The preservation and exploitation of *ex situ* genebank collections – Association mapping studies in wheat

Kerstin Neumann[1], Borislav Kobiljski[2] and Andreas Börner[1]

[1] Leibniz-Institut für Pflanzengenetik und Kulturpflanzenforschung Gatersleben, Germany

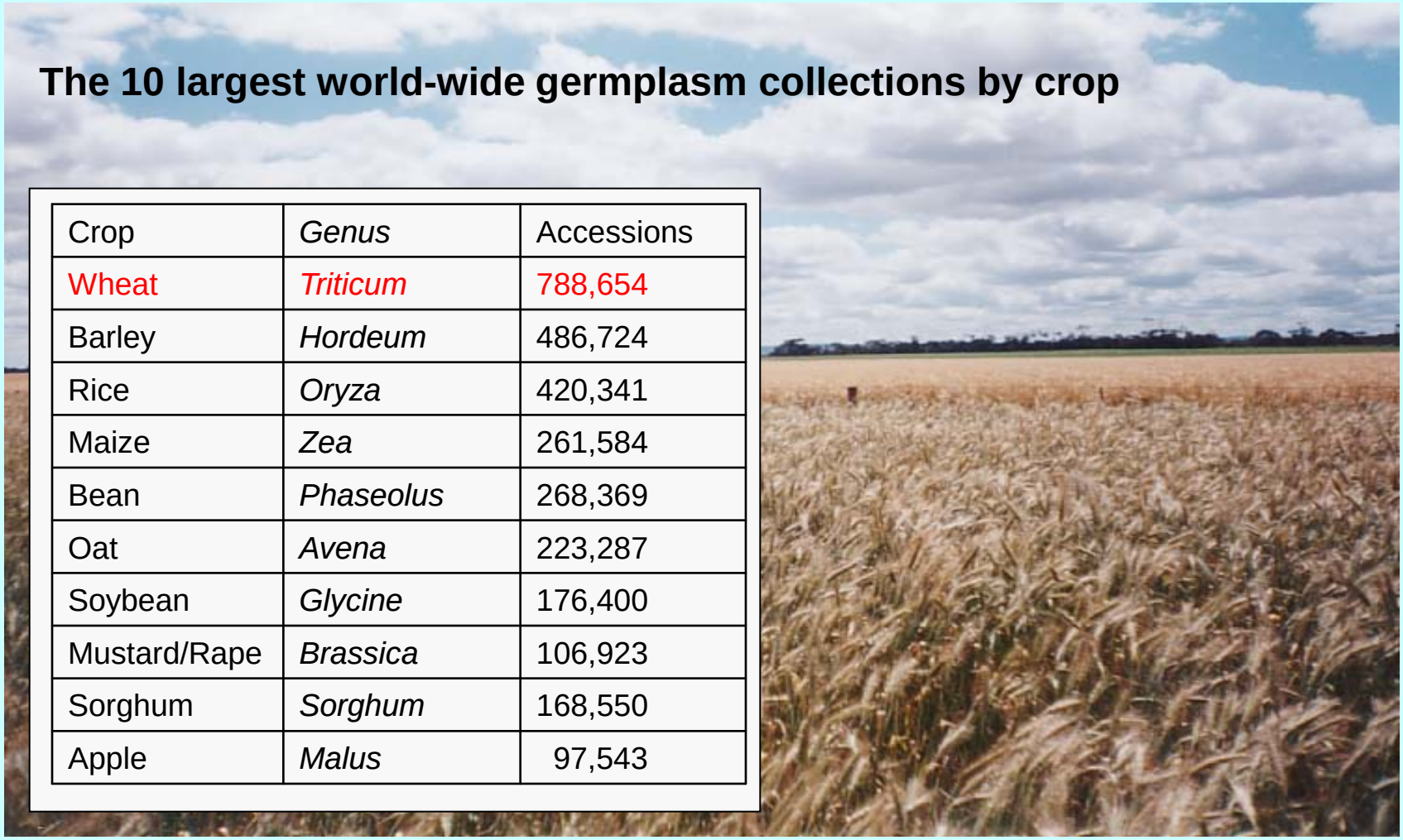
[2] Institute of Field and Vegetable Crops, Novi Sad, Serbia

Contents

- Wheat *ex situ* collections – global
- German wheat *ex situ* collection
- Exploitation by Association

Wheat *ex situ* Collections

6 Million acsessions world-wide, estimated in 1998 → 8 Million



The 10 largest world-wide germplasm collections by crop

Crop	*Genus*	Accessions
Wheat	*Triticum*	788,654
Barley	*Hordeum*	486,724
Rice	*Oryza*	420,341
Maize	*Zea*	261,584
Bean	*Phaseolus*	268,369
Oat	*Avena*	223,287
Soybean	*Glycine*	176,400
Mustard/Rape	*Brassica*	106,923
Sorghum	*Sorghum*	168,550
Apple	*Malus*	97,543

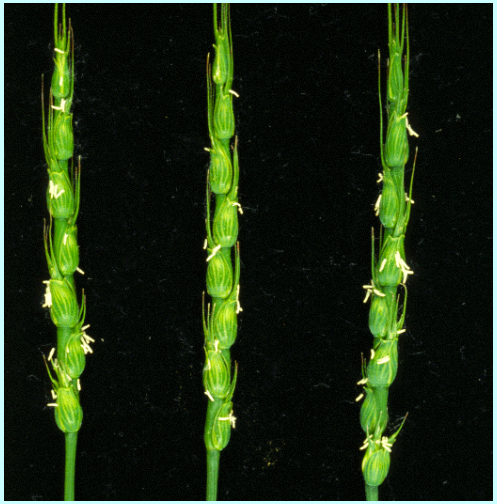
FAO (1998) The state of the world's plant genetic resources for food and agriculture

Wheat *ex situ* Collections

Wheat

Triticum

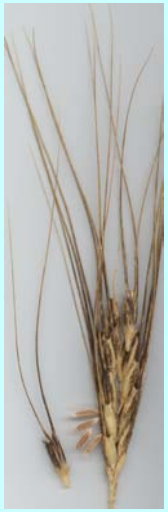
Aegilops



The evolution of hexaploid wheat

AA

T. urartu



AABB

T. dicoccoides

AABBDD

T. aestivum

BB

Ae. speltoides (SS)

DD

Ae. tauschii

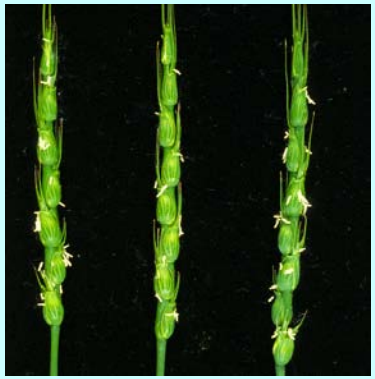
Wheat *ex situ* Collections

Global collections

***Triticum* (>25,000 acc.) and *Aegilops* (>1,500 acc.) collections**

Triticum

CIMMYT	Mexico	98,905
NSGC	USA	43,285
VIR	Russia	35,959
IDG	Italy	32,751
IPK	Germany	28,191
TAMAWC	Australia	27,000



Aegilops

VIR	Russia	3,255
ICARDA	Syria	2,855
TELAVUN	Israel	2,500
KYOPGI	Japan	2,396
IPK	Germany	1,537

FAO (1998) The state of the world's plant genetic resources for food and agriculture

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Wheat *ex situ* Collection (IPK)

Collections	Accessions
Cereals and Grasses	**64,104**
Wheat	**28,191**
Barley	21,244
Oat	4,829
Rye	2,455
Aegilops	**1,537**
Legumes	**28,250**
Beans (*Phaseolus*)	8,640
Peas	5,633
Vegetables	**18,538**
Tomatoes	3,292
Onions	1,545
Beets (*Beta*)	2,509
Oil-/ Fibercrops	**9,737**
Rapeseed	1,045
Linseed	2,338
Medicinal-/ Spiceplants	**5,951**
Forage crops	**12,406**
Potatoes	**5,874**
Others	**2,684**
Total	**147,544**

147,544 Accessions
3,032 Species
770 Genera

<u>Reference Collections</u>

391,000 Herbarium samples
90,000 Seeds & Fruits
49,000 Spikes

Wheat *ex situ* Collection (IPK)

Oldest Material from 1920‘s, Austrian Alps, Erwin Mayr

Forschungsberichte
der Bundesanstalt für Pflanzenbau und Samenprüfung
in Wien

Die
Getreide - Landsorten
und der
Getreidebau
im
Salzachtal und seinen Nebentälern

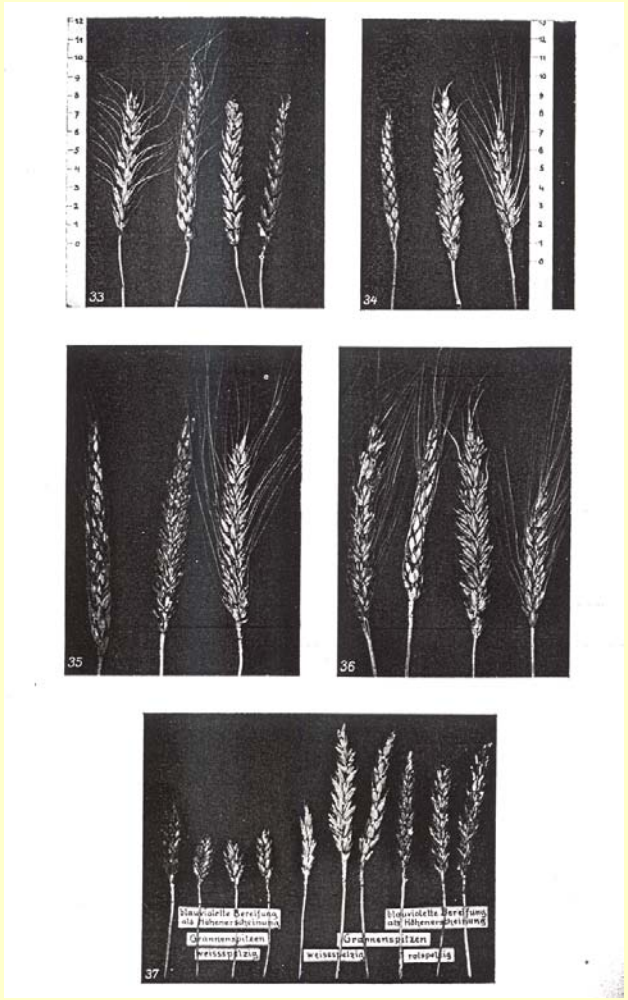
Von
Ing. Dr. Erwin Mayr
prov. Kommissär der Bundesanstalt für Pflanzenbau und Samenprüfung in Wien

Mit zehn Tafeln und einer Landkarte

Preis 3 Schilling

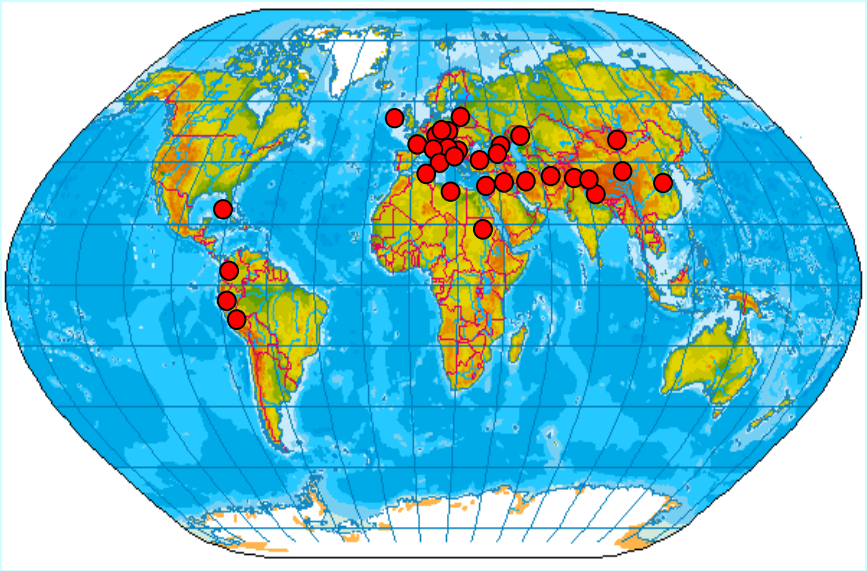
Wien 1928

In Kommission des „Scholle-Verlages“, Buchhandlungs-Ges. m. b. H.,
Wien I., Babenbergerstraße 5.



Wheat *ex situ* Collection (IPK)

Period	Number of expeditions	Main regions
Before 1950	9	Austria, Hindukusch, Tibet, Balkan
1950-1959	4	China, Iran, Italy
1960-1969	5	Mongolia, Cuba, Soviet Union (Amur region)
1970-1979	9	Czechoslovakia, Poland, Spain
1980-1989	57	Italy, Georgia, Austria, Libya, Cuba, Iraq, North Korea, Ethiopia
1990-1999	54	Albania, Tunisia, Romania, Italy, Iran, Uzbekistan, Turkmenistan, Croatia, Bulgaria
2000-2008	15	Uzbekistan, Georgia, Armenia, France, Ireland, Czech Republic, Germany (Bavarian Alps)
Total	153	



Wheat *ex situ* Collection (IPK)

Genus *Triticum*

Species	Ploidy level	Number of accessions
T. aestivum L.	6x	19,314
T. spelta L.	6x	473
T. sphaerococcum Perciv.	6x	96
T. macha Dekapr. Et Menabde	6x	38
T. vavilovii (Thum.) Jakubz.	6x	12
T. zhukovskyi Menabde et Ericzjan	6x	6
		19,939
T. durum Desf.	4x	3,105
T. dicoccon Schrank	4x	699
T. aethiopicum Jakubz.	4x	648
T. turgidum L.	4x	257
T. polonicum L.	4x	138
T. carthlicum Nevski	4x	117
T. dicoccoides (Koern. Ex Aschers. Et Graebn.) Schweinf.	4x	98
T. araraticum Jakubz.	4x	65
T. turanicum Jakubz.	4x	38
T. timopheevii (Zhuk.) Zhuk.	4x	16
T. karamyschevii Nevski	4x	12
T. ispahanicum Heslot	4x	9
		5,202
T. monococcum L.	2x	387
T. baeoticum Boiss. Em. Schiem.	2x	295
T. urartu Thum. Ex Gandil.	2x	89
		771
Others or not classified accessions of the genus *Triticum*	?	2,279
Total		**28,191**

Wheat *ex situ* Collection (IPK)

Genus *Aegilops*

(Hammer, 1980)

Section/Species	Ploidy level	Number of accessions
Subgenus *Amblyopyrum* Jaub. et Sp.		**8**
Ae. mutica Boiss.	2x	8
Subgenus *Sitopsis* Jaub. et Sp.		**152**
Ae. speltoides Tausch	2x	83
Ae. longissima Schweinf. et Muschl. emend. Eig	2x	41
Ae. bicornis (Forsk.) Jaub. et Sp.	2x	7
Ae. searsii Feldman et Kislev ex Hammer	2x	21
Subgenus *Aegilops*		**1,292**
Section *Cylindropyrum* (Jaub. et Sp.) Zhuk. emend. Kihara		**218**
Ae. markgrafii (Greuter) Hammer	2x	120
Ae. cylindrica Host	4x	98
Section *Vertebrata* Zhuk. emend. Kihara		**288**
Ae. tauschii Coss.	2x	183
Ae. crassa Boiss.	4x;6x	44
Ae. ventricosa Tausch	4x	50
Ae. juvenalis (Thell.) Eig	6x	11
Section *Comopyrum* (Jaub. et Sp.) Zhuk. emend. Kihara		**21**
Ae. comosa sibth. Et Sm.	4x	16
Ae. uniaristata Vis.	4x	5
Section *Aegilops*		**765**
Ae. umbellulata Zhuk.	2x	30
Ae. peregrina (Hackel) Maire et Weiller	4x	22
Ae. kotschyi Boiss.	4x	10
Ae. triuncialis L.	4x	290
Ae. lorentii Hochst.	4x	110
Ae. columnaris Zhuk.	4x	15
Ae. neglecta Req. Ex Bertol.	4x; 6x	72
Ae. geniculata Roth	4x	216
Not classified accessions of the genus *Aegilops*	?	**85**
Total		**1,537**

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Exploitation

Phenotyping = Characterisation + Evaluation

Exploitation

Phenotyping = Characterisation + Evaluation

Character	Classification
Presence of awns	Absent **[0],** Short awns present **[1],** Long awns present **[2]**
Awn colour	Uncoloured **[0],** Coloured **[1]**
Glume colour	Uncoloured **[0],** Coloured **[1]**
Presence of hairs on glumes	Absent **[0],** Present **[1],**
Presence of inflate spike type	Absent **[0],** Present **[1],**
Spike density	Loose (rachis segments >3.2 mm) **[0]** Dense (rachis segments between 2.5 and 3.2 mm) **[1]** Compact (rachis segments < 2.5 mm) **[2]**
Spike branching	Normal **[0],** Branched **[1]**
Grain colour	Uncoloured **[0],** Coloured **[1]**
Stem filling	Hollow **[0],** Filled **[1]**
Presence of ligules	Absent **[0],** Present **[1]**

Mansfeld, R (1951) Das morphologische System des Saatweizens, *Triticum aestivum* L.s.l. Der Züchter 21: 41- 60

Exploitation

Phenotyping = Characterisation + Evaluation

Primary Evaluation **Secondary Evaluation**

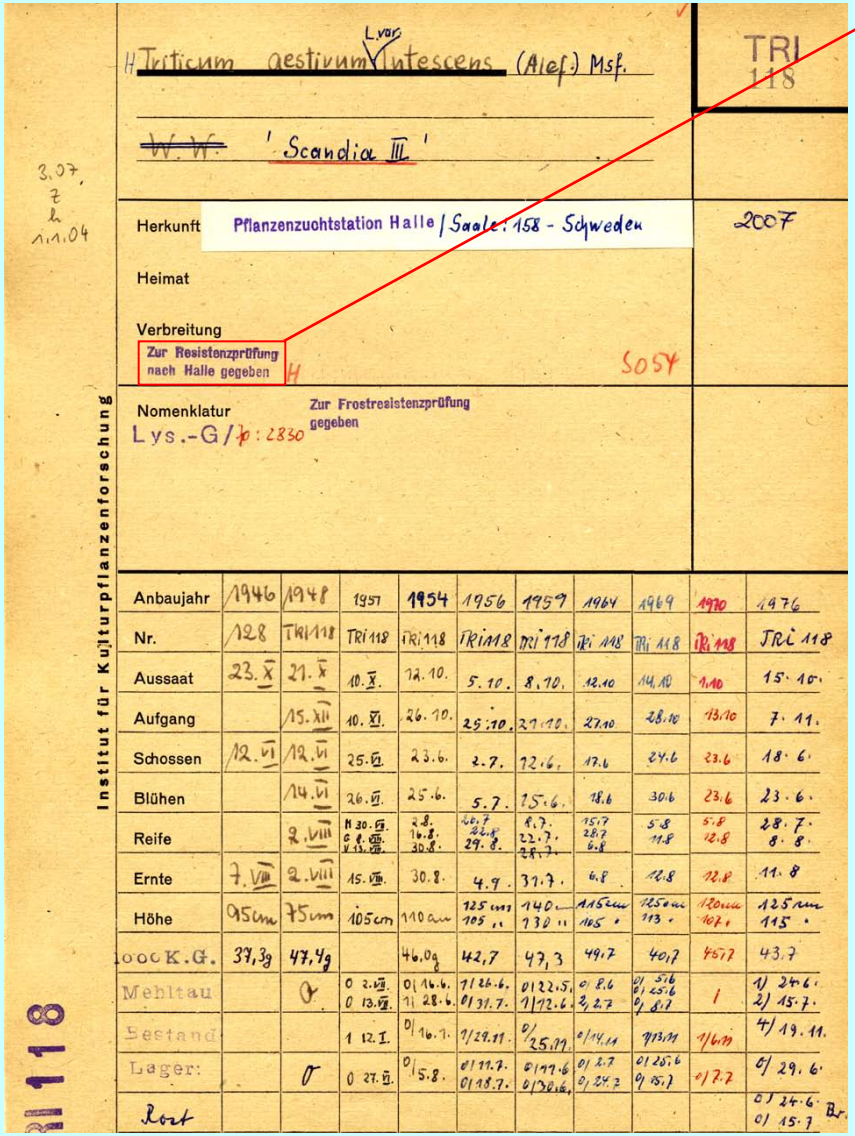
Exploitation

Phenotyping = Characterisation + Evaluation

Primary Evaluation **Secondary Evaluation**

Date sowing
Date plant emergence
Performance before winter
Performance after winter
Growth habit
Date ear emergence
Date flowering
Date maturity
Waxiness
Mildew (natural infection)
Stripe rust (natural infection)
Leaf rust (natural infection)
Plant height
Lodging

Exploitation



H Triticum aestivum L var. lutescens (Alef.) Msf.

TRI 118

W.W. 'Scandia III'

Herkunft: Pflanzenzuchtstation Halle / Saale: 158 - Schweden — 2007

Heimat

Verbreitung: Zur Resistenzprüfung nach Halle gegeben — H — 5057

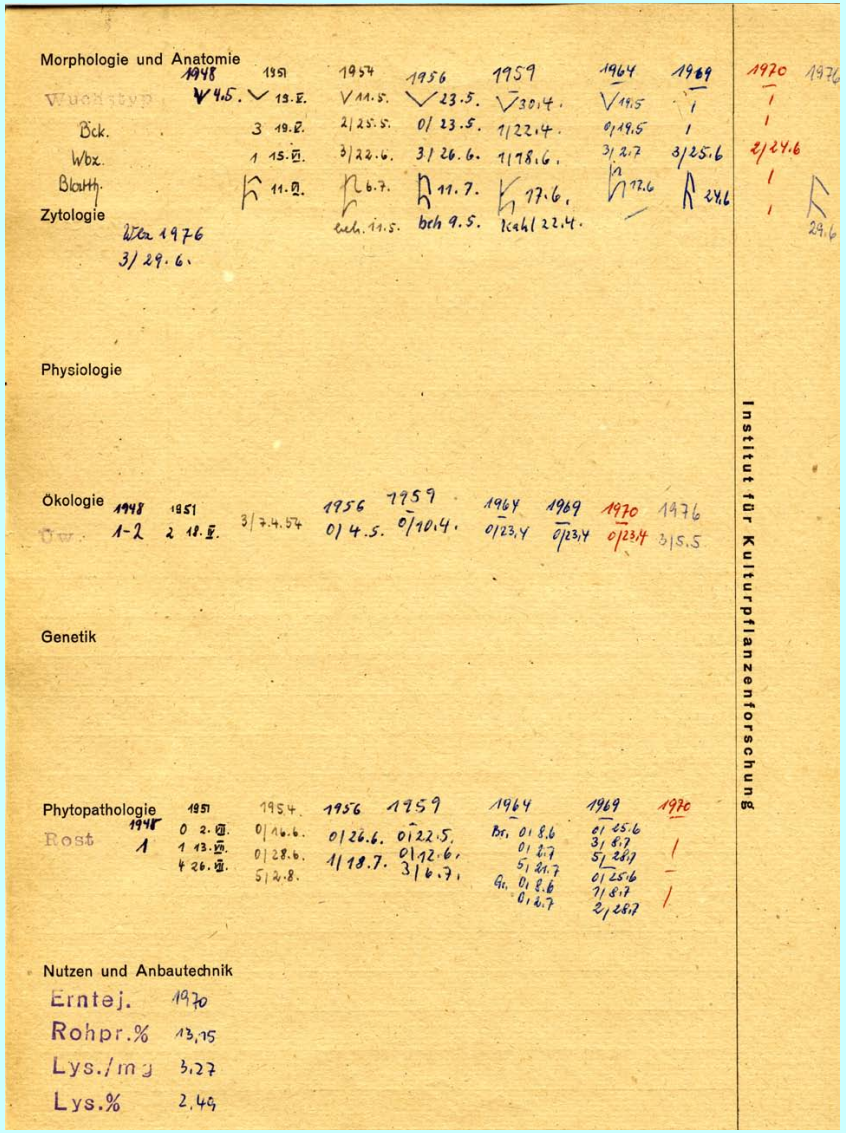
Nomenklatur: Lys.-G/p: 2830

Zur Frostresistenzprüfung gegeben

Institut für Kulturpflanzenforschung

Anbaujahr	1946	1948	1951	1954	1956	1959	1964	1969	1970	1976
Nr.	128	TRI 118	TRI 118	TRI 118	TRI 118	TRI 118	TRI 118	TRI 118	TRI 118	TRI 118
Aussaat	23.X	21.X	10.X.	12.10.	5.10.	8.10.	12.10	14.10	1.10	15.10.
Aufgang		15.XII	10.VI.	26.10.	25.10.	27.10.	27.10	28.10	13.10	7.11.
Schossen	12.VI	12.VI	25.VI.	23.6.	2.7.	12.6.	17.6	24.6	23.6	18.6.
Blühen		14.VI	26.VI.	25.6.	5.7.	15.6.	18.6	30.6	23.6	23.6.
Reife		2.VIII	N 30.VI. G 8.VII. V 13.VII.	28. 16.8. 30.8.	26.7 22.8 29.8.	8.7. 22.7. 28.7.	15.7 28.7 6.8	5.8 11.8	5.8 12.8	28.7. 8.8.
Ernte	7.VIII	2.VIII	15.VIII.	30.8.	4.9.	31.7.	6.8	12.8	12.8	11.8
Höhe	95cm	75cm	105cm	110cm	125cm 105 "	140 " 130 "	115cm 105 "	125cm 113 "	120cm 107 "	125cm 115 "
1000 K.G.	37,3g	47,4g		46,0g	42,7	47,3	49,7	40,7	45,7	43,7
Mehltau		0	0 2.VII. 0 13.VII.	0/ 16.6. 1/ 28.6.	1/26.6. 0/31.7.	0/22.5. 1/12.6.	0/ 8.6 2/ 2.7	0/ 5.6 0/ 25.6 0/ 8.7	1	1/ 24.6. 2/ 15.7.
Bestand			1 12.I.	0/ 16.1.	1/29.11.	0/ 25.11.	0/14.11	1/13.11	1/6.11	4/ 19.11.
Lager:		0	0 27.VI.	0/ 5.8.	0/11.7. 0/18.7.	0/17.6 0/30.6.	0/ 2.7 0/ 24.7	0/ 25.6 0/ 15.7	0/7.7	0/ 29.6.
Rost										0/ 24.6. 0/ 15.7 Br.

3.07. z k 1.11.04



Zur Resistenzprüfung nach Halle gegeben

Morphologie und Anatomie

	1948	1951	1954	1956	1959	1964	1969	1970	1976
Wuchstyp	4.5.	13.5.	11.5.	23.5.	30.4.	19.5	1	1	
Bck.		3 19.5.	2/25.5.	0/ 23.5.	1/22.4.	0/19.5	1	1	
Wbx.		1 15.6.	3/22.6.	3/ 26.6.	1/18.6.	3/ 2.7	3/25.6	2/24.6	
Blattf.		11.6.	6.7.	11.7.	17.6.	17.6	24.6	1	
Zytologie			kein. 11.5.	bch 9.5.	kahl 22.4.			1	

Wa 1976 3/ 29.6.

Physiologie

Ökologie

1948	1951		1956	1959	1964	1969	1970	1976
1-2	2 18.5.	3/7.4.54	0/ 4.5.	0/10.4.	0/23,4	0/23,4	0/23,4	3/5.5

Genetik

Phytopathologie

1948	1951	1954	1956	1959	1964	1969	1970
Rost 1	0 2.VI. 1 13.VI. 4 26.VI.	0/ 16.6. 0/ 28.6. 5/ 2.8.	0/26.6. 1/18.7.	0/22.5. 0/12.6. 3/ 6.7.	Br. 0/ 8.6 0/ 2.7 5/ 21.7 Gr. 0/ 8.6 0/ 2.7	0/ 25.6 3/ 8.7 5/ 28.7 0/ 25.6 1/ 8.7 2/ 28.7	1 1

Nutzen und Anbautechnik

Erntej.	1970
Rohpr.%	13,15
Lys./mg	3,27
Lys.%	2,49

Institut für Kulturpflanzenforschung

Exploitation

Phenotyping = Characterisation + Evaluation

Primary Evaluation **Secondary Evaluation**

Stripe rust
(*Puccinia striiformis*)

Seedling Stage	1933-1977
Adult stage (leaf)	1934-1983

Leaf rust
(*Puccinia recondita*)

Seedling Stage	1933-1992
Adult stage (leaf)	1933-1983

Powdery mildew
(*Erysiphe graminis*)

Seedling Stage	1950-1992
Adult stage (leaf)	1939-1992
Adult stage (spike)	1978-1983

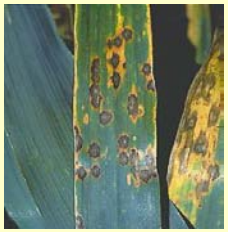
Exploitation

Phenotyping = Characterisation + Evaluation

Primary Evaluation **Secondary Evaluation**

Septoria
(*Septoria nodorum*)

Adult stage (leaf)	1973-1982
Adult stage (spike)	1976-1982



Eyespot
(*Pceudocercosporella herpotrichoides*)

Seedling Stage	1976-1981
Adult stage (natural infection)	1976-1983
Adult stage (artificial infection)	1978-1983

Fusarium
(*Fusarium graminearum*)

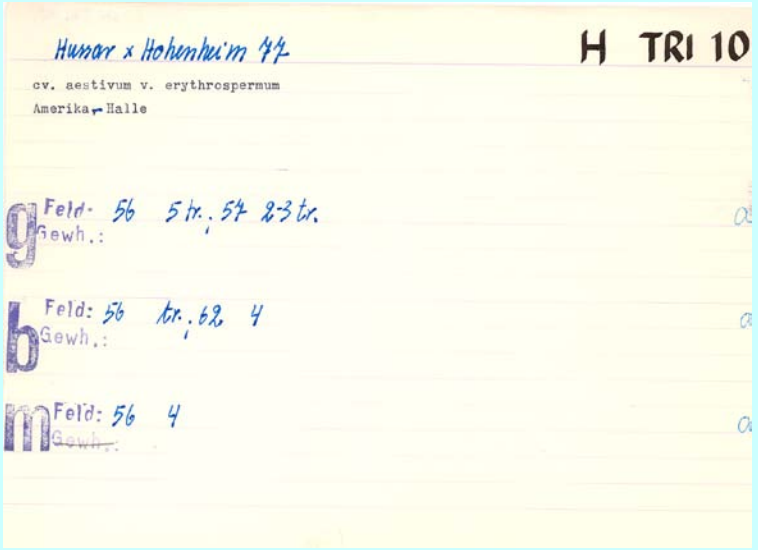
Adult stage (natural infection)	1982-1983

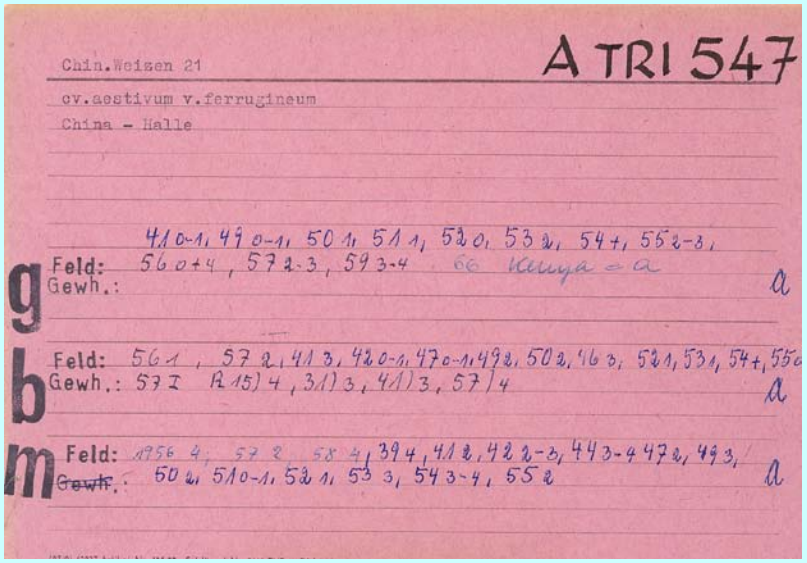
Exploitation

Phenotyping = Characterisation + Evaluation

Primary Evaluation **Secondary Evaluation**

Feld: = Field (Adult stage)
Gewh.: = Green-house (seedling stage)





g = Gelbrost (Stripe rust)

b = Braunrost (Leaf rust)

m = Mehltau (Powdery mildew)

Exploitation

Phenotyping = Characterisation + Evaluation

Primary Evaluation **Secondary Evaluation**

Disease	Period of disease scoring	Resistance data available
Powdery mildew, Seedling stage	1950 – 1992	30,628
Powdery mildew, Adult stage (leaf)	1939 – 1992	16,633
Powdery mildew, Adult stage (spike)	1978 – 1983	2,734
Leaf rust, Seedling stage	1933 – 1992	19,486
Leaf rust, Adult stage (leaf)	1939 – 1983	20,076
Stripe rust, Seedling stage	1933 – 1977	16,565
Stripe rust, Adult stage (leaf)	1939 – 1983	15,294
Septoria, Adult stage (leaf)	1976 – 1982	5,369
Septoria, Adult stage (spike)	1976 – 1982	3,556
Pseudocercosporella, Seedling stage	1976 – 1981	2,414
Pseudocercosporella, Adult stage, (natural infection)	1976 – 1983	6,728
Pseudocercosporella, Adult stage, (artificial infection)	1978 – 1983	89
Fusarium, Adult stage, (artificial infection)	1982 – 1983	4,346
Total	**1933 - 1992**	**143,918**

Börner et al. (2006), Genetic Resources and Crop Evolution 53, 453-465

Exploitation

Phenotyping = Characterisation + Evaluation

Primary Evaluation **Secondary Evaluation**

Genotyping

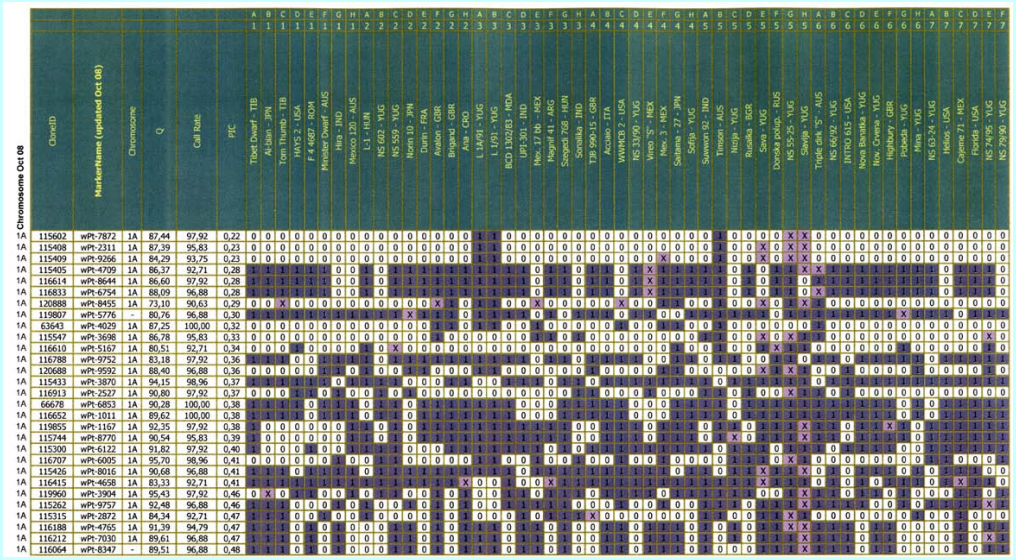
Exploitation by Association

Human Genetics
populations of unrelated individuals
(GENEBANK ACCESSIONS)

High mapping resolution

Great allele number
broader reference population

Highly efficient
less time because no need to find and crosss segregating parents and develop populations
study many traits in one population



DArT marker genotyping
Triticarte Pty Ltd
(http://www.triticarte.com.au/contentFAQ.html)

Exploitation

Case Study

Plant material:

Core collection of 96 genotypes (*T. aestivum*) originated from 21 countries (5 continents) created by the Institute of Field and Vegetable Crops, Novi Sad, Serbia

Name/designation	Origin	Name/designation	Origin	Name/designation	Origin	Name/designation	Origin
Acciaio[1]	ITA	Holly E[1]	USA	NS 22/92[1]	SRB	Slavija[1]	SRB
Ai-bian[1]	CHN	Hope[1]	USA	NS 33/90[2]	SRB	Sofija[2]	SRB
Al-Kan-Tzao[1]	CHN	Inia 66[1]	MEX	NS 46/90[2]	SRB	Sonalika[1]	IND
Ana[1]	CRO	INTRO 615[1]	USA	NS 55-25[2]	SRB	Suwon 92[1]	IND
Avalon[1]	GBR	Ivanka[1]	SER	NS 559[1]	SRB	Szegedi 768[1]	HUN
Bankuty 1205[1]	HUN	Kite[11]	AUS	NS 602[1]	SRB	Tibet Dwarf[1]	CHN
BCD 1302/83[1]	MDA	L - 1[1]	HUN	NS 63-24[1]	SRB	Timson[1]	AUS
Benni multifloret[1]	USA	L 1/91[2]	SRB	NS 66/92[1]	SRB	TJB 990-15[1]	GBR
Bezostaja 1[1]	RUS	L 1A/91[2]	SRB	NS 74/95[2]	SRB	Tom Thumb[1]	CHN
Brigant[1]	GBR	Lambriego Inia[1]	CHL	NS 79/90[1]	SRB	Tr.Compactum[1]	LVA
Cajeme 71[1]	MEX	Lr 10[1]	USA	Peking 11[1]	CHN	Tr.Sphaerococcum[2]	USA
Capelle Desprez[1]	FRA	Lr 12[1]	USA	Phoenix[1]	USA	Triple Dirk B[1]	AUS
Centurk[2]	USA	Magnif 41[1]	ARG	PKB Krupna[2]	SRB	Triple Dirk B (bulk) [2]	AUS
Ching-Chang 6[1]	CHN	Mex. 120[1]	MEX	Pobeda[2]	SRB	Triple Dirk S[1]	AUS
Cook[1]	AUS	Mex.17 bb[1]	MEX	Purdue/Loras[1]	USA	UC 65680[1]	USA
Donska polupat.[1]	RUS	Mex.3[1]	MEX	Purdue 39120[1]	USA	UPI 301[1]	IND
Durin[1]	FRA	Min. Dwarf[1]	AUS	Purdue 5392[1]	USA	Vel[1]	USA
F 4 4687[1]	ROM	Mina[1]	SRB	Red Coat[1]	USA	Vireo"S"[1]	MEX
Florida[1]	USA	Mironovska 808[1]	UKR	Renesansa[1]	SRB	WWMCB 2[1]	USA
Gala[2]	ARG	Nizija[2]	SRB	Rusalka[1]	BGR	ZG 1011[1]	CRO
Hays 2[1]	USA	Norin 101	JPN	Siete Cerros[1]	MEX	ZG 987/3[1]	CRO
Helios[1]	USA	Norin 10/Brevor14[1]	USA	Saitama 27[1]	JPN	ZG K 3/82[1]	CRO
Highbury[1]	GBR	Novosadska Crvena[2]	SRB	Sava[1]	SRB	ZG K 238/82[1]	CRO
Hira[1]	IND	Nova banatka[2]	SRB	Semillia Eligulata[1]	USA	ZG K T 159/82[1]	CRO

Exploitation

Case Study

Plant material:

Core collection of 96 genotypes (*T. aestivum*) originated from 21 countries (5 continents) created by the Institute of Field and Vegetable Crops, Novi Sad, Serbia

Phenotyping:

20 agronomic traits recorded during up to eight growing seasons

Plant height (Hg)	8 years	1994-2001
Heading date (Hd)	8 years	1994-2001
Thousand kernel weight (TKW)	7 years	1993-1999
Flowering time (Fl)	6 years	1994-1999
Biomass (Bm)	6 years	1994-1999
Grain weight per spike (GW)	6 years	1994-1999
Grain number per spike (GN)	6 years	1994-1999
Harvest index (HI)	6 years	1994-1999
Spike weight (SW)	6 years	1994-1999
Spike length (SL)	6 years	1994-1999
Spike index (SI)	6 years	1994-1999
Number of spikelets per spike (SPS)	6 years	1994-1999
Number of sterile spikelets per spike (St)	6 years	1994-1999
Grain yield (GY)	5 years	1995-1999
Protein content (Pr)	5 years	1995-1999
Sedimentation value (Sd)	5 years	1995-1999
Resistance against leaf rust (LR)	5 years	1997-2001
Resistance against powdery mildew (PM)	5 years	1997-2001
Spike number per m2 (SN)	4 years	1996-1999
Peduncle length (PL)	3 years	1997-1999

Exploitation

Case Study

Plant material:

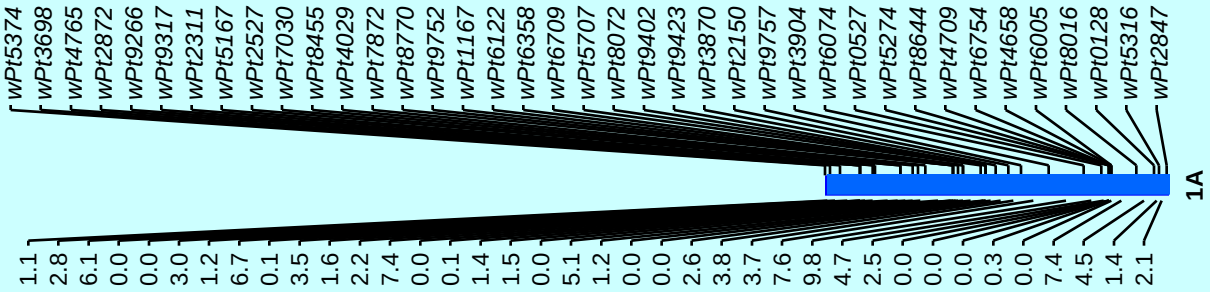
Core collection of 96 genotypes (*T. aestivum*) originated from 21 countries
(5 continents) created by the Institute of Field and Vegetable Crops, Novi Sad, Serbia

Phenotyping:

20 agronomic traits recorded during up to eight growing seasons

Genotyping:

Triticarte Pty Ltd (http://www.triticarte.com.au/contentFAQ.html)
874 DarT markers
501 with known map position - Thanks to CIMMYT (Susanne Dreisigacker)



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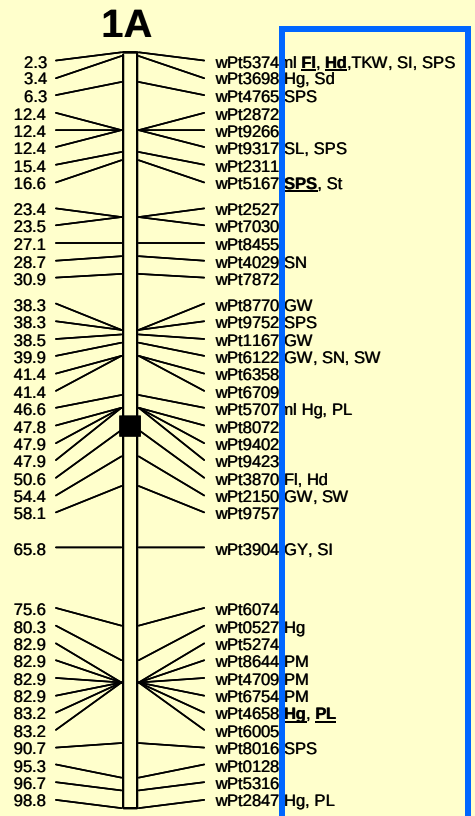
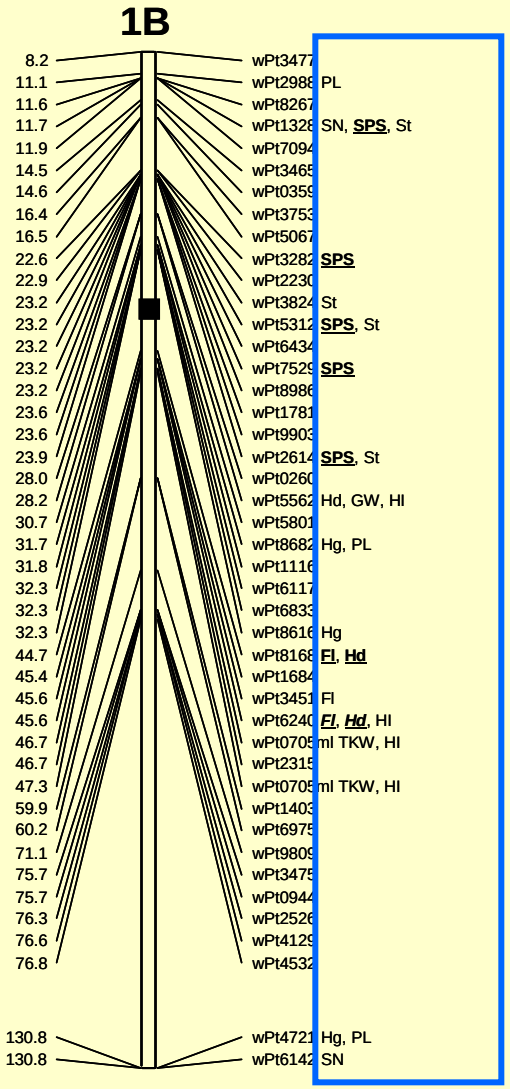
Statistics:

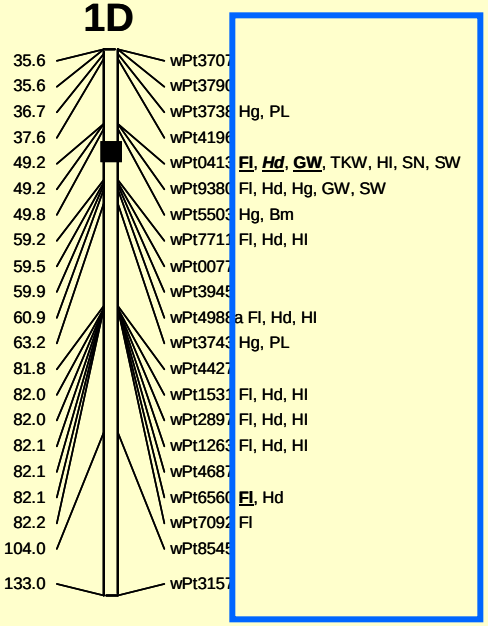
Software STRUCTURE (Pritchard *et al.,* 2000) - population structure
Software Tassel 2.0.1 (Bradbury *et al.*, 2007) - association marker/trait
General linear model (GLM)

Exploitation

Case Study



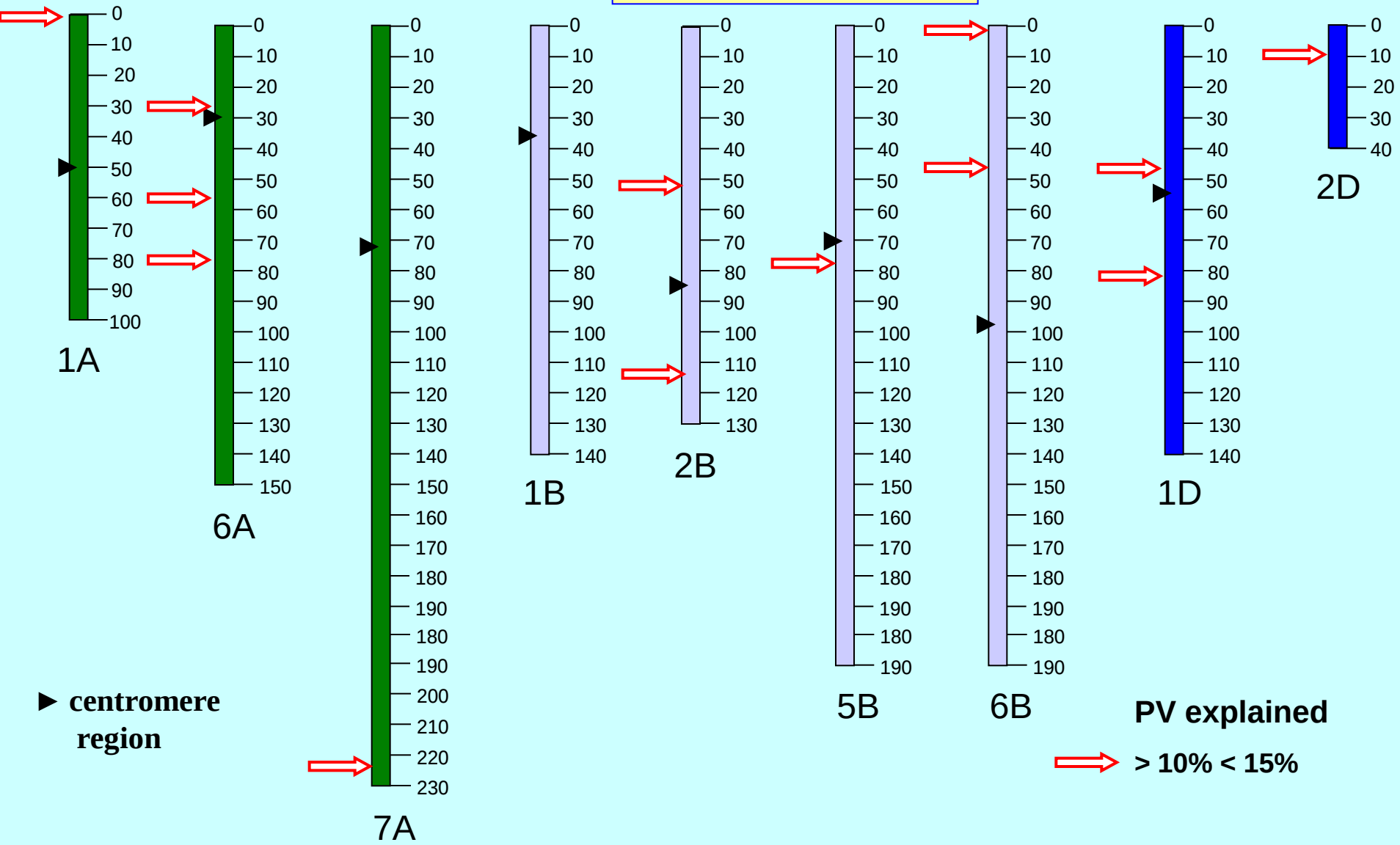




Exploitation

Case Study

Flowering time



Exploitation

Case Study

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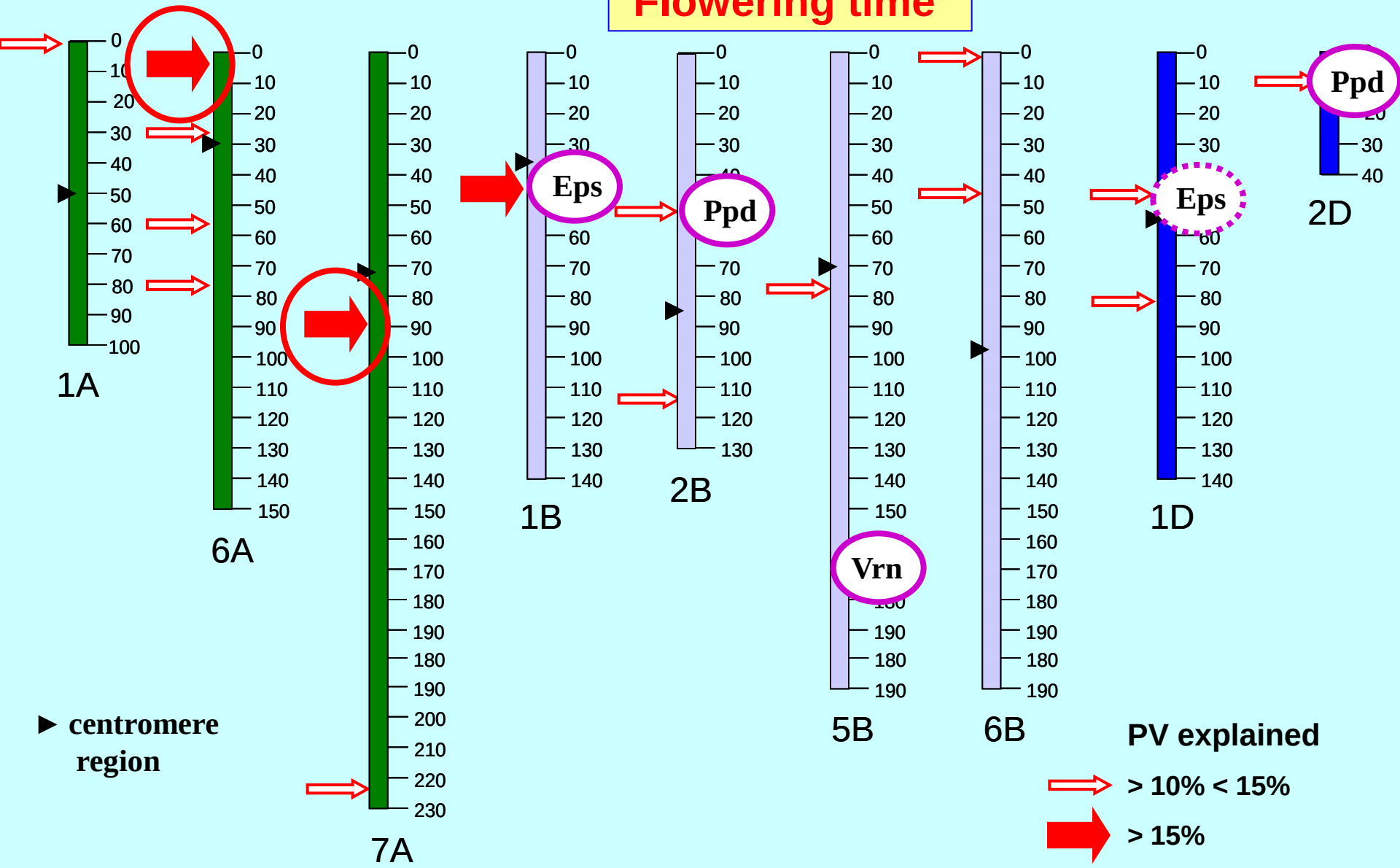

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Thank you for your attention!

IPK GATERSLEBEN

Qualitätsmanagement DQS ISO 9001