

Breeding for Insect Resistance in Winter Wheat



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Orange Wheat Blossom Midge *Sitodiplosis mosellana*



Effective, genetic resistance known

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Yellow Wheat Gall Midge (*Contarinia tritici*)

Oberpleichfeld (Kr. Würzburg)
 6 x wheat without insecticides
 ...Orange Wheat Blossom Midge
 ...Yellow Wheat Blossom Midge
 ...Wheat Saddle Gall Midge
 ...and other insects
 YWBM observed since 2009.
 Official BSA site for Insects



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Ear infestation
 with YWBM



Use of water-trays
 for catching larvae



Ratsch-Ratsch !!
 Use of hand-
 threshers

- Increasing problem in the UK. No official description of resistant varieties.
- Not observed in North Germany, but high infestations in Oberpleichfeld (Bavaria). North-South difference.
- Screening with hand-threshers in 2013 in Woolpit UK indicated resistance in a Limagrain variety.
- Resistance in the UK variety confirmed by use of water-trays in Oberpleichfeld in 2014.
- Main German trial screened in 2014. Resistant line identified and entered to official trial 2015.
- Resistance mechanism postulated morphological aspects of the outer glumes.
- DH-Populations with the resistant variety sown in Oberpleichfeld 2015 to identify further resistant lines and to develop SNP markers for resistance.

Ernte/Ref. Document/Date

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Thrips

Limothrips cerealium
Limothrips denticornis
Thrips angusticeps





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Genetic Resistance to Larvae ?
 No genetic Resistance to Adults?

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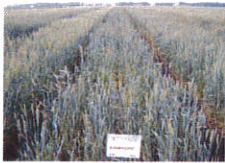


Cereal Aphids
Sitobion avenae
Rhopalosium padi
Metopolophium dirhodum
Diuraphis noxia

Only partial resistance to sucking known
 Resistance to BYDV transfer / Tolerance (cv. Mc Kellar Australia)

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WDV (Wheat Dwarf Virus)


Ukraine 2010
Sowing Date 1st September

Hrubcice June 2012
Frequent Problem in
East Moravia

Rosenthal November 2014
JKI WDV Project Nursery
Sowing Date 16th September

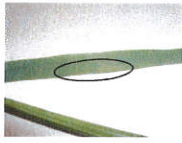
- WDV is already a serious problem in East Moravia and the Ukraine.
- Regions in Germany such as the Thüringer basin already affected.
- Increasingly warm autumns could lead to ist spread in all of Germany.
- The Dwarf Leafhopper vector is difficult to control with insecticides.
- **Pro-Weizen Project** with Dr. A. Habekuss JKI Quedlinburg started.
- Limagrain involvement with two sites (Rosenthal, Brno Mendel-Uni. CZ).
- Marker development for virus in progress.

3-4 mm



Vector :
Dwarf Leafhopper
Psammotettix alienus

**Wheat Saddle Gall Midge
(*Haplodiplosis marginata*)**



Egg rafts 2013



Larvae and Stem Damage



Larvae



Visit to Dr. Skuhravý/a
Prague, May 2013

- Increase in observations since 2010 Especially Germany, UK, Czech Republic.
- Can lead to total crop loss. Almost no literature on differences in variety resistance and no resistant varieties known.
- Massive attack in 2011 in „NIAB Trial“ Adenstedt. Screening indicated large genetic variation in resistance.
- Regular high infestation in Oberpleichfeld.
- „Boris 96“ Genebank-Collection (Novi Sad) used to screen for varietal resistance.
- 2013 Cooperation with Master Degree of Ulrike Schmidt, Uni-Halle.
- 2014 Resistance in a Russian Landrace in observation plots in Oberpleichfeld confirmed !!
- 2015 further screening and observation plots and crosses with the resistant variety for DH-Population production.
- Resistance mechanism not yet known.



Sun Pest

Eurygaster integriceps



Hungary 2009

Breakdown of
Gluten Protein
Quality by Larvae
and Adults

Unimportant so far in
Northern Europe.
Very destructive in South and
South-Eastern Europe,
Turkey, Iran, Ukraine, Hungary

Damage level 3 Adults /m²

**Resistances not known
Destruction of alternative winter hosts**

and

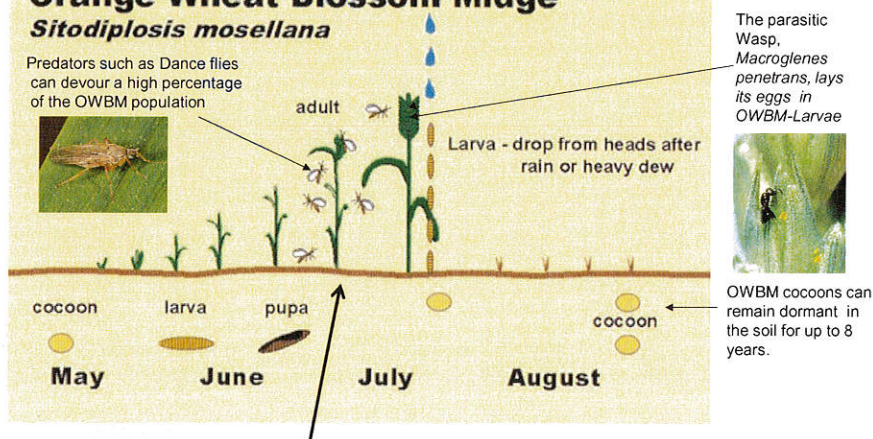
- Root Nematodes**
- Cereal Cyst Eelworms**
- Frit Fly** (*Oscinella frit*)
- Wire Worms** (*Agriotes spp.*) *Ag. sordidus* ... 2 year cycle
- Bulb Fly** (*Delia coarctata*)
- Cereal Leaf Beetle** (*Oulema spp.*)
- Hessian Fly** (*Mayetolia destructor*)
- Wheat Stem Saw Fly** (*Cephus pygmaeus*)
- Gout Fly** (*Chlorops pumilionis*)

Destructive pests
in the USA

Effect of Climate Change

Life Cycle of Orange Wheat Blossom Midge *Sitodiplosis mosellana*

Predators such as Dance flies
can devour a high percentage
of the OWBM population



Greatest danger by early attack and synchronisation of the main flight with flowering
Emergence over a period of 3-4 weeks possible

Geographic und Historic Overview of Cases of Wheat Gall Midge Attacks

(Dissertation „Zur Kenntnis der Weizengallmücken *Contarinia tritici* Kirby und *Sitodiplosis mosellana aurantiaci* Wagner“ Heinrich Klee, Kiel 1936.

Country	First Report	Number of Reports in Years up to 1930
Germany	1856 Bonn	38
	1863-6 Fulda Wagner	
Denmark	1909	15
Sweden	1830 Östergötland	32
Norway	1916 Smaalenene	6
Finland	1894	3
Netherlands	1914	1
England	1771	23
	1779 Damage on Wheat Kirby	
France	1842	10
	1846 Metz	
Czech Republic	1920	1
Italy	1874	3
Russia	1912 South Russia, Ukraine, Siberia	9
USA	1820 West Vermont	57
Australia	1888	4
New Zealand	1922	1

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OWBM Damage on Winter Wheat Ears



**Percentage of Winter Wheat Lines
in Year 1 Official Trials Germany
with Resistance to
the Orange Wheat Blossom Midge**



Year	Number	%
2004	4/110	3.6
2005	4/107	3.7
2006	7/116	6.0
2007	5/114	4.4
2008	8/115	7.0
2009	11/116	7.5
2010	12/119	10.1



Increasing numbers
of lines with
Ae. dicoccooides
background

**Percentage of Winter Wheat lines with
Resistance to Orange Wheat Blossom Midge
in Year 1 Official Trials
Germany, UK and France 2010**



Country	Number	%
Germany	12/119	10.1
France	11/73	15.1
UK	32/63	50.8

OWBM Resistant Winter Wheat Varieties in Europe 2010



- Germany Beschreibende Sortenliste
- Lear ... official description
- Enorm
- Jafet
- Kredo
- Magister
- Skalmetje

- France
- Altigo
- As de Coeur
- Boregar
- Koreli
- Renan

- Poland
- Mewa
- Bogatka
- Batuta

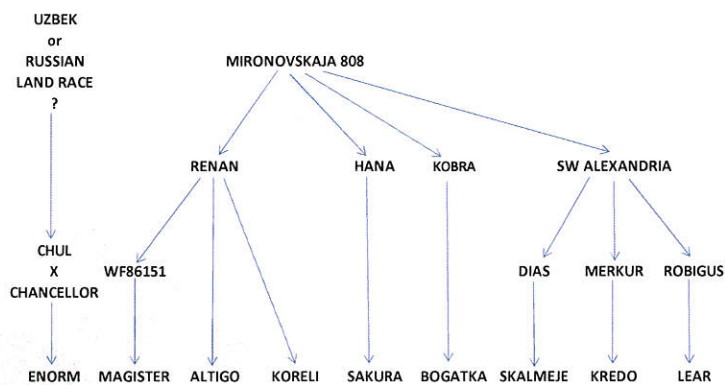
- UK Recommended List
- Gatsby
- Oakley
- Q Plus
- Robigus
- Scout

- Czech Republic
- Magister
- Samanta
- Simila
- Sakura

- Hungary
- Mv Mazurka
- Mv Toldi
- Mv Vekni

- USA
- Caldwell
- Clark
- Knox
- Monon
- Seneca
- Goodstreak

Origin of the Sm1 Resistance to OWBM

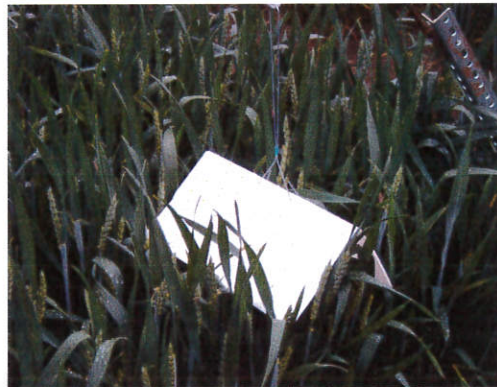


Basics of OWBM Resistance in Wheat



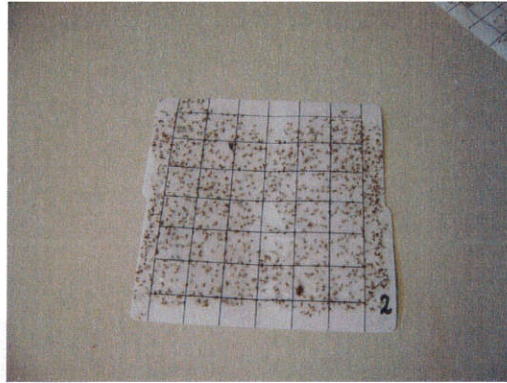
- The Major Gene *Sm1* on Chromosome 2B confers absolute Resistance to OWBM and has maintained its effectiveness for over 50 years.
- Other Major Genes are not yet known.
- Minor genes, which confer partial resistance, are present, but not researched.
- preference, non-preference, physical barriers ?
- The *Sm1* resistance is based on the antibiotic effect of p- Coumaric Acid and Ferulic Acid on OWBM-larvae, which occur in higher amounts in resistant varieties.
- constitutive, inductive ?
- Markers for *Sm1* are being developed. (SSR -> SNP's)

Application of Agrisense OWBM Pheromone Traps



The midges remain in the crop stand and are predominantly active at dusk and during the night. They prefer damp, wind still areas. They are weak fliers, but can be carried long distances by wind. The life-span of a midge is approx. 3 days. They do not feed.

Pheromone Trap after 3 Nights
(damage level 10-20 midges per night)



Screening Wheat Nurseries for OWBM Resistance



Application of ear threshers on wheat ears.
(converted garlic peelers)

Provides good information on qualitative resistance in varieties
This method is very quick and is useful in large screening nurseries.

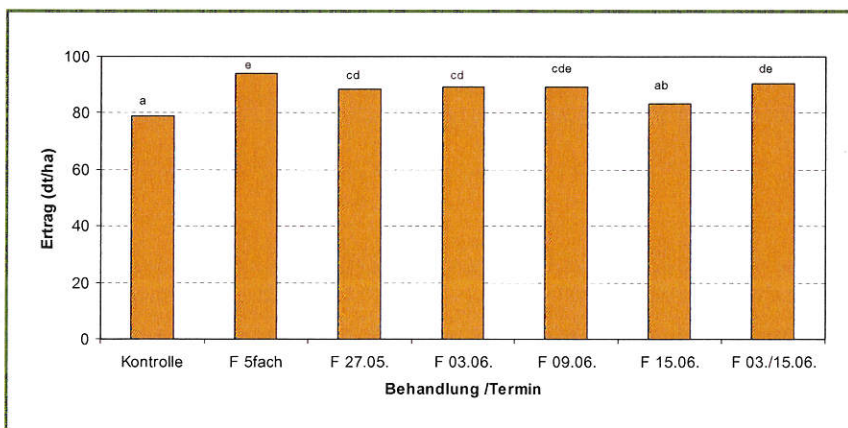
Use of Standard Water Trays in the Wheat Crop



Allows the determination of the *quantitative* resistance of varieties.
Very useful for lines in advanced trials, official and post registration trials.
Allows for selection in the current growing season.
More efficient than conventional ear-counting methods.

OWBM

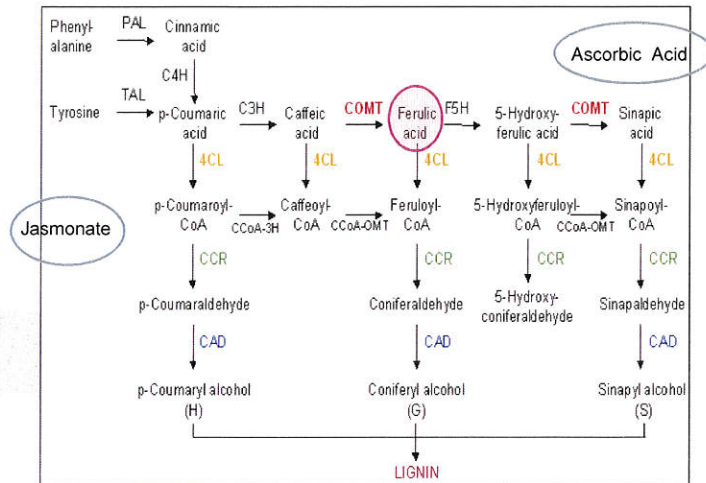
Grain Yield Nordstrand 2005



Source: Gert Petersen 2005

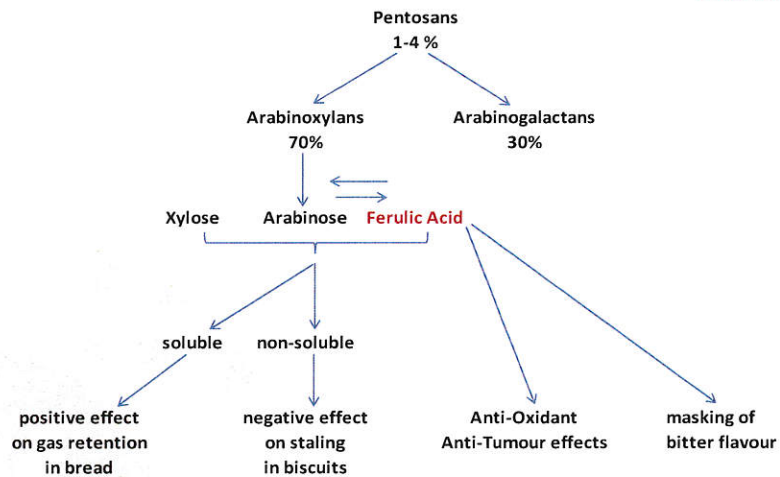


Biosynthesis of p-Coumaric Acid, Ferulic Acid and other polyphenolic Compounds with antibiotic Effects



Wide spread resistance mechanism in the plant world. eg. Fusarium resistance in Maize.

Effect of Ferulic Acid on Wheat Quality



Charun and Morel „Quelles Caractéristiques pour une farine biscuitière ? “
Industries des Céréales No. 125 Nov-Dec 2001

Economic Effects of OWBM on Wheat



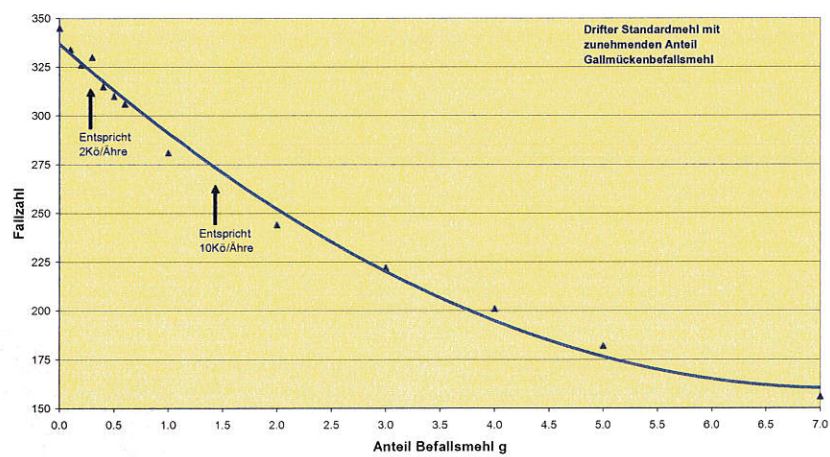
Grain yield losses Up to 30 % possible.

Disruption of grain development TGW, HLW. Protein content.

Predominantly enzymatic effect on quality Falling Number.

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Effekt von Gallmückenbefall auf Fallzahl



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Summary



- **OWBM is present in all temperate wheat growing regions.**
- **The previous cyclical occurrence has now become endemic in many regions.**
- **Genetic resistance offers the best protection against OWBM.**
- **Resistant varieties are competitive with non-resistant varieties on yield.**
- **Insecticides are only partially effective long flight period.**
- **Epidemics possible. (eg. France 2008, 2009)**
- **Effect on quality is mainly enzymatic...Falling Number.**

- **Thanks to :**
- **Dr. E. Schliephake JKI Quedlinburg,**
- **Dr. U. Heimbach JKI Braunschweig,**
- **Dr. G. Petersen LWK S-H.**