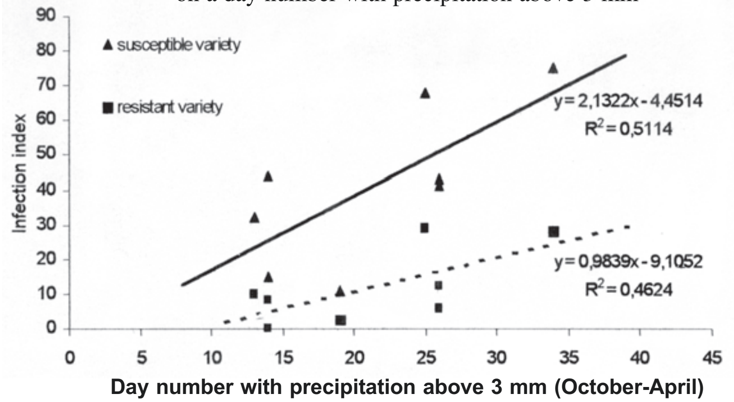


Fig. 2. Infection index for eyespot *(Tapesia yallundae)* on winter wheat in dependence on a day number with relative air humidity above 80%

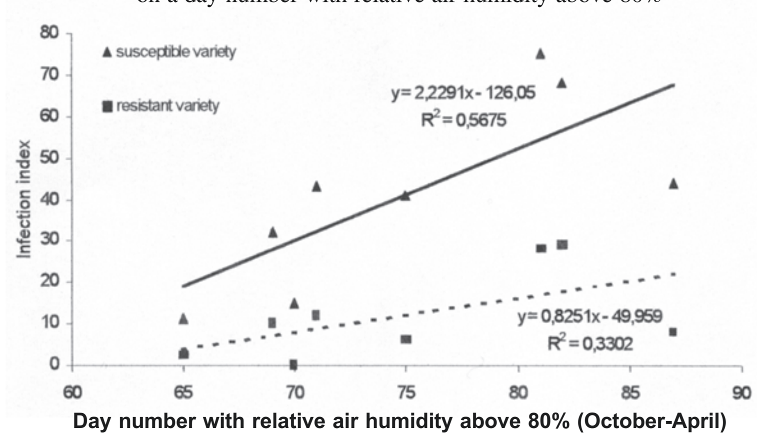
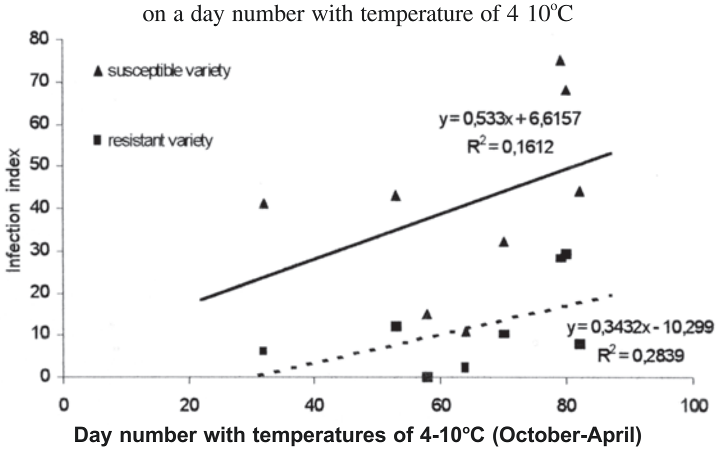


Fig. 3. Infection index for eyespot *(Tapesia yallundae)* on winter wheat in dependence on a day number with temperature of 4 10°C



Finally, the prediction model for infection index based on meteorological characteristics was designed. This model was constructed using multiple regression when a separate parameter is assigned to each factor, i.e. the frequency of days with optimum temperatures, humidity, and precipitation (Tables 2, 3). The equation of the model of multiple regression:

$$y=-123{,}988+0{,}291A\ +1{,}430B+1{,}822C$$

Where: A: Number of days with temperatures of 4-10°C, B: Number of days with relative air humidity above 80% and C: Number of days with precipitation above 3 mm.

Table 2. Multiple regression

Factor	Value	t test
Y: Intercept	123.988	0.029
A: Number of days with temperature of 4 10°C	0.291	0.335
B: Number of days with relative air humidity above 805	1.430	0.079
C: Number of days with precipitation above 3 mm	1.822	0.027

Table 3. Analysis of variance

Item	df	Sum of squares	Mean square	F	P
Model	3	3161573	1053.857	10.71	0.022
Error	4	393.301	98.325		
Total	7	3554.875			

Model of regression is significant

The correlation of frequencies of days (October April) with temperatures of 4-10°C, with relative humidity above 80% and with precipitations above 3 mm shows that reliability of prediction of infection index increases in all parameters and it is significant. For more exact forecasting the actual infection index of plants in the field should be ascertained.

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Ocena ryzyka porażenia pszenicy przez *Tapesia yallundae*

Streszczenie

Celem podjętych badań było opracowanie modelu opisującego ryzyko porażenia roślin przez *T.yallundae*. W przeprowadzonej analizie uwzględnianymi parametrami były liczba dni: z temperaturą 4 10°C, opadami powyżej 3 mm oraz wilgotnością powietrza powyżej 80%.

Stwierdzono występowanie istotnej korelacji pomiędzy indeksem porażenia roślin a wspomnianymi parametrami.