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Traits of relevance for Human Nutrition in European Oat Genetic Resources Collections

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Objectives of the project

European Commission. DG AGRI council regulation 870/2004

Evaluation, characterisation and documentation of genetic resources within genus *Avena* focussed on:

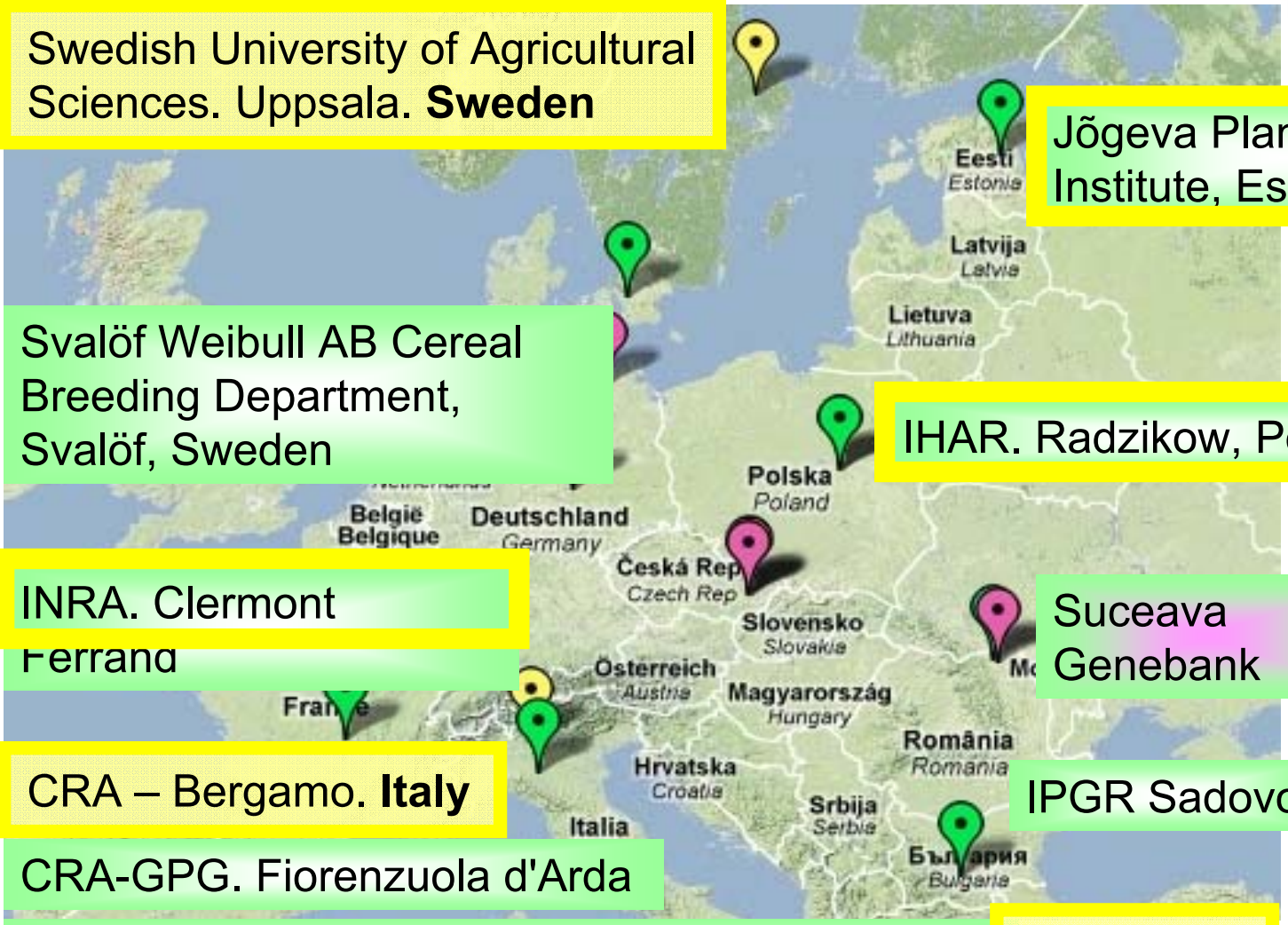
- nutritional (protein, fat, minerals, β-glucan, antioxidants) and technical quality (kernel weight, groat content,...)
- Resistance to *Fusarium* infection and mycotoxin contamination.
- Cold tolerance

http://aveq.jki.bund.de/aveq/

Topic at the 9th IOC Beijing:

Results for	Grain yield, Thousand-kernel weight, Tocopherol, Avenanthramides, Fat β-glucan (BG)
Material and Methods:	Working collection, Growing methods, Analytical methods Statistical analysis

Sites of 15 project partners from 9 countries



Swedish University of Agricultural Sciences. Uppsala. **Sweden**

Jõgeva Plant Breeding Institute, Estonia

Svalöf Weibull AB Cereal Breeding Department, Svalöf, Sweden

IHAR. Radzikow, Poland

INRA. Clermont Ferrand

Suceava Genebank

CRA – Bergamo. **Italy**

IPGR Sadovo

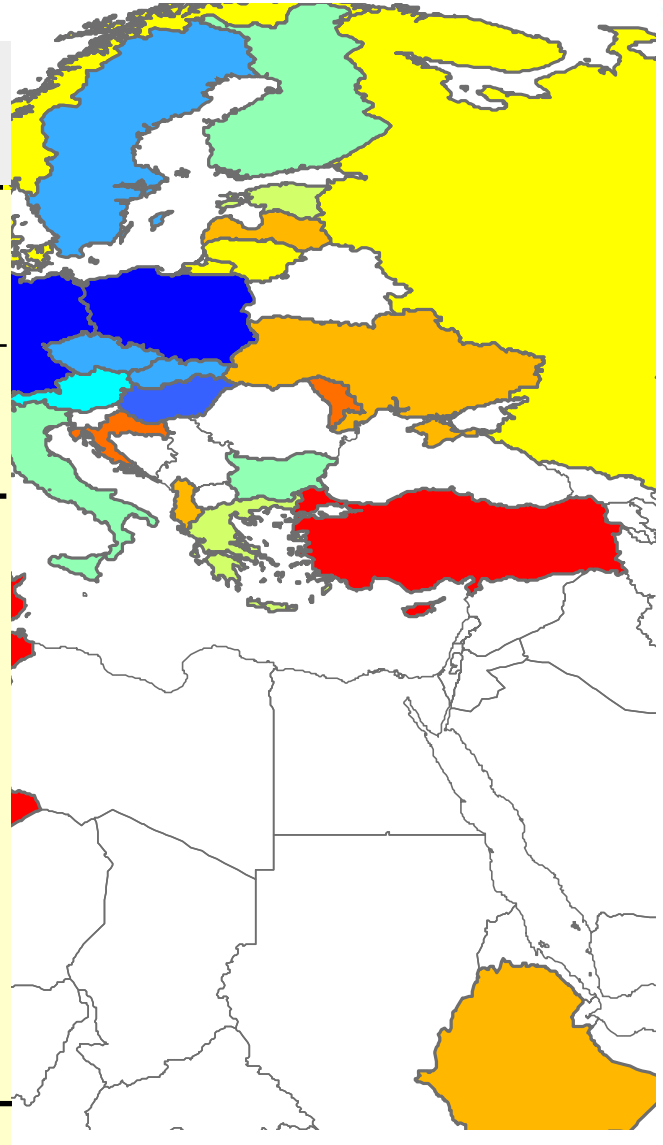
CRA-GPG. Fiorenzuola d'Arda

Agronomic and quality traits evaluation

Analytics

Working Collection

Species	Genome	Accessions evaluated
A. sativa	ACD	543
A. byzantina	ACD	24
A. strigosa	A_s	46
A. abyssinica	AB	5
A. fatua	ACD	16
A. hybrida	ACD	1
A. sterilis	ACD	5
A. barbata	AB	4
A. canariensis	A_c	1
A. damascena	A_d	2
A. hirtula	A_s	4
A. wiestii	A_s	1
		652



Growing methods

	Sites	Plot size m^2	Row Distance	Seed Density	Accessions
2008	BGR Sadovo	2.6	16.6	400	327
	EST Jõgeva	2.0	12.5	400	332
	FRA Clermont	3.6	15.0	250	322
	ITA Fiorenzuola	2.7	12.5	400	340
	POL Radzikov	2.5	13.0	400	340
	ROM Suceava	2.6	13.0	400	341
2009	BGR Sadovo	1.3	16.8	400	315
	EST Jõgeva	2.5	12.0	400	334
	FRA Clermont	2.4	15.0	342	315
	ITA Fiorenzuola	2.4	17.0	400	334
	POL Radzikov	2.5	14.0	400	334
	ROM Suceava	2.6	15.0	400	332

Growing methods

Experimental design: Augmented block design; The core block design with five replications was formed by 11 standard cultivars representing oat breeding in the European regions:

Belinda and Jaak	Northern Europe
Auteuil and Evora	Western Europe
Ivory	Central Europe
Krezus and Saul (n)	Eastern Europe
Argentina and Genziana	Southern Europe
Mures and Mina (n)	South Eastern Europe

n= *Avena sativa* ssp. *nudisativa*

Analytical methods

Samples were dehulled and milled to pass a 0.5 mm screen

Fat: Near Infrared Spectrometry (NIRS), by the use of calibration analysis with a 10% subset of the samples from each site

Tocols: Extraction from groat flour and analysed in duplicate by normal-phase high-performance liquid chromatography (NP-HPLC) (Pisacane et al 2004).

Avenanthramides: Extraction with 80% acidic ethanol. Avenanthramides were quantified by HPLC using external references.

β-glucan (BG): Enzymatic method of McCleary and Codd (1991), using a Megazyme β-glucan kit

Statistical analysis

1. Replicated 11 standard cultivars: ANOVA with package ‘agricolae’ (De Mendiburu 2010) in 'R' (R Development Core Team (2011)
2. Accessions (unreplic.): Adjustment with UNREP command in PLABSTAT (Utz 2010) and the ANOVA with adjusted values; only for yield
3. Multiple comparisons: Tukey’s HSD (Honestly Significant Differences) via 'R' and the least significant difference at the 5% level (LSD 5%) via PLABSTAT

Mean[1] grain yield of the best standards and accessions

Registration	**2008**	t/ha	Registr.	**2009**	t/ha
HSD 5%[2]		**0.5**			**0.6**
2005	Krezus	5.5	2004	Ivory	4.3
1997	Belinda	5.3	2005	Krezus	4.2
2004	Ivory	5.1	1997	Belinda	4.2
	Mures	4.9	1996	AUTEUIL	3.7
1996	AUTEUIL	4.7	1995	Jaak	3.7
1995	Jaak	4.3		Mures	3.3
Highest yielding accessions and cultivars					
2006	Rajtar	6.6	1959	Ariane	4.4
2007	Gailette	6.0		LPSH 02-239	4.3
1992	Expander	6.0		AVE 1627	4.2
2002	Cwal	6.0		LPSH 02-202	4.2
2001	SW Argyle	5.9	2008	Berdysz	4.2
2000	Firth	5.8	2008	Zuch	4.1
2002	Nelson	5.7		03C0701750	4.1
1987	Ebene	5.7		01235	4.1
2007	Flaemingsgold	5.7		AVE 1705	4.1

[1] mean over sites in Estonia, Poland, Bulgaria, France, Italy, Romania

[2] HSD test for comparisons among standards

Standards and accessions with highest thousand-kernel weight (TKW)

	2008	g		2009	g
HSD 5%		**1.7**			**1.7**
Best standards					
	Ivory	42.1		Ivory	38.3
	Genziana	37.6		Argentina	34.9
	Mures	35.9		Genziana	33.4
	Belinda	35.2		Belinda	33.1
	Argentina	35.1		Mures	32.6
	Krezus	34.6		Krezus	31.3
Best accessions					
sativa	Flämingsgold	42.2	sativa	MONTAGNANA	37.8
sativa	White superbe	40.7	sativa	PL50951	36.8
sativa	Nelson	40.6	sativa	LPSH 02-239	36.4
sativa	SW Betania	39.9	sativa	Blanche du vieux moulin	36.1
sativa	Minue	39.7	sativa	Alfred	36.0
sativa	SW Ingeborg	39.4	sativa	LPSH 02-202	36.0
sativa	Novella Antonia	39.2	sativa	Scorpion	35.9
sativa	Monarch	38.8	sativa	POMORSKI POZNY	35.7
sativa	Eugen	38.7	sativa	Avena di santa Maria	35.7

Avenanthramides and tocopherols/tocotrienols:

potential health beneficial qualities, including

1. antioxidant,
2. antiproliferative, and
3. anti-inflammatory properties.

Accessions with highest tocopherol content

Species	2008	mg / kg	Species	2009	mg / kg
LSD 5%		**19.4**			**5.2**
sativa	Rozmar	45.7	*sativa*	Caravelle	35.0
sativa	Flämingskurz	38.1	*sativa*	Castelton potato	34.8
sativa	Grise de houdan	37.4	*strigosa*	PL51733	34.7
sativa	Kehra Varajane	36.7	*strigosa*	AVE 2838	34.6
sativa	Freddy	36.0	*strigosa*	PL51740	34.2
sativa	AVE 2313	35.1	*sativa*	Ariane	34.0
sativa	AVE 544	35.1	*sativa*	Viker	33.7
sativa	AVE 1002	34.5	*strigosa*	BGE023741	33.2
sativa	Hativa des alpes	34.3	*sativa*	Gelber Riesenfahnen	33.1
sativa	TABORSKY	33.6	*strigosa*	Tiree oat	32.9
sativa	HAMEL	33.2	*strigosa*	Schleswiger Geest	32.7
sativa	SOFIA 914	32.6	*strigosa*	PL51756	32.5

Standards and accessions with highest content of total avenanthramides

Species	2008	µmol / g	Species	2009	µmol / g
HSD 5%		**0.69**			**0.78**
	Jaak	4.04		Jaak	5.13
	ARGENTINA	2.30		IVORY	3.89
	IVORY	1.58		ARGENTINA	3.68
	AUTEUIL	1.24		BELINDA	3.13
	BELINDA	1.11		AUTEUIL	2.82
Accessions and cultivars with highest values for avenanthramides					
strigosa	**AVE 128**	8.34	*strigosa*	Tiree oat	7.87
strigosa	200110206	6.75	*strigosa*	AVE 3375	7.16
strigosa	200111912	5.97	*sativa*	Glasnevin Triumph	6.47
sterilis	AVE 446	5.06	*strigosa*	**BGE024801**	6.17
sativa	Donata	4.72	*sativa*	AVE 2728	5.67
strigosa	AVE 4701	4.02	*sativa*	A7BM0002	4.98
fatua	AVE 1758	3.57	*strigosa*	PL51740	4.82
sativa	PI 194895	2.88	*sativa*	01423	4.77
hybrida	AVE 1426	2.48	*sativa*	01243	4.45

Standard cultivars and accessions with highest fat content

2008		g / 100g	2009		g / 100g
HSD 5%		**0.4**			**0.2**
Standards with highest fat content					
	ARGENTINA	8.4		ARGENTINA	7.0
	BELINDA	8.3		EVORA	6.9
	EVORA	8.2		BELINDA	6.6
	Genziana	8.0		Genziana	6.4
Accessions and cultivars with highest fat content					
sativa	Lipoplus	10.5	*sativa*	AVE 1284	8.9
sativa	Matilda	9.7	*sativa*	OSIJEK	8.2
sativa	AVE 2313	9.7	*sativa*	Dunav 2	8.0
strigosa	BGR 7982	9.4	*sativa*	AVE 494	8.0
abyssinica	BGR 8133	9.2	*sativa*	A7BM0006	7.9
sativa	200113379	9.1	*sativa*	PL51130	7.8
sativa	Rajtar	9.0	*sativa*	Kaloian	7.8
sativa nud.	200113898	8.9	*byzantina*	AVE 282	7.8
sativa	AVE 1495	8.9	*sativa*	LUILBREG	7.8

Standard cultivars and accessions with highest β-glucan

	2008	g / 100g		2009	g / 100g
HSD 5%		**0.64**			**0.23**
	Auteuil	4.6		Belinda	4.3
	Mina	4.5		Mina	4.3
	Belinda	4.4		Auteuil	4.2
	Evora	4.3		Jaak	4.1
	Jaak	4.2		Evora	4.1
Accessions and cultivars with highest total β-Glucane					
strigosa	Jari Zlatna Kisa	5.9	*hirtula*	PL52346	4.9
sativa	200110612	5.7	*strigosa*	PL51733	4.9
sativa	Jõgeva Koidukaer	5.6	*strigosa*	AVE 1869	4.7
sativa	AVE 1429	5.6	*strigosa*	BGE003493	4.7
sativa	Danish Island	5.6	*strigosa*	BGE003530	4.7
strigosa	PL51583	5.6	*sativa*	PL50393	4.7
strigosa	200114678	5.6	*fatua*	AVE 440	4.7
strigosa	200112562	5.5	*strigosa*	BGE004766	4.6
strigosa	200106959	5.5	*abyssinica*	200111678	4.6
sativa	Bohun	5.5	*strigosa*	PL51672	4.6

Conclusions (I)

- Evaluation of about 650 *Avena* accessions of European genebanks displayed a high phenotypic variation within and between species.
- Grain yield: “nordic” cv. like Belinda and some elder cultivars (Ariane, Expander) are yielding high as modern cultivars, displaying a wider adaptation to environments involved.
- Total avenanthramides content of accessions are highest in several *A. strigosa* and in a few *A. sativa* accessions. For avenanthramides no correlation to crown rust resistance was found.

Conclusions (II)

- Tocopherols: higher contents were detected in old and modern *A. sativa* cultivars, *A. strigosa, A. abyssinica* and *A. byzantina* accessions.
- In contrast to tocols and avenanthramides, lipids and BG have been considered in various breeding programmes and the highest range for fat is found in *A. sativa* group.
- For BG, a few interesting new *A. sativa* accessions like 'Jõgeva Koidukaer' with high values are detected.

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Thanks for your attention!