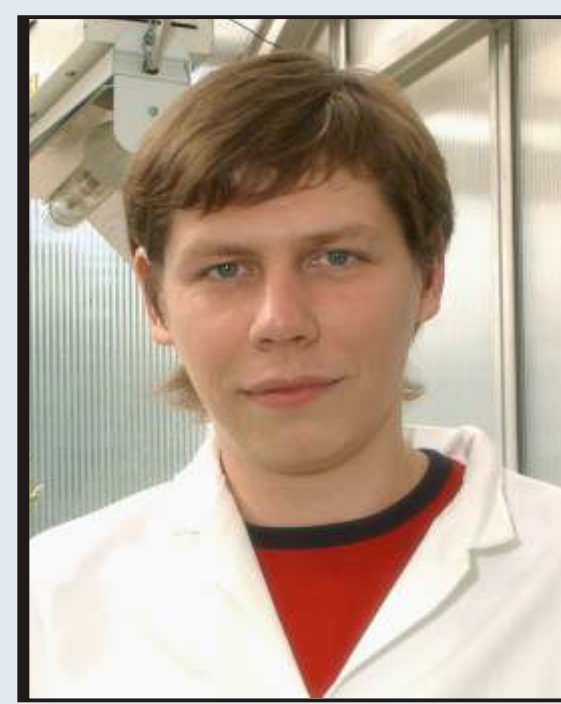


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INTRODUCTION

Triticum monococcum L. (cultivated einkorn) is a diploid wheat with an A^bA^b genome. It is considered a rich source of novel genes and variant alleles and already has been exploited in plant breeding to improve bread wheat.

Many novel disease resistance loci are known to reside within the *T. monococcum* L. genome. For example, novel resistance to eyespot¹ and powdery mildew². Also, in hexaploid bread wheat (*Triticum aestivum* L.) several resistance loci of importance to European agriculture were shown to reside on the A^u genome, such as resistance loci to Septoria leaf blotch³ and Fusarium ear blight⁴.



Ears of crops (from left to right): barley, three samples of cultivated einkorn, bread wheat.

SCIENTIFIC OBJECTIVES

To assess the utility of the cultivated einkorn, *T. monococcum* L. as a source of resistance to various fungal and viral diseases of importance to European agriculture:

Table 1. Plant materials used in this investigation

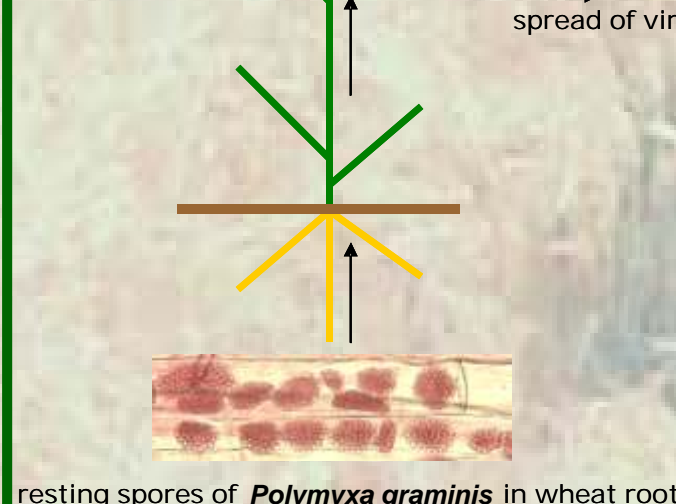
| Source of accessions | Number of accessions | Comments |
|--|----------------------|--|
| JIC, Norwich, UK | 3 | Two accessions performed well in tissue culture (and one of these is readily transformable); for one accession an EMS mutagenised population is available |
| VIR, St Petersburg, Russia | 26 | This set the accessions were selected on the basis of their wide geographical origin and morphological characters; some accessions are known to be resistant to powder mildew ⁵ |
| USDA, Small Grains Collection, Aberdeen, USA | 94 | Accessions were selected that originated primarily from Turkey and the Balkan region (i.e. the centres of diversity); some accessions are known to be resistant to eyespot disease of wheat ¹ |
| Prof. Jorge Dubcovsky, USA | 1 | For this accession comprehensive genetic resources are available (e.g. mapping populations and genetic linkage data, BAC and EST libraries ⁶) |

One hundred and twenty-four accessions of this diploid wheat were evaluated in the screening programme for their resistance and susceptibility to a range of pathogens. The focus was *Soil-borne cereal mosaic virus* (SBCMV, genus *Furovirus*) transmitted by the vector species *Polymyxa graminis*, and non-biotrophic fungi, i.e. *Oculimacula yallundae/Oculimacula acufiformis* (eyespot), *Mycosphaerella graminicola* (*Septoria tritici*) (*Septoria* leaf blotch, STB) and *Fusarium graminearum/Fusarium culmorum* (*Fusarium* ear blight, FEB).

METHODS AND RESULTS

A. Screens for resistance to SBCMV and vector

124 accessions of cultivated einkorn were tested in glasshouse conditions. Plants were grown for 8 weeks in soil highly infested with viruliferous *Polymyxa graminis* carrying SBCMV⁸. Presence of the virus in roots and leaves of plants was verified by ELISA by sampling tissues at 6 and 8 weeks post inoculation.



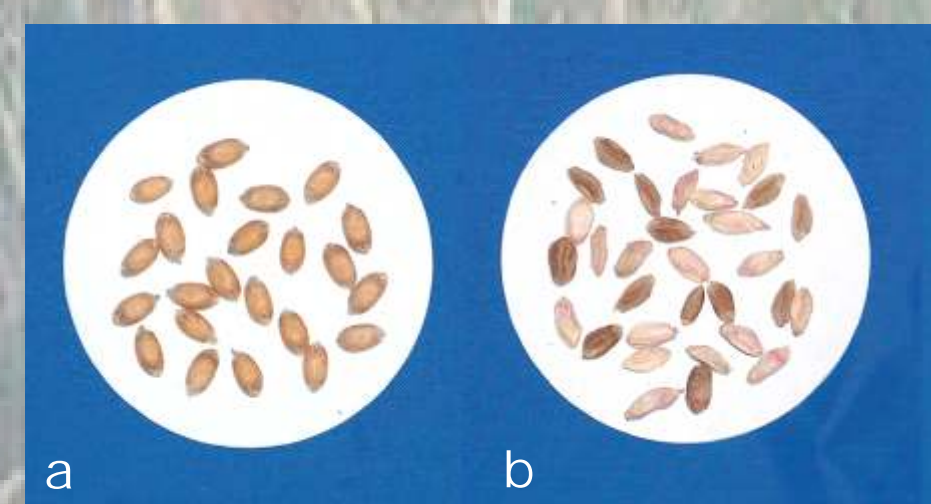
resting spores of *Polymyxa graminis* in wheat roots (staining with 0.1% acid fuchsin)

| Source of accessions | Number of accessions | |
|----------------------|----------------------|-------------|
| | resistant | susceptible |
| JIC | 2 | 1 |
| VIR ⁸ | 1 | 25 |
| USDA, SGC | 27 | 67 |
| J Dubcovsky | 1 | 0 |
| total number | 31 | 93 |

The viral antigen was detected in roots of all *T. monococcum* L. accessions. Therefore, it was predicted that each accession is susceptible to the vector of SBCMV, *Polymyxa graminis*. This was confirmed by microscopic analysis of sampled roots for the presence of resting spores following staining with 0.1% acid fuchsin. However, 31 accessions contained no SBCMV in leaf tissues and were considered to be resistant to SBCMV.

B. Screen for resistance to *Fusarium graminearum/Fusarium culmorum*

This experiment was carried out in field conditions and 28 accessions were evaluated. Twenty ears of each accession were inoculated by suspension of conidiospores of *Fusarium graminearum/Fusarium culmorum*. The severity of disease on *Triticum monococcum* L. plants was visually assessed, and two accessions with probable resistance were identified.



Seeds of bread wheat (cv. Cadenza) from a healthy ear (a) and from an ear, inoculated by a mixture of *Fusarium graminearum/Fusarium culmorum* conidiospores (b).

C. Screen for resistance to *Oculimacula yallundae*

(Eyespot disease) Cultivated einkorn plants were tested in controlled environment conditions and were artificially inoculated with *Oculimacula yallundae*. Development of eyespot disease symptoms was assessed visually at 10 weeks after inoculation¹⁰. Seven accessions were more resistant than the control bread wheat cultivar Capelle Desprez, which bear *Pch2* resistant gene.

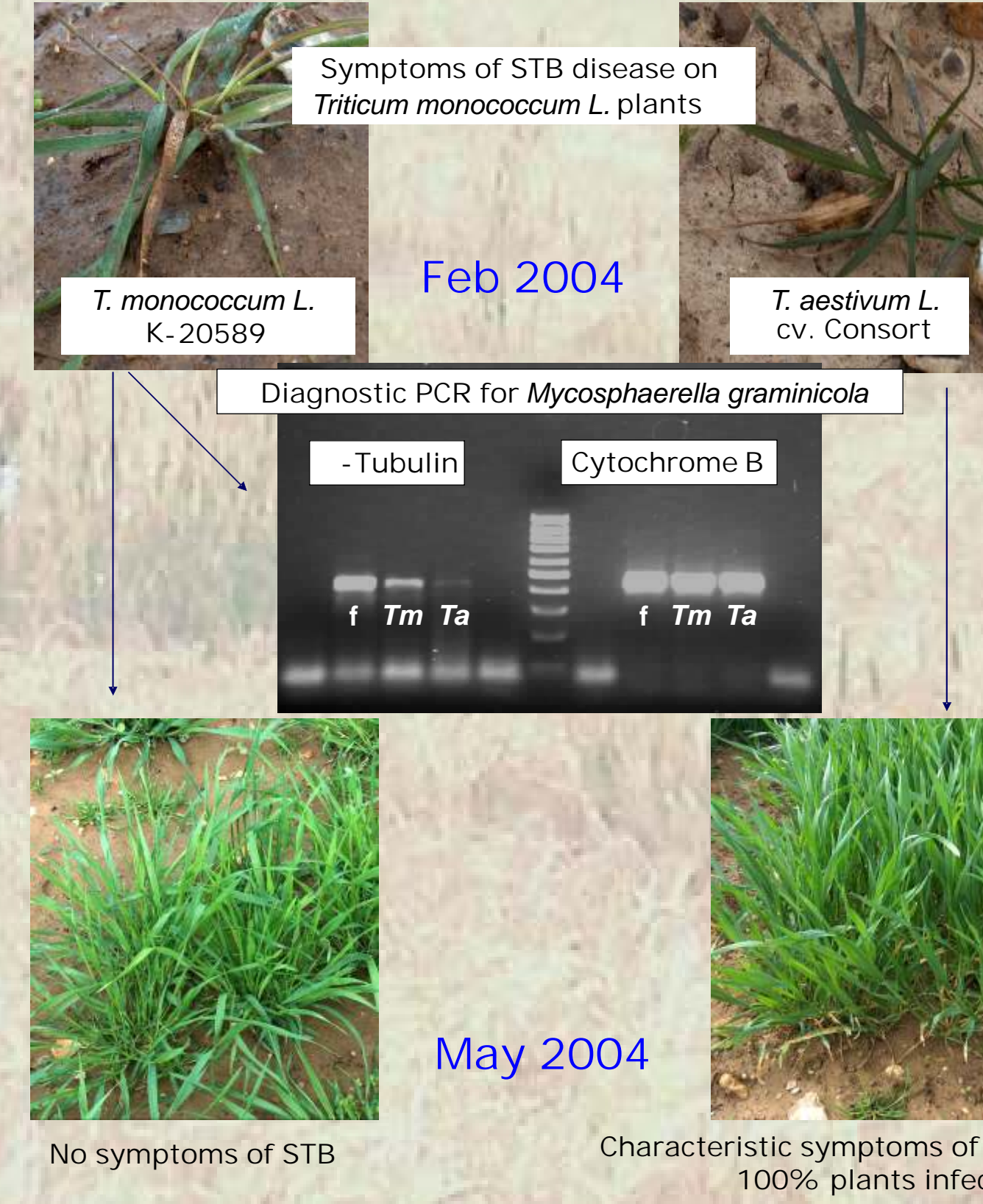


Characteristic symptoms of Eyespot on susceptible control bread wheat cultivar Hereward

D. Screen for resistance to *Mycosphaerella graminicola* (*Septoria* leaf blotch)

29 accessions of *Triticum monococcum* L., JIC, Norwich and VIR, St Petersburg, were tested in field conditions.

Each cultivated einkorn accession and control bread wheats were sown at the Rothamsted Farm in winter 2003 and then again (on a nearby field) in spring 2004 to investigate their reactions to a naturally occurring population of *Mycosphaerella graminicola*. The control bread wheat 'Consort' displayed a high degree of infection. Four accessions of cultivated einkorn showed symptoms of *Septoria* leaf blotch disease. However, only very few disease symptoms were observed on these four *T. monococcum* L. accessions. The nature of the infection was confirmed by PCR-based diagnostic⁹. Surprisingly, a total of 25 accession showed complete resistance to *Mycosphaerella graminicola* in both field trials. These resistance phenotypes were confirmed by spray inoculation of plants in glasshouse conditions.



Overall summary of *Triticum monococcum* L. pathogen screens

| Pathogen | Susceptible | Resistant | Total number |
|---|-------------|-----------|--------------|
| <i>Polymyxa graminis</i> | 124 | 0 | 124 |
| SBCMV | 93 | 31 | 124 |
| <i>Mycosphaerella graminicola</i> | 4 | 25 | 29 |
| <i>Oculimacula yallundae</i> | 22 | 7 | 29 |
| <i>Fusarium graminearum/F. culmorum</i> | 26 | 2 | 28 |

MAIN CONCLUSIONS

1. New sources of resistance to commercially important European pathogens were identified among *Triticum monococcum* L. accessions.
2. Cultivated einkorn plants have strong resistance against natural UK populations of *Mycosphaerella graminicola*.

FURTHER RESEARCH ACTIVITY

1. Cross the best R and S *Triticum monococcum* L. genotypes with each other to create mapping population for assessment of dominant or recessive nature of traits
2. Genotype each diploid accession. The *Triticum aestivum* L. A genome SSR markers are suitable for genotyping in *Triticum monococcum* L., two SSR markers from each chromosome arm will initially be selected for diversity genotyping.
3. Transfer the resistance to *Mycosphaerella graminicola* from cultivated einkorn to bread wheat via sexual crossing.

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