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Surveys of cereal diseases and pests in the Netherlands. 2. Stem-base diseases of winter wheat

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Abstract

In the period 1974-1986, ca. 100 commercial winter wheat fields were surveyed annually for stem-base diseases. In these years, on average 6% of the tillers was infected with eyespot in spring at the first-second node stage. Eyespot intensity in spring was high in years with high temperature during winter. Eyespot intensity in the milky-ripe stage in July, averaged 13% of the culms and was high in years with high temperature in April and high precipitation in March, April and May. These data may improve forecasts.

In the milky-ripe stage, 2% of the culms were infected with sharp eyespot, but its intensity has gradually increased during the survey years. No significant correlation of sharp eyespot intensity with dry periods in autumn, spring or summer was found.

Symptoms of take-all were found on 0.2% of the stem-bases during ripening. Its intensity was low in years with high precipitation in March, April, May and June and high temperature in May and June.

Additional keywords: Triticum aestivum, Pseudocercosporella herpotrichoides, Rhizoctonia cerealis, Gaeumannomyces graminis, epidemiology, weather, forecasts.

Introduction

Systematic annual surveys of diseases and pests in commercial winter wheat fields in the Netherlands were conducted from 1974-1986 (Daamen, 1990). This second report is a compilation and interpretation of the annual survey reports for stem-base diseases in winter wheat. The diseases included were eyespot caused by *Pseudocercosporella herpotrichoides*, sharp eyespot caused by *Rhizoctonia cerealis* and the root and stem-base disease take-all caused by *Gaeumannomyces graminis*. Brown footrot caused by *Fusarium* spp. and *Monographella nivalis* may also be considered stem-base diseases, but as their occurrence on stem-bases is associated with that on leaves, ears and seeds, these pathogens will be discussed in a separate paper. In this paper, disease intensities are expressed as the percentage fields with disease (prevalence) and as the percentage tillers or culms with disease (incidence).

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Table 1. Mean annual incidence (% tillers or culms infected) and prevalence (% fields infected) of stem-base diseases in winter wheat and % fields treated to control eyespot. An – indicate no data.

Year	74	75	76	77	78	79	80	81	82	83	84	85	86
Number of fields surveyed:													
May:	143	88	89	105	124	305	219	132	123	107	176	–	–
July:	143	88	94	105	124	129	164	138	152	143	123	94	94
Incidence:													
May: Eyespot	13	7	4	4	7	1	9	3	4	6	9	–	–
July:													
Eyespot	17	10	7	6	9	20	8	21	10	35	10	16	4
Sharp eyespot	–	–	0.4	0.8	1.7	1.0	1.7	1.1	2.3	1.5	4.8	4.3	2.4
Take-all	1.0	0.2	0.2	0.3	–	0.0	0.0	0.0	0.0	0.0	0.5	0.1	0
Prevalence:													
May: Eyespot	80	68	60	65	–	39	82	52	57	69	77	–	–
July:													
Eyespot	86	74	60	63	–	87	85	89	74	92	74	80	52
Sharp eyespot	–	–	9	16	–	13	28	22	33	28	47	34	35
Take – all	30	14	9	15	–	1	1	4	2	1	10	2	0
% fields with eyespot treatment[a]	28	9	4	9	–	3	14	10	8	9	22	–	–
Mean weighted resistance rating of the cultivars[b]	5.8	5.5	6.0	6.2	6.8	7.0	7.1	7.2	7.2	7.2	7.2	7.2	7.2

[a] 1974-1977 based on surveyed fields, 1989-1984 based on treatments in all EPIPRE fields.
[b] A higher rating indicate greater resistance against eyespot.

Materials and methods

Disease assessments. Crops were visited on two occasions. On the first, usually in May, at the first to second node stage, 25 plants per field were sampled, from which the two main tillers per plant were used to assess disease intensities. In July at the milky-ripe stage, sample size was 50 culms per field, which was reduced to 40 culms per field after 1980.

To assess incidence of stem-base diseases in May, in each field the number of tillers with disease symptoms on living basal leaf sheaths was counted and expressed as percentage of the number of tillers sampled. In July, the number of culms with disease symptoms on stems was counted and expressed as percentage infected culms. Incidences were averaged over all fields to obtain mean annual incidence for the two periods. Disease prevalence was calculated by expressing the number of fields with disease as percentage of the number of fields sampled in the country.

Disease development. Special attention was paid to the effect of weather on disease development. Mean monthly temperature (°C) and precipitation (mm) were used as parameters to characterize weather. Correlation coefficients of these two meteorological parameters with mean disease intensities were calculated. If successive months indicated trends, correlation coefficients were also computed with the meteorological parameters for these months combined. Data were analysed with a stepwise regression procedure. The result was compared to literature data. Because the weather conditions were not experimentally controlled, causality of the relations is not guaranteed and it is emphasised that results are descriptive.

Disease intensities in the different cultivars were described in the annual survey reports. Because some cvs. are mainly sown in certain districts, effects of cvs. on disease intensity can be confounded with regional effects. From 1980 to 1984, disease intensities in cvs. were analysed, taking the differences in regional disease intensity into account. The degree of susceptibility to diseases of the cultivars were derived from the cultivar lists of the Government Institute for Research on Varieties of Cultivated Crops (RIVRO). Mean annual winter wheat susceptibility to eyespot was computed by weighting the RIVRO resistance ratings of the cultivars over their area in a year.

Results and discussion

Pseudocercosporella herpotrichoides. Apart from *P. herpotrichoides*, *R. cerealis* also causes eyespot-like symptoms. In May, it is difficult to distinguish visually between most of the lesions caused by the two pathogens. The symptoms that could be distinguished visually, the most developed symptoms, were mainly caused by *P. herpotrichoides*.

In May, mean annual incidence averaged 6% tillers and mean prevalence averaged 65% fields over the years 1974-1984 (Table 1). Both measures of annual disease intensity were positively correlated ($r = 0.90$). The disease intensities in May varied considerably between years. Annual disease intensities in May were positively correlated with average temperature during the winter months December, January and February (Figs. 1a,b). Optimum temperature for sporulation and infection by *P. herpotrichoides* is between 4-10 °C at high humidities (Schrödter and Fehrmann, 1971 and Siebrasse and Fehrmann,

Fig. 1a,b. Mean annual eyespot incidence (a, Y in % infected tillers) and prevalence (b, Y in % infected fields) in May, in relation to average temperature (X, °C) over the months December, January and February.
Regression a: Y = 1.8 + 1.4 X (R^2 = 0.44).
Regression b: Y = 47 + 6.0 X (R^2 = 0.55).

1987). Temperature during winter is usually below this optimum, while moisture conditions are usually favourable. Therefore, high temperatures during winter favour infections. The R^2-values are low and the data show a considerably scatter (Fig. 1a,b). This scatter is presumably partly due to differences in sowing dates. These relations could not be analysed as data on sowing dates were not collected systematically in the surveys.

In July at the milky-ripe stage, nearly all symptoms of eyespot (*P. herpotrichoides*) and sharp eyespot (*R. cerealis*) could be distinguished visually and intensities for both diseases were recorded from 1976 onwards. Mean annual incidence and prevalence of eyespot (*P. herpotrichoides*) in July averaged 13% culms and 76% fields (Table 1), respectively, and were positively correlated (r = 0.70). Mean eyespot intensity in July was lower than was recorded in the neighbouring countries Belgium (Meunier, 1984 and 1985; Lagneau et al., 1986), Germany (Reinecke and Fehrmann, 1979) and England and Wales (Clarkson and Polley, 1981).

Mean annual eyespot intensities in July were positively correlated with mean temperature in April and cumulative precipitation in March, April and May (Fig. 2a,b). Wet weather in spring is favourable for spore dispersal and infections. Moreover dry weather during this period may accelerate death of basal leaf sheaths, so that established eyespot lesions on leaf sheaths may not grow into the stem (Higgins et al., 1986; Fitt and White, 1988). Mean temperature in April is close to optimum for sporulation and infection, hence the correlation with temperature in April seems unlikely to be due to these processes. The effect of weather on the processes governing leaf sheath penetration and stem infection are still under discussion (Fitt et al., 1988). Our observations indicate that these processes are favoured in this country by high temperatures in April, presumably by acceleration of the leaf sheath penetration rate (Rapilly et al., 1979).

Eyespot intensity in July may be predicted from temperature in April an precipitation in March, April and May (Fig. 2a,b). A decision for eyespot control in the Netherlands usually takes place mid May, based on eyespot intensity in May only. These decisions can be improved by taking the average temperature in April and the cumulative precipitation in March, April and May into account. Though precipitation in May is then only partly known, the remainder may be estimated from mean precipitations or weather forecasts.

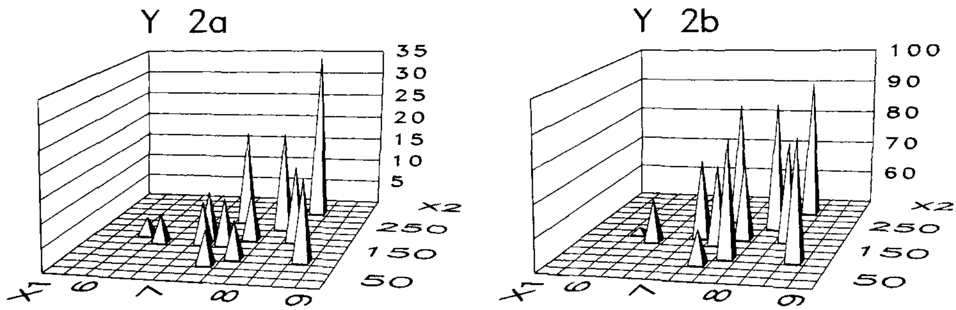


Fig. 2a,b. Mean annual eyepot incidence (a, Y in % infected culms) and prevalence (b, Y in % infected fields) in July, in relation to mean temperature in April (X_1, °C) and cumulative precipitation (mm) in March, April and May (X_2).
Regression a: $Y = -49 + 6.3\ X_1 + 0.09\ X_2$ ($R^2 = 0.91$).
Regression b: $Y = -30 + 12\ X_1 + 0.08\ X_2$ ($R^2 = 0.86$).

No significant correlation coefficients were obtained between mean eyespot intensities and mean resistance ratings of the cultivars. This is surprising as the mean annual resistance rating of the cultivars varied considerably though gradually over the years (Table 1). Differences in eyespot intensity between cultivars were seldom significant. At the start of the surveys, cv. Manella was usually more severely affected than cv. Clement, while cv. Caribo had the lowest disease incidence. In 1983 cv. Saiga was more, and in 1984 and 1985, cv. Granada was less affected than cvs. Okapi and Arminda.

Mean annual eyespot intensities in May and July were not significantly correlated. The intensities in May were positively correlated with the frequency of chemical treatments to control eyespot (Fig. 3). Thus, the natural variability in annual disease intensity in May is masked by disease control and the annual disease intensity in July depends mainly on other factors, as indicated above.

Though eyespot is the most common stem-base disease in the Netherlands, its impact is relatively small. Cereals are cropped most often in one of three years on a field, and they are sown usually in the second half of October, by which the amount of primary infections is low. As a consequence the frequency of eyespot control was low, about 10% (Table 1, Fig. 3). Data of 1983 and 1984 did not indicate failures of eyespot control with carbendazim-generating fungicides, as reported in neighbouring countries (reviewed by Fitt et al., 1988). In 1984 carbendazim-resistant strains were isolated from stubbles

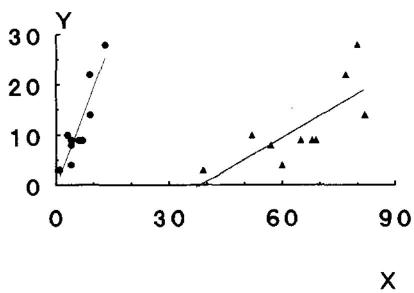


Fig. 3. Percentage fields treated in May against eyespot (Y), in relation to eyespot intensity in May (X).
Regression incidence (●): $Y = -0.3 + 2.0\ X$ ($R^2 = 0.81$)
Regression prevalence (▲): $Y = -17 + 0.4\ X$ ($R^2 = 0.56$)

from fields with continuous wheat cultivation and consequent annual eyespot control in the Northern part of the country (Sanders et al., 1986), but as stated above no control problems have been met in crop rotations usually practiced.

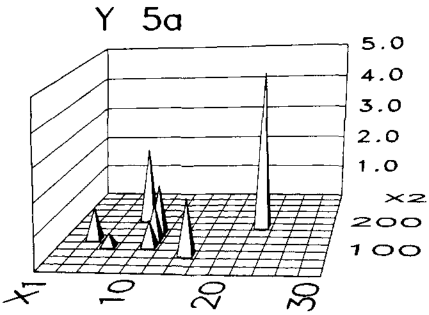
Rhizoctonia cerealis. Young lesions of sharp eyespot are difficult to distinguish from those of eyespot on basal leaf sheaths in May. Later in the season, mycelial growth of sharp eyspot takes place between the leaf sheaths and the stem, which after stem extension result in specific chain-like symptoms on both plant organs.

Averaged over 1976-1986, in 27% of the fields sharp eyespot was found and 2% of the culms were diseased in July (Table 1). Annual incidence and prevalence were positively correlated (r = 0.90). Sharp eyespot incidence was lower than recorded in England (Clarkson and Cook, 1983) and Belgium (Meunier, 1984), but similar to that in Germany (Reinecke and Fehrmann, 1979).

Mean sharp eyespot incidence and prevalence has increased annually with an average of 0.4% culms and 4% fields, respectively (Fig. 4a,b). This trend indicates that sharp eyespot could become a major disease, if favourable conditions persist. The annual increase presumably is not the result of the increased use of fertilizers (Prew et al., 1986). An increase of sharp eyespot was also observed in England (Clarkson and Cook, 1983) and attributed to earlier sowings and an increased use of carbendazim-generating fungicides. However, in these years the use of these fungicides has declined, but the increased pesticide input in other crops might have affected survival of *R. cerealis*. For example the stimulating effect of nematicides on *R. solani* (Tisserat et al., 1977; Scholte, 1987) might hold for *R. cerealis* as well.

Fig. 4a,b. Mean annual sharp eyespot incidence (a, Y in % infected culms) and prevalence (b, Y in % infected fields) in July in relation to year (X, from 1900).
Regression a: Y = $-29 + 0.38$ X (R^2 = 0.59)
Regression b: Y = $-285 + 3.9$ X (R^2 = 0.78)

With respect to weather, no significant positive correlation coefficients between annual sharp eyespot intensity and dry weather in spring or any other period was found, which is in contradiction with the conclusions of Pitt (1964) and Cavelier and Hanrion (1986). A further analysis showed that annual sharp eyespot intensity in July was positively correlated with the percentage fields treated with carbendazim-generating fungicides in May and with cumulative precipitation in September and October. (Fig. 5a,b). When sharp eyespot intensities were corrected for these variables, the positive correlations of mean sharp eyespot intensities with year were not significant. The effect of



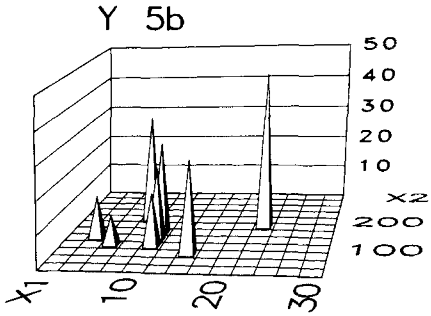


Fig. 5a,b. Mean annual sharp eyespot incidence (a, Y in % infected culms) and prevalence (b, Y in % infected fields) in July, in relation to the percentage of fields treated against eyespot in May (X_1) and cumulative precipitation (mm) in September and October (X_2).
Regression a: $Y = -2.0 + 0.17\ X_1 + 0.015\ X_2$ ($R^2 = 0.91$).
Regression b: $Y = -9.8 + 1.5\ X_1 + 0.14\ X_2$ ($R^2 = 0.95$)

carbendazim-generating fungicides on sharp eyespot intensity is well documented (Van der Hoeven and Bollen, 1972 and 1980; Prew and McIntosh, 1975; Reinecke and Fehrman, 1979; Cavelier et al., 1985). Sharp eyespot is insensitive to doses of carbendazim-generating fungicides commonly used, whereas some antagonistic organisms are sensitive to these fungicides. Thus the correlation with the percentage fields treated in May is plausible. The positive correlation with precipitation in autumn is rather unexpected and conflicts with the conclusion by Pitt (1964). Based on results of pot experiments he concluded that sharp eyespot was favoured by low temperatures and low soil moisture content which was in agreement with field observations over four years. The positive correlation with cumulative precipitation remains unclear. However it could be a spurious correlation, because it was determined mainly by the high disease intensity of 1984 (Table 1), when autumn 1983 was wet and many fields were treated with carbendazim (Fig 5a,b).

The disease was most common on sandy and improved peat soils which is in accordance with observations in other countries (Pitt, 1964 and Reinecke and Fehrmann, 1979). However, during the surveys reported here, the disease was more frequently observed in fields on clay soils. Cultivars Arminda and Saiga were less affected than cvs. Okapi and Marksman (Fig. 6). Also Lucas (1988) reported that cv. Arminda was more resistant than other cultivars tested.

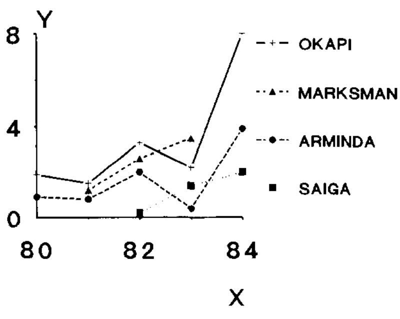


Fig. 6. Sharp eyespot incidence in July (Y, % infected culms) in different winter wheat cvs. in the years 1980-1984 (X).

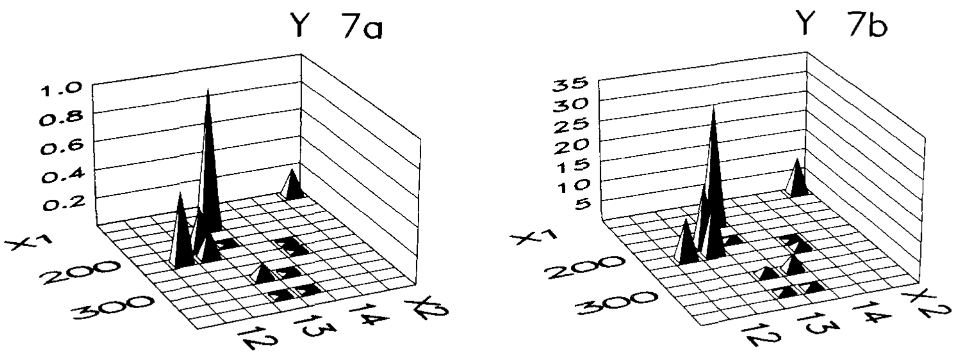


Fig. 7a,b. Mean annual take-all incidence (a, Y in % infected stem bases) and prevalence (b, Y in % infected fields) in July, in relation to cumulative precipitation (mm) in March, April, May and June (X_1) and average temperature in May and June (X_2, °C).
Regression a: $Y = 3.7 - 0.003\ X_1 - 0.21\ X_2$ ($R^2 = 0.67$)
Regression b: $Y = 104 - 0.09\ X_1 - 5.7\ X_2$ ($R^2 = 0.64$)

Gaeumannomyces graminis. Mean annual prevalence and incidence of take-all in July 1974-1986 was low, being 7% fields and 0.2% culms, respectively (Table 1), and were positively correlated ($r = 0.93$). Disease intensity was lower than recorded in Belgium (Lagneau et al., 1986) and England (Clarkson and Polley, 1981), but it should be realised that in the surveys reported here only symptoms on stem-bases were recorded; roots were not examined. In addition, the Dutch clay soils are highly suppressive to take-all (Gerlagh, 1968; Lamers et al., 1988).

Mean annual take-all intensities were negatively correlated with cumulative precipitation in March, April, May and June and negatively with average temperature over May and June (Fig. 7a,b). These correlations partly agree with the study of Hornby (1978) who concluded that take-all intensity in Rothamsted was favoured by above average temperature in autumn, winter and spring and by colder, duller and wetter than average summers. The Dutch clay soils are water-saturated when precipitation is high. High moisture content and the resulting low aeration status of the soil is presumably not favourable for take-all survival or infection (Zimmermann, 1984; Heritage et al., 1989).

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Samenvatting

Inventarisaties van ziekten en plagen in granen. 2. Voetziekten in wintertarwe

Een honderdtal percelen wintertarwe werd in 1974-86 jaarlijks op voetziekten geïnventariseerd. In het voorjaar, tijdens het eerste en tweede knoopstadium van het gewas, was gemiddeld 6% van de spruiten aangetast door oogvlekkenziekte. De intensiteit van de ziekte was hoog in jaren met een hoge gemiddelde wintertemperatuur. Tijdens het melkrijpe stadium, in juli was gemiddeld 13% van de halmen aangetast door oogvlekkenziekte. De aantasting in juli was hoog in jaren met een hoge temperatuur in april en veel neerslag in de maanden maart, april en mei. Met deze gegevens kunnen adviessystemen worden verbeterd.

Scherpe oogvlekkenziekte was op gemiddeld 2% van de halmen in juli aanwezig. De ziekte nam geleidelijk met de jaren toe. De jaarlijkse intensiteit was niet gecorreleerd met droge perioden in de herfst, voorjaar of zomer.

Symptomen van halmdoder waren op gemiddeld 0.2% van de halmen aanwezig. De intensiteit van de ziekte was hoog in jaren met weinig neerslag in maart, april, mei en juni en met een lage temperatuur in mei en juni.

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