THE EFFECT OF RAINFALL AND TEMPERATURE ON THE INCIDENCE OF SEED-BORNE *MICRODOCHIUM NIVALE* ON WINTER WHEAT IN SCOTLAND 1991 –2000

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Summary: An analysis of disease test results from winter wheat seed samples submitted to the Official Seed Testing Station for Scotland between 1991 and 2000 showed that the incidence of seed-borne *M. nivale* fluctuated from year to year with average infection ranging from 3% in 1995 to 42% in 1997. In eight of the ten years examined average infection was higher than the 5% advisory threshold. In the two years when the average infection level was below 5% there were samples that exceeded this threshold. There appears to be no real regional differences in incidence of *M. nivale* seed infection in the main wheat growing areas of Scotland. The correlation between mean infection with *M. nivale* and total rainfall during the period 15 May – 30 June was 0.74 (p=0.015). The mean level of infection generally increased with increasing rainfall. However, the year 2000 was inconsistent with the general relationship, having low infection levels in a year with high rainfall. There did not appear to be a relationship between mean *M. nivale* levels and mean temperature for the same period 15 May – 30 June.

INTRODUCTION

Microdochium nivale (*Fusarium nivale*) is the seed-borne pathogen with the greatest potential to cause pre-emergence blight of cereal seed in Scotland. Both Cockerell (1995) and Humphreys *et al.* (1995) have shown that the emergence of untreated winter wheat seed is related to levels of *M. nivale* on the seed. As seed infection increases emergence decreases. Although at present, most winter wheat seed lots in Scotland are sown with a seed treatment to control *M. nivale*, surveys of pesticide usage, on winter wheat, have shown a 2% increase (from 1%-3%) in the area sown untreated between 1998 and 2000 (Snowden & Thomas 1999, Kerr and Snowden 2001). Possible reasons for growers to sow seed untreated are: 1) an increasing interest in treating seed only when disease levels exceed an advisory threshold of 5% *M. nivale* (Cockerell 1995); 2) a drive to cut variable costs; and 3) an increase in the demand for organically grown wheat. The threshold of 5% is used by advisors to determine when seed treatment is required. With a result of less than or equal to 5% it is considered as safe to sow seed untreated in certain circumstances.

According to Hewett (1965), seed produced in the north and west of the UK tends to be more heavily infected with *M. nivale* than seed from the south and east. Similarly, an analysis of six years data (1994-1999) from samples submitted to the Official Seed Testing Station for England and Wales, showed variation between regions with samples from the north and south-west of England most likely to be more heavily infected (Kenyon and Thomas, 2001). In contrast, a survey of cereal seed-borne diseases from 1992-94, showed levels of infection recorded on Scottish produced wheat seed were lower than those on seed produced in England (Cockerell & Rennie, 1996).

In order to provide the Scottish Executive Environment and Rural Affairs Department (SEERAD) with information on cereal seed-borne pathogen levels in Scotland the Official Seed testing Station for Scotland (OSTS) collates data from seed samples submitted for testing by growers and producers. Although limited, this information can then be used to help determine the extent of disease incidence and trends that may be associated with changes to agronomic practice and climate.

MATERIALS AND METHODS

Seed samples

Winter wheat samples submitted to the OSTS for disease analysis and a random selection of samples submitted for germination assessment were tested for *M. nivale* infection from 1991-2000. A working sample of either 200 or 100 seeds respectively was prepared and surface sterilised in a solution of NaOCl containing 1.4% available chlorine for 10 minutes. Seeds were plated onto potato dextrose agar containing 100ppm streptomycin sulphate and incubated at 20^{o}C in the dark for 7 days. Identification of *M. nivale* was determined by visual examination of colony characteristics and spore morphology. Results were expressed as a percentage of seeds infected.

For regional analysis, data was arranged according to the six main wheat growing areas in Scotland: the Borders; East Lothian and Berwick; Fife; Perthshire and Kinross-shire; Angus; and the North East. Test results from other areas were not used in the regional analysis.

Rainfall and temperature

Total rainfall and mean daily temperature recordings for the period 15 May to 30 June from six Scottish weather stations were obtained from the Met Office in Glasgow. Weather stations at Kelso, Haddington, Cupar, Dundee, Brechin and Dyce were chosen. The 15 May to 30 June was chosen to cover the period directly before anthesis and during anthesis in Scottish wheat crops.

Statistical Analysis

Variance components were calculated using REML (Residual Maximum Likelihood) (Anon. 1993) to study the relative variation in infection levels between years and regions. Correlation coefficients were used to measure the relationship between total rainfall or mean temperature and mean *M. nivale* infection.

RESULTS

Incidence

REML analysis of the average infection levels from 1991-2000 showed large variations between years (Table 1). Maximum infection in all years was greater than the 5% advisory threshold. With the exception of 1995 the percentage of samples infected with *M. nivale* was greater that 80%. However in 5 of the 10 years examined more than 40% of samples had less than or equal to the 5% threshold.

Table 1
Incidence of *Microdochium nivale* infection on Scottish winter wheat seed 1991– 2000

Year harvested	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Mean % *M.nivale*	29	12	16	7	3	6	42	35	15	4
Range (% *M.nivale*)	0-70	0-63	0-69	0-56	0-24	0-45	0.5-89.5	3-78.5	0-53.5	0-34.5
Percentage samples infected	92	96	98	83	71	82	100	100	98	81
Percentage of samples > 5%	82	58	80	35	11	33	96	94	68	27

When the data was subdivided according to the main wheat growing regions, it was found that there were no consistent differences between regions. Average infection levels between regions within a year were also broadly similar (Figure 2), although the north-east had notably higher average infection levels than other regions in 1992 and 1993.

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The relationship between rainfall and temperature, and the incidence of *M. nivale*

Since the variation in infection between the main growing regions was relatively low, we focussed on the relationships between the infection levels, and rainfall and temperature over the years, averaged over the regions. The correlation between mean infection and rainfall over the ten years was 0.74 (p=0.015) and the mean level of infection generally increased with increasing rainfall (Figure 3). The year 2000 was inconsistent with the general relationship, having low infection levels in a year with high rainfall.

There did not appear to be a relationship between *M. nivale* levels and the mean temperature experienced before and during anthesis. The correlation between average infection and mean temperature was - 0.16 (p=0.66) over the ten years.

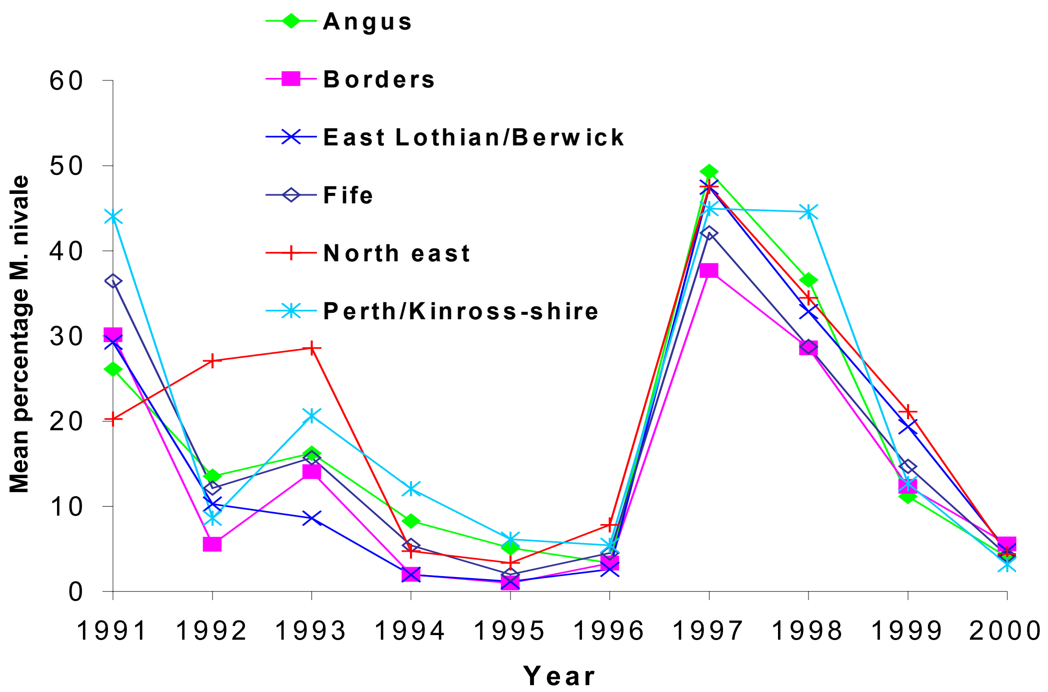

Figure 2
Mean *M. nivale* infection for each region and year

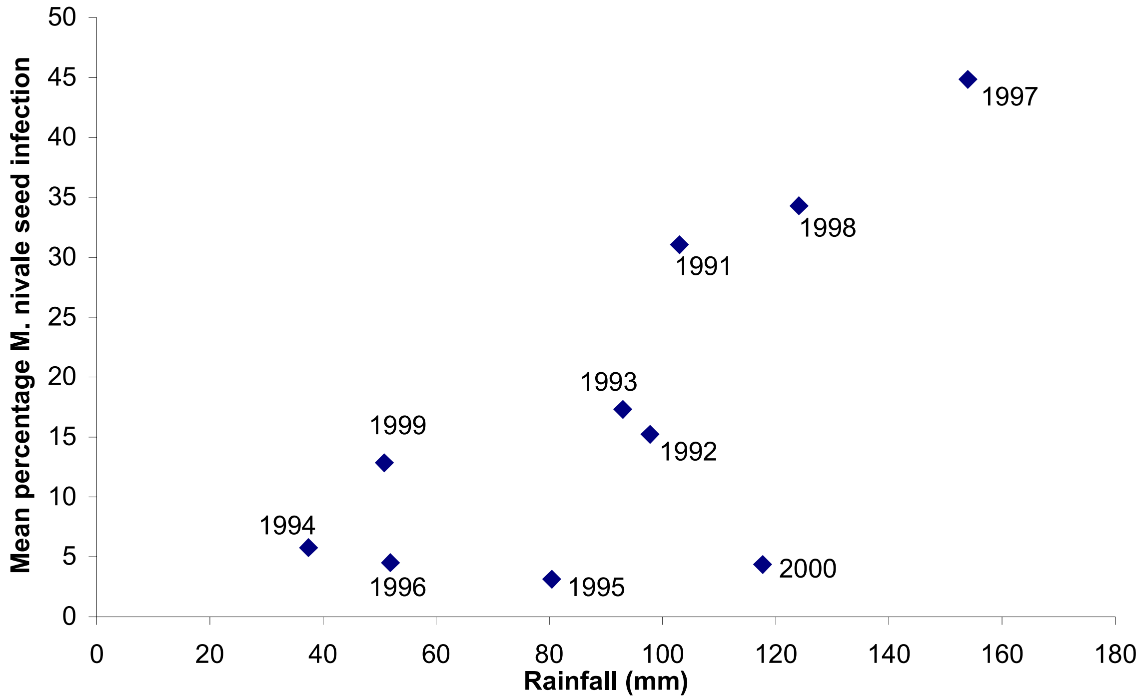

Figure 3
The relationship between total rainfall and mean *M. nivale* infection, 1991-2000

DISCUSSION

Levels of seed-borne *M. nivale* fluctuated from year to year with average infection in eight of the 10 years higher than the 5% advisory threshold. In the two years when the average infection level was below 5% there were samples that exceeded the threshold. In 5 of the 10 years more than 40% of samples, met the 5% threshold and could have been sown untreated. Unlike the experience in England (Hewett 1965 and Kenyon & Thomas 2001) there appears to be no consistent regional differences in incidence of *M. nivale* seed infection in the main wheat growing areas of Scotland.

M. nivale seed infection has been associated with wet weather during anthesis, with rainfall providing a dispersal mechanism for inoculum (Parry *et al.* 1995). Kenyon and Thomas (2001) found that total rainfall during the period 9-14 June produced a broadly linear relationship with seed infection on English wheat samples but this only accounted for 53% of the variation on seed samples tested between the years 1994–1999. Similarly the Scottish data showed an association between rainfall and infection level over the 10 years, 1991-2000 and this accounted for 55% of the variability in infection levels between years. The data available is limited to 10 years and one of these, 2000, is inconsistent with the general relationship, having low infection levels in a year with high rainfall.

The mean temperature recorded during the period for each year ranged from 10.89°C to 13.43 °C. Statistical analysis showed no relationship between *M. nivale* levels and temperature. It is likely that factors in addition to rainfall and temperature have an influence on *M. nivale* incidence.

Kenyon and Thomas (2001), considered the relationship between resistance ratings of different wheat varieties and *M. nivale* infection but found that it only accounted for 5.8% of the variation between samples. Whilst investigating the development of ear blight Jennings and Turner (1996), suggested that cool dry weather in the spring which encouraged the development of *M. nivale* on the stem base, followed by heavy rainfall during anthesis may have accounted for widespread ear infection by *M. nivale* in their experimental plots. Ear infection was highest in plots maintained at a high humidity. However, *M. nivale* is one of many fungi associated with ear blight and years where high levels of ear blight are recorded may not necessarily be consistent with years when high levels of seed-borne *M. nivale* are recorded.

Recently a class of fungicides called the strobilurins used to control ear blight have been introduced. There have been suggestions that these fungicides may be responsible for low levels of *M. nivale* recorded in some crops. Experimental data has shown that wheat ears sprayed with the fungicide azoxystrobin (a stobilurin) before being artificially inoculated with *M. nivale* at anthesis reduced levels of *M. nivale* on the harvested seed compared to seed from unsprayed controls (Winson *et al*, 2001). Strobilurins have been used in Scotland since 1998. Usage has increased by 125%, from 7700Kg of active ingredient used in 1998 to 17346Kg in 2000, (Snowden &Thomas, 1999, Kerr and Snowden, 2001). Over the next few years the incidence of *M. nivale* and strobilurin usage will be monitored to determine whether there is indeed a relationship between strobilurin ear sprays and *M. nivale* incidence.

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