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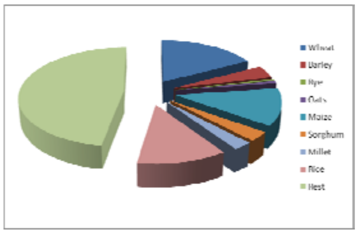
Bundesforschungsinstitut für Kulturpflanzen
Federal Research Centre for Cultivated Plants

Breeding for virus resistance in cereals

Frank Ordon

www.jki.bund.de

Acreage of cereals 2009



http://faostat.fao.org

home.arcor.de

http://www.usinenouvelle.com

https://www.uni-hohenheim.de/qisserver/rds?st...

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Important viruses of *Poaceae* (*Gramineae*)

Wheat - *Triticum*	Barley yellow dwarf virus, Wheat dwarf virus, Soil-borne wheat mosaic virus, Wheat spindle streak mosaic virus, **Soil-borne cereal mosaic virus**, Wheat yellow mosaic virus, Aubian wheat mosaic virus, Barley yellow striate mosaic virus, Indian peanut clump virus, Wheat rosette stunt virus, Wheat American striate virus
Barley - *Hordeum*	**Barley yellow dwarf virus**, Wheat dwarf virus, **Barley mild mosaic virus**, **Barley yellow mosaic virus**, Barley stripe mosaic virus, Northern cereal mosaic virus, Barley yellow streak mosaic virus, Arabis mosaic virus, Tobacco rattle virus
Rye - *Secale*	Barley yellow dwarf virus, Wheat dwarf virus, Soil-borne cereal mosaic virus, Wheat spindle streak mosaic
Triticale - *Triticosecale*	Barley yellow dwarf virus, Wheat dwarf virus, Soil-borne cereal mosaic virus, Wheat spindle streak mosaic virus
Oat - *Avena*	Barley yellow dwarf virus, Oat sterile dwarf virus, Oat golden stripe virus, Oat chlorotic stunt virus, Oat mosaic virus, Wheat dwarf virus
Corn - *Zea*	Maize dwarf mosaic virus, Johnsongrass mosaic virus, Sugarcane mosaic virus, Maize rough dwarf virus, Maize chlorotic mottle virus, Maize chlorotic dwarf virus, Maize bushy stunt virus, Cereal chlorotic mottle virus, Barley yellow dwarf virus, Sorghum chlorotic spot virus, High Plains virus, Wheat streak mosaic virus
Rice - *Oryza*	Rice tungro virus, Rice dwarf virus, Rice gall dwarf virus, Rice grassy stunt virus, Rice hoja blanca virus, Rice necrosis mosaic virus, Rice ragged stunt virus, Rice stripe necrosis virus, Rice yellow mottle virus, Barley yellow dwarf virus
Sorghum / Millet - *Sorghum/Pennisetum*	Maize dwarf mosaic virus, Sorghum yellow banding virus, Sorghum chlorotic spot virus

A.. Habekuß u. E. Schliephake

F. Ehrig

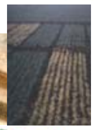
W. Huth

Barley yellow mosaic virus disease

Cultivar	BaYMV/BaMMV-Reaction	Yield t/ha	Yield relative
Asorbia (6-rowed)	resistant	5.33	100
Corona (6-rowed)	susceptible	3.53	65
Romanze (2-rowed)	resistant	4.20	100
Marinka (2-rowed)	susceptible	2.38	57
Yuka (6-rowed)	resistant	7.66	100
Grete (6-rowed)	susceptible	4.10	54
Duet (2-rowed)	resistant	6.30	100
Angora (2-rowed)	suceptible	4.24	67

10 m^2 plots, 3 replications; LSD (5%) = 0.25 t/ha and 0.35 t/ha; yield in ATM

W. Huth



BaMMV, BAMMV-SIL, BaMMV-Teik, BaYMV, BaYMV-2

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Economic loss caused by BaMMV/BaYMV

Acreage (2010): 1303000 ha

Yield: 6.66 t = 8677980 t

Barley price: 150 € per t

Economic value: 1301697000 €

50% of barley acreage potentially infested (Huth 1988): 651500 ha

Moderate yield loss of 25%: 1074975 t

Economic loss: 161246250 €

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Genetic base of BaMMV/BaYMV-resistance

Year	No. Cultivars resistant	No. Cultivars susceptible	Yield resistant	Yield susceptible
1986	6	37	4.3*	5.6
1995	24	41	6.5	6.3
2005	52**	23	6.7	6.1
2011	55	9	6.9	6.4

*1=minimum, 9=maximum, List of registered cultivars, Federal Seedboard, different years

**48: *rym4* derived from Ragusa
4: *rym5* **Tokyo (1996): [(Fallon x 13060) x 87-5381 B] x Swift]**

↓

Resistant Ym. No.1 x Igri

(Hemker, pers. Comm.)

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Screening for resistance and genetic analysis

	BaMMV	BaYMV	BaYMV-2	No. Genotypes
Hordeum vulgare ssp. *vulgare*				
	-	-	-	201
	-	-	+	86
	+	-	-	53
	-	+	+	43
Hordeum vulgare ssp. *spontaneum*				
	-	+	+	3
	-	-	-	2

- = negative ELISA (resistant), + = positive ELISA (susceptible)

Ordon et al. 1993, Habekuss et al. 2000


Cross	F_2 Segregation r : s	χ^{2**} 7r:9s	Infect.-rate (%)
H. vulgare ssp vulgare			
Chikurin Ibaraki 1 x Ogra	49 : 69	0.233	98
Russia 57 x Diana	68 : 81	0.214	95
Bulgarian 347 x Diana	61 : 89	0.574	95
Bulgarian 347 x Russia 57	42 : 73	2.442	100
Taihoku A x Chikurin Ibaraki 1	50 : 68	0.091	100
Bulgarian 347 x Chikurin Ibaraki	53 : 63	0.0114	100

Götz & Friedt 1993, Ordon & Friedt 1993

Prebreeding

Success of selection

$R=h^2 x S_D$

Phenotype

Reliable selection on the single plant level (A_1, F_2) in the lab independently from the incidence of viruses in the field and symptom development in early developmental stages

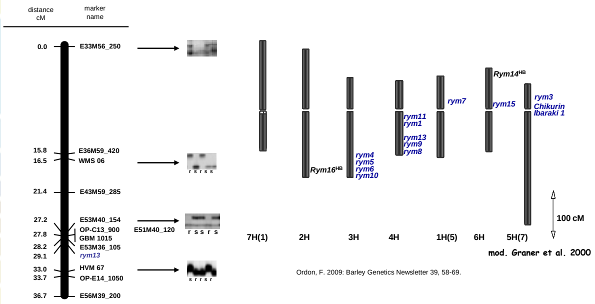
$V_p=V_g+V_E+V_{gE}$

The better the inference from the phenotype to the genotype the higher the success of selection

- Viruses do not incide each year
- Symptom development is often influenced by environmental factors

Reliable selection for resistance on the phenotypic level can not be carried out each year

Mapped resistance genes against BaMMV/BaYMV

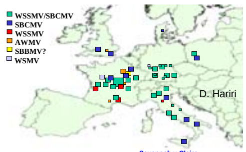


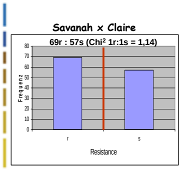
mod. Graner et al. 2000

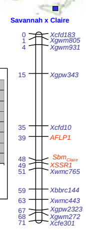
Ordon, F. 2009: Barley Genetics Newsletter 39, 58-69.

Humbroich, K., H. Jaiser, A. Schiemann, P. Devaux, A. Jacobi, L. Cselenyi, A. Habekuss, W. Friedt, F. Ordon, 2010.. Plant Breeding **129**, 346-348.

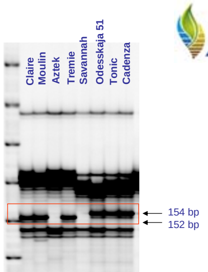
Wheat – SBCMV-Resistance







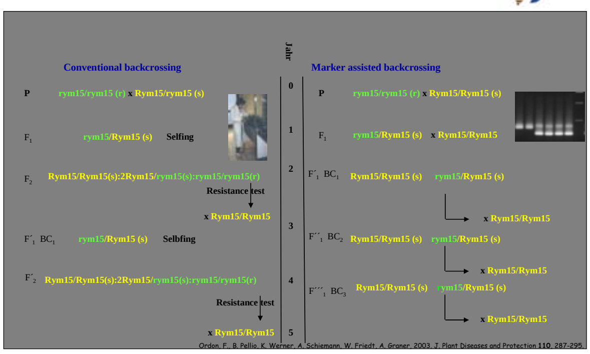
Chromosome 5DL



3 alleles identified in about 100 genotypes tested.154bp diagnostic for „Cadenza-derived resistance", 152 bp for „Tremie/Claire-derived resistance". All suceptible genotypes displayed a null allele.

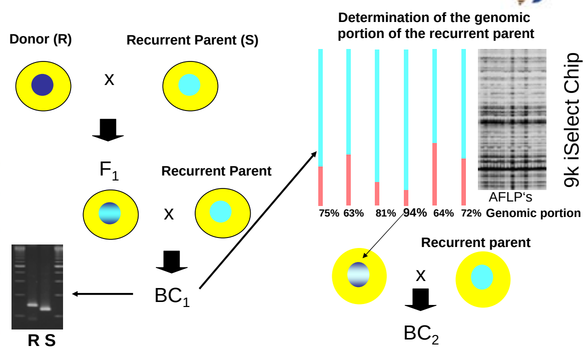
Perovic, D., J. Förster, P. Devaux, D. Hariri, M. Guilleroux, K. Kanyuka, R. Lyons, J. Weyen, D. Feuerhelm, U. Kastirr, P. Sourdille, M. Röder, F. Ordon, 2009. Molecular Breeding **23**, 641-653.

Marker assisted backcrossing



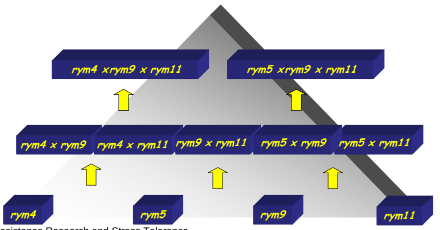
Ordon, F., B. Pellio, K. Werner, A. Schiemann, W. Friedt, A. Graner, 2003. J. Plant Diseases and Protection **110**, 287-295.

Marker assisted backcrossing



Pyramiding of BaMMV/BaYMV Resistance Genes

	BaYMV	BaYMV-2	BaMMV	BaMMV-SIL	BaMMV-EIK
rym4	r	s	r	r	r
rym5	r	r	r	s	s
rym9	s	s	r	r	r
rym11	r	r	r	r	r



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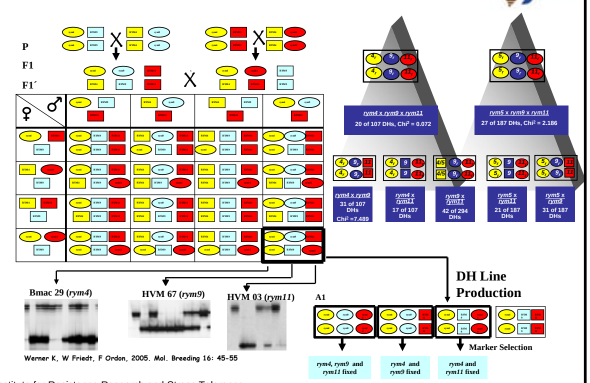
Pyramiding of BaMMV/BaYMV Resistance Genes



Werner K, W Friedt, F Ordon, 2005. Mol. Breeding 16: 45-55

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Barley yellow dwarf virus (BYDV)

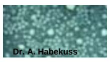
Luteovirus

BYDV-PAV → *Rhopalosiphum padi & Macrosiphum avenae*

BYDV-MAV → *Macrosiphum avenae*

Polerovirus

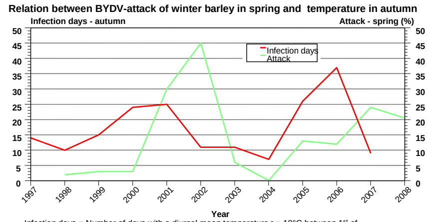
CYDV-RPV → *Rhopalosiphum padi*



+ssRNA-Virus, isometric particles (25-30 nm), phloem limited

yield losses 20-40%

Relation between BYDV-attack of winter barley in spring and temperature in autumn



Infection days = Number of days with a diurnal mean temperature >= 10°C between 1st of October and 31st of December

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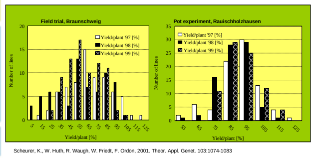
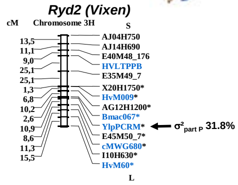
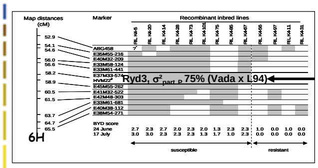
Identification von QTL for BYDV-tolerance



Scheurer, K., W. Huth, R. Waugh, W. Friedt, F. Ordon, 2001. Theor. Appl. Genet. 103:1074-1083

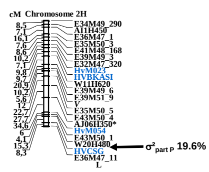
Ryd2 (Vixen)





Niks, R.E., A. Habekuß, B. Bekele, F. Ordon, 2004. Theor. Appl. Genet. Theor. Appl. Genet. **109**, 1536-1543

QTL 2HL (Post)



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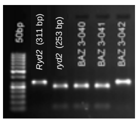
Scheurer, K., W. Huth, R. Waugh, W. Friedt, F. Ordon, 2001. Theor. Appl. Genet. 103:1074-1083

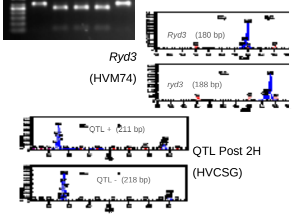
BYDV – Pyramiding of QTL in winter barley and spring barley

´RIL K4-56´ (*Ryd3*) x ´DH21-136´ (*Ryd2* + QTL Post)



Ryd2

(YLP + HSP92 II)

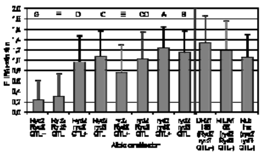


Ryd3

(HVM74)

QTL Post 2H

(HVCSG)



Segregation *Ryd2/ Ryd3/ Post-QTL*

	rrr	rrs	rsr	srr	ssr	srs	rss	sss
No. DH-lines	89	49	45	99	49	77	38	29

(*ryd2, ryd3*, QTL-) (*Ryd2, Ryd3*, QTL+) winter barley, Quedlinburg, April 2008

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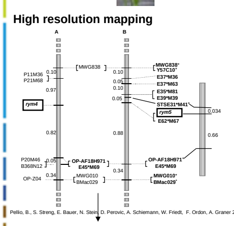
Riedel, C., A. Habekuss, E. Schliephake, R. Niks, I. Broer, F. Ordon, 2011 Theor. Appl. Genet. **123**, 69-76.

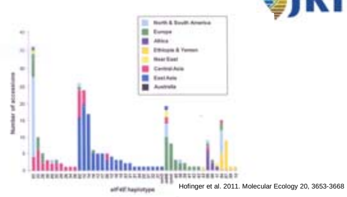
Isolation of resistance genes - allele mining

Rym4/Rym5

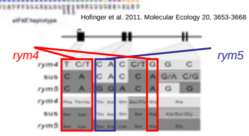
High resolution mapping



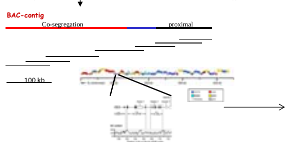
Pellio, B., S. Streng, E. Bauer, N. Stein, D. Perovic, A. Schiemann, W. Friedt, F. Ordon, A. Graner 2005. Appl. Genet. **110**, 283-293.



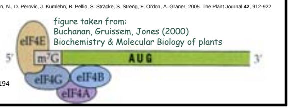
Hofinger et al. 2011. Molecular Ecology 20, 3653-3668



Stein, N., D. Perovic, J. Kumlehn, B. Pellio, S. Stracke, S. Streng, F. Ordon, A. Graner, 2005. The Plant Journal **42**, 912-922



Wicker et al. 2005. The Plant Journal, 41, 184-194



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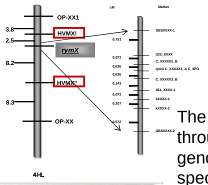
Summary and future prospects

Molecular markers facilitate already today efficient selection procedures to improve virus resistance in cereals



Fernie, A.R., N. Schauer, 2008: Trends in Genetics 25, 39-48

The availability of dense marker maps, high throughput genotyping platforms, physical maps and genome sequences of cereals itself and related species will facilitate an enhanced isolation of resistance genes in the future thereby leading to a deeper understanding of virus resistance and the transfer of marker based selection to the allele level.

This together with new selection strategies, e.g. genomic selection procedures, will lead to an enhanced breeding of virus resistant cultivars.

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