

## **Wild Crucifer Species as Sources of Traits**

### **Wild Crucifer Species as Sources of Agronomic Traits**

The following guide to the wild germplasm of *Brassica* and allied crops reviews the potential of wild crucifers, particularly members of the tribe Brassiceae, as sources of agronomic traits. In addition to traditional breeding methods, interspecific and intergeneric transfer of genes governing qualitative and quantitative characters from wild allies to cultivated forms will be facilitated with various in vitro methods, such as somatic cell genetics and recombinant DNA techniques (See Guide Part III). Examples of genetic variability in potential agronomic traits of germplasms of *Brassica* and related genera (Tribe Brassiceae) will be presented under 14 sections. Data will be presented for all species in the Family.

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## Wild Crucifer Species as Sources of Traits

### 1. GERMPLASM

#### 1.1 Brassicaceae Species Checklist

Species checklist provides taxonomy and synonymy for 338 genera and 3709 species in the family. The database contains ca. 14,000 taxonomic names [see Warwick et al. 2006a].

#### 1.2 North American Germplasm – Tribe Brassiceae

The genus *Brassica* is considered a native of Eurasia and to have been introduced into the New World by European settlers around 400 years before present (B.P). Recent archaeological and ethnobotanical studies, reviewed in Jacobson et al. (1988), have provided evidence for a North American distribution of *Sinapis*. *Sinapis arvensis* was found to have occurred in the northeastern United States as early as 8000 B.P. and was abundant and widespread by 2000 B.P. These suggest the original existence of a semi-circumboreal distribution for *S. arvensis* (and perhaps other *Brassica* spp.) which was maintained during the late-Quaternary, with the range in North America changing during the glacial/interglacial cycles.

North American germplasm of the Tribe Brassiceae, whether naturalized introductions/crop escapes or native components, represents both a wild source of agronomic traits as well as agricultural weed problems.

##### 1.2.1 North American Ethnobotany [Arnason et al. 1981; Jacobson et al. 1988]

Historically, native peoples of North America have used a number of "wild" *Brassica* spp. for both food and medicinal purposes:

- Brassica* spp. - young shoots cooked as greens by Iroquois and Malecite Indian Tribes.
- Brassica nigra* - seeds ground and used as snuff to cure head colds by the Meskwaki.  
- leaves used to relieve toothaches and headaches by the Mohegans.
- Brassica napus* - bark used to treat colds, cough, grippe and small pox by the Micmac.  
- used for chilbains by the Rappahannock.
- Brassica oleracea* - used for headaches by the Rappahannock.
- Brassica rapa* - used as medicine by the Bois Fort Chippewa.
- Sinapis alba* - used to treat tuberculosis by the Malecite and Micmac.

##### 1.2.2 Weed and crop species of tribe Brassiceae in Canada [Warwick et al. 1999; Gulden et al. 2008]. Note: All in weedy habitats with exception of *Cakile* spp.

Species	Common name	Distribution <sup>1</sup>
<i>Brassica juncea</i>	Indian mustard	NT NF NS PE NB PQ ON MB SK AB BC
<i>Brassica napus</i>	rapeseed, canola	NT NF NS PE NB PQ ON MB SK AB BC
<i>Brassica nigra</i>	black mustard	NF NS NB PQ ON SK BC
<i>Brassica oleracea</i>	cabbage	BC naturalized; rare escape in NF PE PQ ON AB
<i>Brassica rapa</i>	bird rape	NT YT NF NS PE NB PQ ON MB SK AB BC
<i>Cakile edentula</i>	sea-rocket	NF NS PE NB PQ ON BC
<i>Cakile maritima</i>		BC
<i>Conringia orientalis</i>	hare's-ear mustard	NF NS PE NB PQ ON MB SK AB BC

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<i>Diplotaxis muralis</i>	sand-rocket	NS PE NB PQ ON MB SK AB
<i>Diplotaxis tenuifolia</i>	wall-rocket	NS NB PQ ON
<i>Eruca vesicaria</i> subsp. <i>sativa</i>	garden rocket	rare escape, not naturalized in PQ ON SK AB
<i>Erucastrum gallicum</i>	dog mustard	NT NF NS PE NB PQ ON MB SK AB BC [Warwick and Wall 1998]
<i>Raphanus raphanistrum</i>	wild radish	NF NS PE NB PQ ON AB BC [Warwick and Francis 2005]
<i>Raphanus sativus</i>	radish	NF NS PE NB PQ ON AB BC
<i>Rapistrum rugosum</i>		rare escape, not naturalized in PQ ON
<i>Sinapis alba</i>	white mustard	YT NS PE NB PQ ON MB SK AB BC
<i>Sinapis arvensis</i>	wild mustard	NT YT NF NS PE NB PQ ON MB SK AB BC [Warwick et al. 2000]

NOTE: <sup>1</sup> Northwest Territories, Dist. Mackenzie, NT; Yukon Territory, YT; Newfoundland and Labrador, NF; Prince Edward Island, PE; Nova Scotia, NS; New Brunswick, NB; Quebec, PQ; Ontario, ON; Manitoba, MB; Saskatchewan, SK; Alberta, AB; British Columbia, BC.

\*NOTE: The genus *Cakile* (North American component includes *C. edentula* (Bigel.) Hook., *C. constricta* Rodman, *C. geniculata* (B.L. Rob.) Millsp., *C. lanceolata* (Willd.) O.E. Schulz) is generally considered the only member of the Brassiceae with indigenous species in the New World.

### 1.2.3 Weed and crop species in United States and Mexico [Al-Shehbaz 1985; Lemke and Worthington 1991; Luken et al. 1993; Rollins 1993, Warwick, unpubl. data]

<b>Species</b>	<b>Distribution<sup>1</sup></b>
<i>Brassica elongata</i>	NV
<i>Brassica fruticulosa</i>	CA (1951 and 1996)
<i>Brassica juncea</i>	Almost every US state, Mexico
<i>Brassica napus</i>	Almost every US state, Mexico
<i>Brassica nigra</i>	Almost every US state, Mexico
<i>Brassica oleracea</i>	CA (naturalized, rare escape) CT IL IA KY MA NY OH RI TX VT
<i>Brassica rapa</i>	Almost every state, Mexico
<i>Brassica tournefortii</i>	AZ CA LA NM NV TX, Mexico
<i>Cakile</i> spp.*	AK, Great Lakes, Atlantic and Pacific Coasts, Mexico
<i>Cakile maritima</i>	AL CA FL NJ
<i>Coincya monensis</i>	CA NC PA
<i>Conringia orientalis</i>	Almost every US state, Mexico
<i>Crambe maritima</i>	OR
<i>Diplotaxis muralis</i>	AZ AR CA CT IL IN KS LA MA MI MN NE NJ NY NC OH OR PA SC SD TX UT WV, Mexico
<i>Diplotaxis tenuifolia</i>	AZ CA CT DE IL IN KY MD MA MI NY OH OR PA TX VA
<i>Eruca vesicaria</i> subsp. <i>sativa</i>	AZ CA NM NV UT TX, Mexico
<i>Erucastrum gallicum</i>	AL CA CN FL ID IL IN KS KY ME MA MI MN MO MT NH NY ND PA SD TX VT WA WV WI WY

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<i>Hirschfeldia incana</i>	CA NV
<i>Raphanus raphanistrum</i>	Almost every US state, Mexico
<i>Raphanus sativus</i>	Almost every US state, Mexico
<i>Rapistrum rugosum</i>	TX (naturalized); reports from CA LA MA NY PA, Mexico
<i>Sinapis alba</i>	Almost every US state, Mexico
<i>Sinapis arvensis</i>	Almost every US state, Mexico

CODE: <sup>1</sup> Alabama, AL; Alaska, AK; Arizona, AZ; Arkansas, AR; California, CA; Colorado, CO; Connecticut, CT; Delaware, DE; Florida, FL; Georgia, GA; Idaho, ID; Illinois, IL; Indiana, IN; Iowa, IA; Kansas, KS; Kentucky, KY; Louisiana, LA; Maine, ME; Maryland, MD; Massachusetts, MA; Michigan, MI; Minnesota, MN; Mississippi, MS; Missouri, MO; Montana, MT; Nebraska, NB; Nevada, NV; New Hampshire, NH; New Jersey, NJ; New Mexico, NM; New York, NY; North Carolina, NC; North Dakota, ND; Ohio, OH; Oklahoma, OK; Oregon, OR; Pennsylvania, PA; Rhode Island, RI; South Carolina, SC; South Dakota, SD; Tennessee, TN; Texas, TX; Utah, UT; Vermont, VT; Virginia, VA; Washington, WA; West Virginia, WV; Wisconsin, WI; Wyoming, WY.

### 1.2.4. Invasives

- <i>Alliaria petiolata</i>	[Durka et al. 2005]
- <i>Brassica tournefortii</i>	[Bangle et al. 2008]
- <i>Berteroa incana</i>	[Warwick and Francis 2006]
- <i>Hesperis matronalis</i>	[Francis et al. 2009]
- <i>Lepidium draba</i>	[Francis and Warwick 2008]
- <i>Lepidium latifolium</i>	[Francis and Warwick 2007]

The Brassicaceae ranked 4<sup>th</sup> most successful invasive family among 164 families surveyed (Pysek 1998).

## 2. MORPHOLOGICAL CHARACTERS [survey of tribe, Gómez-Campo 1980]

### 2.1 Hairs/Trichomes (potential insect resistance)

**Hairs on cotyledons** [Gómez-Campo and Tortosa 1974; Warwick pers. observ.]

<i>Boleum asperum</i>	(petiole and edge lamina)
<i>Carrichtera annua</i>	(petiole)
<i>Ceratocnemum rapistroides</i>	(petiole)
<i>Crambe sventenii</i>	(petiole, all over lamina)
<i>Otocarpus virgatus</i>	(petiole)
<i>Psychine stylosa</i>	(petiole and edge lamina)
<i>Sinapis alba</i>	(petiole and lamina)
<i>Sinapis flexuosa</i>	(petiole and lamina)
<i>Vella anremerica</i>	(petiole)
<i>Vella pseudocytisus</i>	(petiole and lamina)
<i>Vella spinosa</i>	(petiole)

**Hairs very dense on juvenile leaves** [Gómez-Campo and Tortosa 1974]

<i>Boleum asperum</i>	<i>Brassica incana</i>
<i>Brassica fruticulosa</i> subsp. <i>cossoniana</i>	<i>Brassica villosa</i>

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<i>Coincya monensis</i>	<i>Crambe arborea</i>
<i>Coincya rupestris</i>	<i>Crambe orientalis</i>
<i>Crambe strigosa</i>	<i>Sinapis pubescens</i>
<i>Euzomodendron bourgaeum</i>	<i>Vella pseudocytisus</i>
<i>Hirschfeldia incana</i>	<i>Vella spinosa</i>
<i>Sinapis alba</i>	
<i>Sinapis flexuosa</i>	
<b>Hairs on fruit</b> [Warwick pers. observ.]	<i>Psychine stylosa</i>
<i>Boleum asperum</i>	<i>Rapistrum rugosum</i>
<i>Carrichtera annua</i>	<i>Sinapis alba</i> [Lamb 1980]
<i>Ceratocnemum rapistroides</i>	<i>Sinapis flexuosa</i>
<i>Cordylocarpus muricatus</i>	<i>Trachystoma aphanoneurum</i> (antrose hair)
<i>Enarthrocarpus arcuatus</i>	<i>Trachystoma ballii</i> (retroseed hair)
<i>Guiraoa arvensis</i>	<i>Trachystoma labasii</i> (antrose hair)
<i>Muricaria prostrata</i>	<i>Vella mairei</i>
<i>Otocarpus virgatum</i>	<i>Vella pseudocytisus</i>

*Arabidopsis lyrata* - Glucosinolate and trichome defenses in a natural *A. lyrata* population  
[Clauss et al. 2006]

### 2.2 Leaf Thickness/Waxiness (drought and insect tolerance)

- *Brassica cretica*
- *Brassica oleracea* [Stoner 1990]
- *Diplotaxis harra*
- *Moricandia* spp.
- *Rytidocarpus*

#### Epicuticular wax columns

9 spp. wild *Brassica oleracea* complex: *Brassica alboglabra*, *B. bourgeauii*, *B. incana*, *B. hilarionis*, *B. macrocarpa*, *B. montana*, *B. insularis*, *B. rupestris*, *B. villosa* [Gómez-Campo et al. 1999]

### 2.3 Petal Colour (yellow with the following exceptions)

#### White:

- *Brassica "alboglabra"*
- *Brassica cretica* subsp. *cretica*
- *Brassica insularis*
- *Diplotaxis eruroides*
- *Erucastrum leucanthum*

**Purple/White:** subtribe Cakilinae (*Cakile*, *Didesmus*, *Erucaria*, *Reboudia*)

#### Purple (Tribe Brassiceae):

- *Eruca setulosa*
- *Moricandia* spp. and *Rytidocarpus*
- *Raphanus raphanistrum* (some populations)
- subtribe Zillinae (*Foleyola*, *Fortuynia*, *Physorhynchus*, *Schouwia*, *Zilla*)

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### Purple (Other Tribes):

- *Hesperis matronalis*
- *Lunaria annua*
- *Matthiola incana*

### 2.4 Resistance to Pod Shattering

<i>Brassica juncea</i>	[Prakash and Chopra 1988a]
<i>Brassica macrocarpa</i>	[Mithen and Herron 1991]
<i>Brassica hilarionis</i>	[Mithen and Herron 1991]
<i>Brassica tournefortii</i>	[Salisbury 1989]
<i>Conringia orientalis</i>	[Salisbury 1989]
<i>Enarthrocarpus</i> spp.	[Warwick (pers. observ.)]
<i>Hirschfeldia incana</i>	[Salisbury 1989]
<i>Raphanus</i> spp.	[Agnihotri et al. 1991]

### 2.5 Growth Form and Geocarpy

Tribe Brassiceae: Annual, winter annuals, biennials, perennials, woody shrubs (eg. *Vella* spp. (Spain); sub-trees: Canary Island *Crambe* spp. (e.g. *C. arborea* and *C. strigosa*)

Family: - herbs (rarely vines, subshrubs, shrubs or even small trees)

eg. vine/woody climber: *Heliophila scandens* (South Africa); *Lepidium scandens* (Australia); *Cremolobus peruvianus* (Peru)

large shrubs: *Foleyola* (N. Africa), *Parolinia* (Canary Islands)

small tree: *Farsetia somalensis* (E. Africa)

Geocarpy or burial of fruit underground:

Tribe Brassiceae: *Morisia monanthos* (Corsica and Sardinia) and *Raffenaldia primuloides*

Family: *Cardamine chenopodiifolia* (South America); *Geococcus pusillus* (Australia);

*Lignarella* spp. (Japan).

### 2.6 Floral Structure

Family: Typically perfect: sepals 4, petals 4

-Zygomorphic flowers (bilaterally symmetrical): e.g. *Streptanthus*

-Petals very small and occasionally absent: *Conringia orientalis*

-Stamen number: usually 6 (2 short, outer + 4 long, inner), with exceptions, e.g. 2 or 4 stamens in *Lepidium* and 8-24 stamens in *Megacarpaea polyandra*

- Nectaries: lateral, median, or both combined, some glucose-, others sucrose-dominant [Davis et al. 1998]

### 2.7 Fruit type and Dispersal

#### Fruit type:

- Typically dehiscent bivalvate capsule (silique or silicule) OR

- Indehiscent, becoming lomentaceous or achenelike

- Rarely nutlet, samara, schizocarp or even a drupe



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### Dispersal other than normal dehiscence:

- Transport by sea with salt tolerant/corky fruit: *Cakile*; *Crambe*; *Raphanus*; more rarely by freshwater
- Tumbling weed, *Anastatica hierochuntica* (Rose of Jericho) (Saharo-Sindian region)
- Explosive dehiscence: *Cardamine*
- By mammals: hooked hairs; spines

### 2.8 Seed Size

- Family: - largest *Megacarpaea gigantea* (central Asia): 1.8 x 1.5 cm, up to 90 mg; seed is borne inside a large 4 x 3 cm winged mericarp
- smallest *Mancoa mexicana* (Mexico) -0.3mm long, 0.02 mg; Saharan species of *Diploaxis* (0.05mg)

### 2.9 Vegetative Reproduction

- Family: - American water cress: *Neobeckia lacustris* and horseradish: *Armoracia rusticana*

## 3. GENOME ARRANGEMENT

### 3.1 Chromosome Numbers

Chromosome checklist for Family; ca. 10,000 counts [see Warwick and Al-Shehbaz 2006]

Family: - Known for c. 1400 of 3500 species; 200 of 350 genera

Range :  $n = 4$  to  $n = 128$

$n = 4$  *Stenopetalum* (Australia); *Physaria* (North America)

$n = 128$  *Cardamine laciniata*

### 3.2 Genome Size

	Nuclear DNA content		
	pg/2C(N)	Mbp/1C	
<i>Arabidopsis arenosa</i>	0.42	203	[Johnston et al. 2005]
<i>Arabidopsis arenosa</i>	--	196, 382	[Lysak and Lexer 2006]
<i>Arabidopsis cebennensis</i>	--	284	[Lysak and Lexer 2006]
<i>Arabidopsis halleri</i>	0.26	255	[Johnston et al. 2005]
<i>Arabidopsis lyrata</i>	--	247, 490	[Dart et al. 2004]
<i>Arabidopsis lyrata</i>	0.47	230	[Johnston et al. 2005]
<i>Arabidopsis suecica</i>	0.36	174	[Johnston et al. 2005]
<i>Arabidopsis suecica</i>	--	349	[Lysak and Lexer 2006]
<i>Arabidopsis thaliana</i>	0.30	145	[Arumuganathan and Earle 1991]
<i>Arabidopsis thaliana</i>	0.13	120	[Adhami et al. 1999]
<i>Arabidopsis thaliana</i>	0.16	157	[Johnston et al. 2005]
<i>Arabis alpina</i>	--	392	[Lysak and Lexer 2006]
<i>Arabis hirsuta</i>	0.69	335	[Johnston et al. 2005]
<i>Boechera holboellii</i>	--	195	[Lysak and Lexer 2006]
<i>Boechera stricta</i>	--	215	[Lysak and Lexer 2006]
<i>Brassica carinata</i>	1.31	642	[Johnston et al. 2005]

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<i>Brassica carinata</i>	--	1280-1548	[Bennett and Leitch 2004]
<i>Brassica juncea</i>	2.29	1105	[Arumuganathan and Earle 1991]
<i>Brassica juncea</i>	1.09	534	[Johnston et al. 2005]
<i>Brassica juncea</i>	--	1070-1500	[Bennett and Leitch 2004]
<i>Brassica napus</i>	2.34-2.56	1129-1235	[Arumuganathan and Earle 1991]
<i>Brassica napus</i>	1.15	566	[Johnston et al. 2005]
<i>Brassica napus</i>	--	1127	[Bennett and Leitch 2004]
<i>Brassica nigra</i>	0.97	468	[Arumuganathan and Earle 1991]
<i>Brassica nigra</i>	0.65	632	[Johnston et al. 2005]
<i>Brassica nigra</i>	--	634-765	[Bennett and Leitch 2004]
<i>Brassica oleracea</i>	0.71	696	[Johnston et al. 2005]
<i>Brassica oleracea</i>	--	696-765	[Bennett and Leitch 2004]
<i>Brassica oleracea</i> subsp. <i>botrytis</i>	1.30-1.37	628-662	[Arumuganathan and Earle 1991]
<i>Brassica oleracea</i> subsp. <i>capitata</i>	1.25	603	[Arumuganathan and Earle 1991]
<i>Brassica oleracea</i> subsp. <i>gemmifera</i>	1.30	628	[Arumuganathan and Earle 1991]
<i>Brassica oleracea</i> subsp. <i>italica</i>	1.24, 1.28	599, 618	[Arumuganathan and Earle 1991]
<i>Brassica rapa</i>	0.54	529	[Johnston et al. 2005]
<i>Brassica rapa</i>	--	528-784	[Bennett and Leitch 2004]
<i>Brassica rapa</i> subsp. <i>chinensis</i>	1.05	507	[Arumuganathan and Earle 1991]
<i>Brassica rapa</i> subsp. <i>oleifera</i>	0.97-1.07	468-516	[Arumuganathan and Earle 1991]
<i>Brassica rapa</i> subsp. <i>rapifera</i>	1.06	511	[Arumuganathan and Earle 1991]
<i>Brassica tournefortii</i>	1.64	791	[Arumuganathan and Earle 1991]
<i>Bunias erucago</i>	2.13/1C	---	[Greilhuber and Obermayer 1999]
<i>Bunias orientalis</i>	2.64/1C	---	[Greilhuber and Obermayer 1999]
<i>Capsella bursa-pastoris</i>	0.41	203	[Johnston et al. 2005]
<i>Capsella rubella</i>	0.26	250	[Johnston et al. 2005]
<i>Cardamine amara</i>	0.23	221	[Johnston et al. 2005]
<i>Cardamine hirsuta</i>	0.23	225	[Johnston et al. 2005]
<i>Cardamine impatiens</i>	0.21	206	[Johnston et al. 2005]
<i>Caulanthus amplexicaulis</i>	0.38	372	[Johnston et al. 2005]
<i>Caulanthus heterophyllus</i>	0.70	686	[Johnston et al. 2005]
<i>Caulanthus heterophyllus</i>	0.69	671	[Johnston et al. 2005]
<i>Crucihimalaya himalaica</i>	0.32	319	[Johnston et al. 2005]
<i>Crucihimalaya wallichii</i>	0.33	323	[Johnston et al. 2005]
<i>Diplotaxis erucoides</i>	1.31	632	[Arumuganathan and Earle 1991]
<i>Draba nemorosa</i>	0.24	235	[Johnston et al. 2005]
<i>Eruca vesicaria</i> subsp. <i>sativa</i>	1.16	560	[Arumuganathan and Earle 1991]
<i>Guillenia lasiophyllum</i>	0.38	377	[Johnston et al. 2005]
<i>Lepidium sativum</i>	0.58	380	[Johnston et al. 2005]
<i>Lepidium virginicum</i>	0.33	164	[Johnston et al. 2005]
<i>Olimarabidopsis cabulica</i>	0.42	206	[Johnston et al. 2005]
<i>Olimarabidopsis pumila</i>	0.42	203	[Johnston et al. 2005]
<i>Raphanus sativus</i>	1.09	526	[Arumuganathan and Earle 1991]
<i>Raphanus sativus</i>	0.58	573	[Johnston et al. 2005]

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<i>Sinapis alba</i>	1.02	492	[Arumuganathan and Earle 1991]
<i>Sinapis alba</i>	0.57	553	[Johnston et al. 2005]
<i>Sinapis arvensis</i>	0.76	367	[Arumuganathan and Earle 1991]
<i>Sisymbrium irio</i>	0.53	262	[Johnston et al. 2005]
<i>Sisymbrium orientale</i>	0.31	304	[Johnston et al. 2005]
<i>Thlaspi arvense</i>	0.55	539	[Johnston et al. 2005]

[See also data in Bennett and Leitch 2004; Lysak et al. 2009]

### 3.3 Genome Comparative Mapping

<i>Arabidopsis thaliana</i>	[Koch and Kiefer 2005; Yang et al. 2005]
<i>Arabidopsis lyrata</i>	[Kuittinen et al. 2004]
<i>Arabidopsis lyrata</i> subsp. <i>petraea</i>	[Koch and Kiefer 2005]
<i>Boechera stricta</i>	[Schranz et al. 2007b]
<i>Brassica oleracea</i>	
<i>Brassica napus</i>	[Parkin et al. 2005]
<i>Brassica nigra</i>	[Lagercrantz 1998]
<i>Brassica rapa</i>	[Yang et al. 2005]
<i>Capsella rubella</i>	[Boivin et al. 2004; Koch and Kiefer 2005]
<i>Crambe hispanica</i>	[Parkin and Lydiate]
<i>Moricandia arvensis</i>	[Parkin and Lydiate]
<i>Raphanus sativus</i>	[Bett and Lydiate 2003]
<i>Thellungiella halophila</i>	
Genome Building Blocks	[Parkin et al. 2005; Schranz et al. 2006a, 2007a; Ziolkowski et al. 2006]

### 3.4 Cruciferae: Compendium of Trait Genetics [See Séguin-Swartz et al. 1997]

## 4. CHEMICAL TRAITS

### 4.1 Fatty Acids surveys of wild species

- 172 spp. in 70 genera in the family [Kumar and Tsunoda 1980]
  - 25 wild *Brassica* spp. [Vioque et al. 1990; Velasco et al. 1998]
  - 11 wild taxa in tribe Brassiceae [Yaniv et al. 1991, 1995]
  - *Brassica oxyrrhina* and *B. tournefortii* [Ahuja et al. 1998]
  - *Cakile maritima* [Guil-Guerrero et al. 1999]
- High erucic acid (>45-50%):**
- *Brassica cretica* [Yaniv et al. 1991, 1995]
  - *Brassica incana* [Velasco et al. 1998]
  - *Brassica rupestris* [Velasco et al. 1998]
  - *Brassica villosa* [Velasco et al. 1998]
  - *Crambe abyssinica*, *C. hispanica* [Yaniv et al. 1991, 1995; Mulder and Mastebroek 1996; Prakash and Bhat 2007]

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- *Eruca vesicaria* (*E. sativa*) [Yaniv et al. 1991, 1995]
  - *Erucastrum cardaminoides* [Prakash and Bhat 2007]
  - *Sinapidendron angustifolia* [Prakash and Bhat 2007]
  - *Sinapis alba* [Yaniv et al. 1994, 1995]
  - *Sinapis arvensis* [Daun et al. 2003]
- High linoleic and/or linolenic acids:**
- *Alyssum* spp. [Prakash and Bhat 2007]
  - *Barbarea* spp. [Prakash and Bhat 2007]
  - *Brassica elongata* [Velasco et al. 1998]
  - *Camelina sativa* [Budin et al. 1995; Shukla et al. 2002; Matthäus and Zubr 2000; Zubr and Matthäus 2002]
- *Cardamine* spp. [Prakash and Bhat 2007]
  - *Conringia* spp. [Prakash and Bhat 2007]
  - *Descurainia sophia* [Luo et al. 1999]
  - *Diplotaxis harra* [Yaniv et al. 1995]
  - *Lepidium sativum* [Prakash and Bhat 2007]
  - *Lepidium spinosum* [Yaniv et al. 1995]
  - *Matthiola incana* [Ecker et al. 1992]
  - *Matthiola livida* [Yaniv et al. 1995]
  - *Nasturtiopsis arabica* (= *coronopifolia*) [Yaniv et al. 1995]
  - *Orychophragmus violaceus* [Wang et al. 1999]
  - *Raphanus* spp. [Yaniv et al. 1995]
  - *Sisymbrium irio* [Yaniv et al. 1995]
- High hydroxy fatty acid:**
- *Lesquerella* and *Physaria* spp. [Schroder-Pontoppidan et al. 1999; Salywon et al. 2005]
- Sterols:**
- 4 wild *Brassica* spp. [Vioque et al. 1990]
  - *Camelina sativa* [unusual sterols] [Shukla et al. 2002]  
  high cholesterol & brassicasterol
  - *Crambe abyssinica* [Lechner et al. 1999]
  - *Lesquerella* spp. [Lechner et al. 1999]

### 4.2 Glucosinolates (Mustard oil glucosides)

Characteristic odours and flavours of crucifers are due to the glucosinolate hydrolysis products. These have long been of toxicological interest [Daxenbichler et al. 1991]), as certain glucosinolates and their degradation products have shown adverse effects on animals. More recently there is an interest in their pharmacological role in the prevention of disease and in their use as insect attractants/repellants and role in chemical defense against pathogens, herbivores, weeds [e.g. Angelini et al. 1998], etc. More than 85 glucosinolates are present in the Family, and many of these are unique to certain species and genera.

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### Surveys of glucosinolates in wild crucifers:

- 51 crucifer spp. [Al-Shehbaz and Al-Shammary 1987]
- 259 crucifer spp. [Daxenbichler et al. 1991]
- 12 crucifer spp. [Mandal et al. 2002]
- 4 crucifer spp. [Sang et al. 1984]
- 9 crucifer spp. [Vaughn and Berhow 2005]
- 85 crucifer spp. [Bennett et al. 2004]
- Family survey: 96 glucosinolates [Fahey et al. 2001]
  
- *Brassica* 4 spp. [Bellostas et al. 2007]
- *Brassica* 14 spp. [Horn and Vaughan 1983]
- *Brassica oleracea* and 9 wild C genome spp. [Mithen et al. 1987a]
- *Brassica* spp.wild [Cole 1997]
- *Brassica* 20 spp. [Velasco and Becker 2000]
- highest *B. montana*, *B. nigra* and *B. oleracea*
- *Cakile* 13 spp. [Rodman 1974, 1976]
- *Camelina sativa* [Schuster and Friedt 1998; Matthäus and Angelini 2005]
  
- *Capsella bursa-pastoris* [Vaughan and Berhow 2005]
- *Coincya* 3 spp. [Agerbirk et al. 2008]
- *Diplotaxis tenuifolia* [Bennett et al. 2007]
- *Diplotaxis* and *Eruca* spp. [D'Antuono et al. 2008]
- *Eruca vesicaria* subsp. *sativa* [Vaughan and Berhow 2005; Bennett et al. 2007]
  
- *Erysimum allionii* [Vaughan and Berhow 2005]
- *Erysimum cheiri* [Vaughan and Berhow 2005]
- *Hesperis matronalis* [Vaughan and Berhow 2005]
- *Kremeriella cordylocarpus* [Agerbirk et al. 2008]
- *Lepidium peruvianum* [Li et al. 2001]
- *Lesquerella fendleri* [Vaughan and Berhow 2005]
- *Lobularia maritima* [Vaughan and Berhow 2005]
- *Matthiola longipetala* [Vaughan and Berhow 2005]
- *Sinapis* spp. [Agerbirk et al. 2008]
- *Zilla* 3 spp. [El-Menshawi et al. 1980]
  
- 4.3 Phenolics**
- 23 taxa in tribe (sinapine) [Bouchereau et al. 1991]
- *Brassica* spp. [Sánchez-Yélamo 2000, 2002]
- *Diplotaxis tenuifolia* [Özeker and Esiyok 1999]
- *Eruca vesicaria* subsp. *sativa* [Özeker and Esiyok 1999]
- *Erucastrum* spp. [Sánchez-Yélamo 2000]
- *Lepidium sativum* [Özeker and Esiyok 1999]

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### 4.4 Secondary Metabolites

- *Erysimum cheiri* - cardenolides [Al-Shehbaz 1984]
- *Iberis amara* - cucurbitacins [Al-Shehbaz 1984]
- *Lesquerella fendleri* - cinnamoyl esters-sunscreen [Compton et al. 2004]
- *Lunaria annua* - alkaloids [Al-Shehbaz 1984]

### Floral Pigments:

- *Cheiranthus cheiri* - acylated cyanidin glucosides [Tatsuzawa et al. 2006]
- *Lobularia maritima* - acylated cyanidin glucosides [Tatsuzawa et al. 2006]
- *Lunaria annua* - acylated cyanidin glucosides [Tatsuzawa et al. 2006]

### 4.5 Anti-pest/Allelopathy

- *Alliaria petiolata* [McCarthy and Hanson 1998; Roberts and Anderson 2001; Aminidehaghi et al. 2006]
- *Armoracia rusticana* [Kotova et al. 1999]
- *Brassica nigra* [Turk and Tawaha 2003]
- *Crambe abyssinica* [Peterson et al. 2000]
- *Descurainia sophia* [Yang and Mu 2006]
- *Diplotaxis erucooides* (anti-microbial compounds) [Peláez et al. 1998]
- *Lepidium perfoliatum* [Aminidehaghi et al. 2006]
- *Nasturtium officinale* (anti-nematode) [Kotova et al. 1999]
- *Sinapis arvensis* (anti-mosquito) [Bowers et al. 1997]
- *Zilla spinosa* (anti-weed and -rhizosphere fungi) [El-Khatib and Abd-Elaah 1998]

### 4.6 Flavonoids

- *Brassica* spp. [Sánchez-Yélamo 2004]
- *Camelina sativa* [Onyilagha et al. 2003]
- *Crambe* spp. [Aguinagalde and Gómez-Campo 1984; Onyilagha et al. 2003]
- *Diplotaxis acris*, *D. harra* [Hussiney et al. 1998]
- *Diplotaxis* 13 spp. [Sánchez-Yélamo 1994]
- *Erucastrum* spp. [Sánchez-Yélamo 2001, 2004]
- *Thlaspi arvense* [Onyilagha et al. 2003]

### 4.7 Peroxidase

- *Armoracia rusticana* [Kushad et al. 1999]

### 4.8 Tocopherols (Vitamin E)

- survey of in 91 crucifer spp [Goffman et al. 1999]
- [range mg kg<sup>-1</sup> oil: 68 in *Diplotaxis viminea* to 2479 in *Schivereckia doerfleri*]

### 4.9 Nectar production

- 9 crucifer spp. [Davis et al. 1998]

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### 4.10 Mucilage

- *Camelina sativa*
- *Lepidium sativum* [Bailey 1935; Mathews et al. 1993]
- *Sinapis alba* [Bailey and Norris 1932; Cui et al. 1993a, b, 1995]

### 4.11 Cyanide

- *Alliaria petiolaris* [Cipollini and Gruner 2007]

## 5. PHOTOSYNTHESIS (All C<sub>3</sub> plants with the following exceptions)

### C<sub>3</sub>-C<sub>4</sub> Intermediate:

- *Moricandia arvensis*, *M. nitens*, *M. sinaica* [Bauwe 1983; Hylton et al. 1988; Razmjoo et al. 1996; Apel et al. 1997; Rylott et al. 1998; Tian and Meng 1998; Meng et al. 1999; Yan et al. 1999]
- *M. spinosa*, *M. suffruticosa* [Hylton et al. 1988].
- *Diplotaxis tenuifolia* [Apel et al. 1996, 1997; Peisker et al. 1998; Bang et al 2003; Ueno et al. 2003]

### High photosynthetic rates :

- *Brassica oxyrrhina*, *B. amplexicaulis*, *Diplotaxis catholica*, *D. viminea*, *Enarthrocarpus lyratus*, *Erucastrum laevigatum*, *Moricandia arvensis*, *Sinapis arvensis*, *Trachystoma ballii* [Uprety et al. 1995]
- *Orychophragmus violaceus* [Wu et al. 2007]

## 6. BREEDING SYSTEMS

### 6.1 Breeding systems:

Insect pollination: the norm >>>> conserved flower architecture of Family

Wind pollination - rare:

- *Pringlea antiscorbutica* [Al-Shehbaz 1984]
- *Hormathophylla spinosa* [Gomez and Zamora 1996]

Apomixis:

- *Arabis* spp. [Roy and Rieseberg 1989; Roy 1995]
- *Arabis gunnisoniana* [Taskin et al. 2004]
- *Arabis holboellii* [Naumova et al. 2001]
- *Boechera* spp. [Schranz et al. 2005, 2006b]

Autogamy (self-fertilization): common in many weedy species

- *Erysimum* (8 spp.) [Nieto 1991]

Cleistogamy (self-fertilization without flower opening)

- *Subularia aquatica* (submersed aquatic) [Al-Shehbaz 1984]
- *Cardamine kokaiensis* [Morinaga et al. 2008]

## Brassicaceae: Wild Crucifer Species as Sources of Traits

### Dioecism (♂ and ♀ plants):

- *Lepidium* (3 spp. New Zealand) [Al-Shehbaz 1984]
- wild *Raphanus sativus* (Japan) [Murayama et al. 2004]

### Gynodioecism :

- *Hirschfeldia incana* [Horovitz and Galil 1972]

### Monoecism (♂ and ♀ flowers on same plant)

- *Megacarpaea megalocarpa* (c Asia) [Al-Shehbaz 1984]

## 6.2 Cytoplasmic male sterility

- *Brassica juncea* [Bhat et al. 2003; Singh et al. 2003; Ito et al. 2004; Sodhi et al. 2006; Wan et al. 2007, 2008]
- *Brassica napus* 'nap and pol' [Brown 1999]
- *Brassica oleracea* 'Ms-cd1' [Wang et al. 2004]
- *Brassica oxyrrhina* 'oxyrrhina' [Prakash and Chopra 1988b; Kanada and Kato 1997]
- *Brassica rapa*, yellow sarson YSMS-6 [Bhajan 2000]
- *Brassica tournefortii* 'tournefortii' [Pradhan et al. 1991; Pahwa et al. 2004]
- *Diplotaxis berthautii* [Malik et al. 1999; Bhat et al. 2008]
- *Diplotaxis catholica* [Mohapatra et al. 1998; Pathania et al. 2003]
- *Diplotaxis erucooides* [Malik et al. 1999]
- *Diplotaxis harra* [Klimaszewska and Keller 1988]
- *Diplotaxis muralis* [Hinata and Konno 1979; Riungu and McVetty 2000, 2003a,b]
- *Diplotaxis siifolia* "siifolia" [Rao et al. 1994; Rao and Shivanna 1996]
- *Enarthrocarpus lyratus* [Banga et al. 2003b; Deol et al. 1999, 2003; Janeja et al. 2003]
- *Eruca vesicaria* subsp. *sativa* [Matsuzawa et al. 1999]
- *Erucastrum canariense* [Prakash et al. 2001; Banga et al. 2003a]
- *Lesquerella fendleri* [Dierig et al. 2001c]
- *Moricandia arvensis* "moricandia" [Kirti et al. 1998; Prakash et al. 1998; Bhat et al. 2005]
- *Raphanus sativus* "ogura" [Ogura 1968; Yamagishi 1998; Zhang et al. 2002; Murayama et al. 2004]
- *Sinapis incana* [Horovitz and Galil 1972]
- *Trachystoma ballii* "trachystoma" [Kirti et al. 1997]

## 6.3 Plant Regeneration/Transformation

- *Alyssum borzaeanum* [Paunescu 2008]
- *Alyssum murale* [Vinterhalter et al. 2008]
- *Arabidopsis halleri* [Dal-Corso et al. 2005]
- *Arabidopsis thaliana* [Gaj 2004]



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- *Brassica carinata* [Verma et al. 2008]
- *Brassica juncea* [Dhawan et al. 2000; Eapen 2007; Dutta et al. 2008; Prem et al. 2008; Wang et al. 2008a]
- *Brassica oleracea* [Munshi et al. 2007; Zhang et al. 2008]
- *Brassica napus* [Huang et al. 1999b ; Ali et al. 2007; Guan et al. 2007a, b ; Ben-Ghnaya et al. 2008; Haddadi et al. 2008; Munir et al. 2008; Verma et al. 2008]
- *Brassica rapa* [Gao et al. 2008]
- *Camelina sativa* [Tattersall and Millam 1999; Lu and Kang 2008]
- *Crambe abyssinica* and *C. hispanica* [Sonntag and Rudloff 2001; Sonntag and Gramenz 2004]
- *Diplotaxis muralis* [Sikdar et al. 1990]
- *Eruca vesicaria* subsp. *sativa* [Sikdar et al. 1987; Zhang et al. 2005]
- *Isatis indigotica* [Hu et al. 1999a; Zhang et al. 2003; Xu et al. 2004]
- *Lesquerella fendleri* [Skarjinskaia et al. 2003; Wang et al. 2008b]
- *Matthiola incana* [Mensuali-Sodi et al. 1994; Siemens et al. 1995]
- *Moricandia arvensis* [Rashid et al. 1996; Craig et al. 1997]
- *Moricandia nitens* [Tian and Meng 1998]
- *Orychophragmus violaceus* [Hu et al. 1999a, b]
- *Rorippa indica* [Mandal and Sikdar 2003]
- *Rorippa nasturtium-aquaticum* [Jin et al. 1999]
- *Sinapis arvensis* [Mithila and Hall 2007]
- *Thlaspi caerulescens* [Guan et al. 2008]
- *Thellungiella halophila* [Li et al. 2007]

## 7. EDAPHIC AND AQUATIC ADAPTATION

### 7.1 Salt tolerance

- *Cakile maritima* [Boyd and Barbour 1986; Megdiche et al. 2007]
  - *Crambe maritima*
  - *Eruca vesicaria* subsp. *sativa* [Ashraf and Noor 1993; Ashraf 1994]
  - *Lesquerella fendleri* [Dierig et al. 2001a, 2004]
  - *Lobularia maritima* [Popova et al. 2008]
  - *Raphanus raphanistrum* ssp. *maritimus*
  - *Thellungiella salsuginea* [= *T. halophila*] [Inan et al. 2004]
- model system

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Tolerance of calcareous (limestone) soils:

*Vella bourgaeana* and *Moricandia moricandioides* (Spain)

### 7.2. Heavy metal (Ar, Cd, Ni, Pb, Se, Sr, Zn) Tolerance and Hyperaccumulation

- 11 genera: 90 species in Family [Palmer et al. 2001; Prasad and Freitas 2003; Ghaderian et al. 2007; Przedpelska and Wierzbicka 2007; Reeves and Adiguzel 2008]
- *Alyssum* [48 spp.], *Thlaspi* [28 spp.]
- *Arabis* [1], *Arabidopsis* [3], *Bornmuellera* [4], *Cardamine* [1],  
*Cochlearia* [1], *Peltaria* [2], *Pseudosempervivum* [2],  
*Stanleya* [1], *Streptanthus* [1]
- *Brassica juncea* accessions [Belimov et al. 2007]
- *Lepidium sativum* [Robinson et al. 2003]
- *Streptanthus* spp. [Boyd et al. 1994; Kruckeberg and Reeves 1995]
- *Thlaspi montanum* [Boyd and Martens 1998]
- *Thlaspi caerulescens* [model system] [Pollard and Baker 1996, 1997; Assunção et al. 2001, 2003; Guan et al. 2008]

### 7.3 Aquatic habitats

- *Nasturtium officinale* or *Rorippa nasturtium-aquaticum* [Al-Shehbaz 1984]
- *Neobeckia aquatica* [Al-Shehbaz 1984]
- *Subularia aquatica* [Al-Shehbaz 1984]
- *Rorippa indica* [Guan et al. 2007b]

### 7.4 Mycorrhiza

- Arbuscular mycorrhiza associations are very limited for the family [Medve 1983]
- Weak facultative mycorrhization occurred in 8 of 36 species surveyed [Medve 1983]
- *Biscutella laevigata* [Orlowska et al. 2002]
- *Brassica campestris* [Joseph and Dube 1988]
- *Brassica napus*, *B. nigra*, *B. oleracea* [Medve 1983]
- *Capsella bursa-pastoris* [Medve 1983]
- *Coronopus didymus* [Kapoor et al. 1996]
- *Capsella bursa-pastoris* [Medve 1983]
- *Lobularia maritima* [Medve 1983]

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- *Lunaria annua* [Medve 1983]
- *Raphanus sativus* [Medve 1983]
- *Rorippa indica* [Medve 1983]
- *Sisymbrium irio* [Kapoor et al. 1996]

## 8. COLD TOLERANCE

**Mountainous habitats** (elevations > 2000-2500 m or above snow line):

- *Brassica nivalis* (Mt. Olympus, Greece)
- *Brassica jordanoffii* (Mt Pirin Planina, Bulgaria)
- *Coincya richeri* (French and Italian Alps - 1750-2500m) [Leadley and Heywood 1990]
- *Erucastrum abyssinicum* and *E. pachypodum*, Ethiopian Highlands (> 3000m) [Al-Shehbaz 1985]
- Several genera in the family, e.g. *Arabis*, *Crucihimalaya*, *Draba*, adapted to alpine areas up to 6000m in Himalayas, Alps, Rockies, Andes [Al-Shehbaz 1984]:
- *Romanschulzia* (Mexico and Central America) and *Oreophyton* (East Africa) adapted to high mountains of the tropics [Al-Shehbaz 1984]:

### Arctic habitats:

- Several genera, e.g. *Draba*, *Eutrema*, *Parrya*
- *Thellungiella salsuginea* "Yukon ecotype" [Wong et al. 2005]

### Sub-antarctic habitat

- *Pringlea antiscorbutica* [Hennion et al. 2006]

### Cold tolerance studies/genes

- *Barbarea vulgaris* [Laroche et al. 1992]
- *Descurainia sophia* [Laroche et al. 1992]
- *Thellungiella salsuginea* [Taji et al. 2004; Gong et al. 2005; Griffith et al 2007]
- *Thlaspi arvense* [Laroche et al. 1992; Sharma et al. 2007; Zhou et al. 2007; see review Warwick et al. 2002]

## 9. DROUGHT TOLERANCE

- *Brassica carinata* [Mishra et al. 1999]
- *Brassica juncea* [Mishra et al. 1999]
- *Brassica tournefortii* [Salisbury 1989; Prakash and Bhat 2007]
- *Carrichtera annua* [Boaz et al. 1990]

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- <i>Diplotaxis acris</i>	[Boaz et al. 1990; Prakash and Bhat 2007]
- <i>Diplotaxis harra</i>	[Boaz et al. 1990; Prakash and Bhat 2007]
- <i>Enarthrocarpus strangulatus</i>	[Boaz et al. 1990]
- <i>Eruca vesicaria</i> subsp. <i>sativa</i>	[Sun et al. 1991, 1999; Prakash and Bhat 2007]
- <i>Erucaria boveana</i>	[Boaz et al. 1990]
- <i>Erucaria microcarpa</i> and <i>E. uncata</i>	[Boaz et al. 1990]
- <i>Foleyola billotii</i>	[see Guide: Warwick et al. 2000]
- <i>Fortuynia</i> spp.	[see Guide: Warwick et al. 2000]
- <i>Lesquerella</i> spp.	[Rollins 1993; Ravetta and Soriano 1998; Ploschuk et al. 2001; Prakash and Bhat 2007]
- <i>Moricandia</i> spp.	[McVetty et al. 1989]
- <i>Physorhynchus</i> spp.	[see Guide: Warwick et al. 2000]
- <i>Pseuderucaria clavata</i>	[Boaz et al. 1990]
- <i>Savignya parviflora</i>	[Boaz et al. 1990]
- <i>Schouwia purpurea</i>	[Boaz et al. 1990]
- <i>Thellungiella salsuginea</i> 'model spp. '	[Wong et al. 2005]
- <i>Zilla spinosa</i>	[see Guide: Warwick et al. 2000]

## 10. HERBICIDE RESISTANCE (Note: country and date when first reported indicated below)

### 10.1 Acetolactate synthase (ALS) inhibitors [Group 2 herbicides]

- <i>Arabidopsis thaliana</i> (IMIs)	--	--	[Roux et al. 2005a , 2005b]
- <i>Brassica tournefortii</i> (SUs)	Australia	1992	[Adkins et al. 1997; Boutsalis et al. 1999; Heap 2009]
- <i>Camelina microcarpa</i> (SUs)	USA-Oregon	1999	[Hanson et al. 2004]
- <i>Descurainia sophia</i> (tribenuron-methyl)	China	2005	[Heap 2009]
- <i>Diplotaxis tenuifolia</i> (SUs)	Australia	2004	[Heap 2009]
- <i>Neslia paniculata</i> (SUs)	Canada-AB	1998	[Heap 2009]
- <i>Raphanus raphanistrum</i> (SUs)	Australia	1997	[Hashem et al. 2001; Walsh et al. 2001) Tan and Medd 2002]
- <i>Raphanus raphanistrum</i> (SUs+IMI)	Australia	2002	[Hashem and Dhammu 2002; Yu et al. 2003]

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- <i>Raphanus raphanistrum</i> (SUs)	South Africa	1997	[Smit and Cairns 2001]
- <i>Raphanus sativus</i> (SUs+IMI)	Brazil	2001	[Heap 2009]
- <i>Rapistrum rugosum</i> (SUs)	Australia	1996	[Adkins et al. 1997]
- <i>Sinapis arvensis</i> (SUs)	Australia	1996	[Heap 2009]
- <i>Sinapis arvensis</i> (SUs)	Canada-MB	1992	[Morrison and Devine 1994; Heap 2009; Warwick et al. 2005]
- <i>Sinapis arvensis</i> (SUs)	Canada-AB	1993	[Jeffers et al. 1996; Veldhuis et al. 2000; Warwick et al. 2005]
- <i>Sinapis arvensis</i> (Sus+IMI)	Canada-SK	2002	[Warwick et al. 2005; Heap 2009]
- <i>Sinapis arvensis</i> (Sus)	Turkey	2001	[Heap 2009]
- <i>Sinapis arvensis</i> (SUs)	USA -N.Dakota	1999	[Christoffers et al. 2006]
- <i>Sisymbrium orientale</i> (SUs)	Australia	1995	[Boutsalis and Powles 1995; Adkins et al. 1997; Boutsalis et al. 1999]
- <i>Sisymbrium thellungii</i> (SUs)	Australia	1996	[Adkins et al. 1997]
- <i>Thlaspi arvensis</i> (IMI)	Canada-AB	2001	[Heap 2009; Beckie et al. 2007]

### 10.2 Synthetic auxins [Group 4 herbicides]

- <i>Sinapis arvensis</i> (dicamba/2,4D)	Canada-MB	1990	[Heap and Morrison 1992; Jasieniuk et al. 1995; Warwick et al. 2000; Zheng and Hall 2001; Yajima et al. 2004; Jugulam et al. 2005; Mithila and Hall 2007]
- <i>Sisymbrium orientale</i> (ALS+2,4,D)	Australia	2005	[Heap 2009]

### 10.3 Photosystem II inhibitors [Group 5 herbicides] -Triazines:

- <i>Brassica rapa</i> (atrazine)	Canada-QB	1978	[Maltais and Bouchard 1978; Warwick 1991; Warwick and Black 1993; Plowman and Richards 1997; Plowman et al. 1999; Heap 2009]
- <i>Capsella bursa-pastoris</i> (simazine)	Poland	1984	[Lipecki 1988; Stanek and Lipecki 1991; Heap 2009]
- <i>Raphanus raphanistrum</i>	Australia	1999	[Walsh et al. 2004, 2007; Friesen and Powles 2007; Heap 2009]
- <i>Sinapis arvensis</i> (triazine)	Canada-ON	1983	[Ali et al. 1986; Heap 2009]
- <i>Sinapis arvensis</i> (metribuzin)	Canada-MB	1994	[Heap 2009]

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### 10.4 Bipyrilidiums, photosystem I-electron diversion [Group 22 herbicides]

- *Lepidium virginicum* (paraquat) Canada-ON 1993 [Smisek et al. 1998; Heap 2009]

### 10.5 Multiple herbicide resistance

- *Raphanus raphanistrum* Australia 2004 [Walsh et al. 2004]
- *Sisymbrium orientale* (ALS+2,4,D) Australia 2005 [Heap 2009]

## 11. DISEASE RESISTANCE

### 11.1 White rust - *Albugo candida*

- *Brassica carinata*, *B. rapa*, *B. juncea*, *B. nigra* [Liu and Rimmer 1991; Gulati et al. 1991; Kolte et al. 1991]
- *Brassica maurorum* [Chrungu et al. 1999]
- *Eruca vesicaria* subsp. *sativa* [Bansal et al. 1997]
- *Raphanus sativus* [Williams and Pound 1963; Kolte et al. 1991]

### 11.2 Black leaf spot/ *Alternaria* spp. - *Alternaria brassicae*, *A. brassicicola*, *A. raphani*

- *Alliaria petiolata*, *Barbarea vulgaris*, *Brassica nigra* [Westman and Dickson 1998]
- *Brassica coenospecies* [Sharma et al. 2002]
- *Brassica elongata* [Siemens 2002]
- *Brassica fruticulosa* [Siemens 2002]
- *Brassica maurorum* [Chrungu et al. 1999]
- *Brassica nigra* [Westman and Dickson 1998; Westman et al. 1999]
- *Brassica souliei* [Siemens 2002]
- *Brassica spinescens* [Agnihotri et al. 1991]
- *Camelina sativa* [Conn et al. 1988, reviewed in Tewari 1991; Westman and Dickson 1998; Sigareva and Earle 1999; Westman et al. 1999; Siemens 2002; Pedras et al. 2003b; Pedras and Adio 2008]
- *Capsella bursa-pastoris* [Conn et al. 1988, reviewed in Tewari 1991; Westman and Dickson 1998; Siemens 2002; Pedras et al. 2003b]

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- *Coincya* spp. [Prakash and Bhat 2007]
- *Diplotaxis catholica* [Prakash and Bhat 2007]
- *Diplotaxis eruroides*, *D. tenuifolia* [Siemens 2002; Klewer et al. 2003]
- *Eruca vesicaria* subsp. *sativa*: [Conn and Tewari 1986; Tewari 1991]
- *Hemicrambe fruticulosa* [Siemens 2002]
- *Hesperis matronalis* [Siemens 2002]
- *Neslia paniculata* [Siemens 2002; Francis and Warwick 2003]
- *Raphanus sativus* [Siemens 2002]
- *Sinapis alba* [Brun et al. 1987; Sharma and Singh 1992; Sigareva et al. 2000; Siemens 2002; Pedras et al. 2003b]
- *Sinapis avensis* [Siemens 2002]

### 11.3 Blackleg - *Leptosphaeria maculans* [= *Phoma lingam*]

- *Arabidopsis thaliana* [Brun and Tribodet 1995; Chen and Séguin-Swartz 1997, 1999]
- *Brassica carinata*, *B. juncea*, *B. nigra* [Rimmer and van den Berg 1992]
- *Brassica elongata*, *B. fruticulosa* [Siemens 2002]
- *Brassica insularis*, *B. atlantica*, *B. macrocarpa* [Mithen et al. 1987b; Mithen and Herron 1991; Mithen and Magrath 1992]
- *Camelina sativa* [Siemens 2002; Li et al. 2005]
- *Carrichtera*, *Diplotaxis*, *Hirschfeldia*, *Raphanus*, *Rapistrum* and *Sinapis* weedy species in Australia [Salisbury 1987]
- *Coincya monensis* [Siemens 2002; Winter et al. 1999, 2002, 2003]
- *Diplotaxis muralis*, *D. tenuifolia* [Chen and Séguin-Swartz 1997, 1999]
- *Eruca vesicaria* and *E. pinnatifida* [Tewari et al. 1996; Siemens 2002]
- *Hirschfeldia incana* [Siemens 2002]
- *Raphanus raphanistrum* [Chen and Séguin-Swartz 1999]
- *Raphanus sativus* [Siemens 2002]
- *Sinapis alba* [Gugel and Séguin-Swartz 1997]
- *Sinapis avensis* [Siemens 2002; Winter et al. 1999, 2002, 2003]
- *Sisymbrium loeselii* [Chen and Séguin-Swartz 1997, 1999]

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- *Thlaspi arvense* [Pedras et al. 2003a]

### 11.4 Downy mildew - *Peronospora parasitica*

- *Brassica oleracea*, wild accessions [Greenhalgh and Mitchell 1976]

- *Eruca vesicaria* [Singh and Kolte 1999]

### 11.5 Clubroot - *Plasmodiophora brassicae*

- *Arabidopsis thaliana* [Rehn et al. 2004]

- *A Armoracia rusticana* [Prakash and Bhat 2007]

- *Brassica rapa* [Suwabe et al. 2004]

- *Capsella bursa-pastoris* [Siemens 2002]

- *Raphanus spp.* [Crute et al. 1980; Long et al. 1992]

### 11.6 Sclerotinia stem rot - *Sclerotinia sclerotiorum*

- *Capsella bursa-pastoris* [Chen et al. 2007]

- *Eruca vesicaria* subsp. *sativa* [Guan et al. 2004]

- *Erucastrum gallicum* [Lefol et al. 1996, 1997; Gugel et al. 1997]

### 11.7 Turnip mosaic virus

- *Alliaria petiolata*, *Hesperis matronalis* [Stobbs and Stirling 1990]

- *Sinapis alba*, *S. arvensis* [Mamula et al. 1997]

### 11.8 Wilt disease –

#### *Verticillium dahliae*

- *A Armoracia rusticana* [Atibalentja and Eastburn 1998]

#### *Verticillium longisporum*

- *Brassica napus* [Rygulla et al. 2007b]

- *Brassica oleracea*, *B. rapa* [Rygulla et al. 2007a]

### 11.9 Black rot - *Xanthomonas campestris*

- *Alliaria petiolata*, *Barbarea vulgaris*, *Brassica juncea*,



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- B. nigra*, *Erysimum hieraciifolium*, *Matthiola incana* [Westman and Dickson 1998]
- *Brassica carinata* [Griffiths and Nickels 2001]
- *Brassica nigra* [Marthe et al. 2004]
- *Brassica rapa* [Ignatov et al. 1999]
- *Brassica* crop spp. [Vicente et al. 2000]

### 11.10 Peppery leaf spot - *Pseudomonas syringae*

- *Brassica juncea* [Wechter et al. 2007]

### 11.12 Defensin genes

- *Lepidium meyenii* against *Phytophthora infestans* [Soltis et al. 2007]

## 12. INSECT RESISTANCE

### 12.1 Flea beetles [*Phyllotreta cruciferae* and *P. striolata*]

- *Arabidopsis thaliana* [Prakash and Bhat 2007]
- *Brassica incana* [Bodnaryk (pers. comm.), in Warwick et al. 2000]
- *Brassica juncea* [Bodnaryk 1997]
- *Brassica villosa* [Bodnaryk (pers. comm.), in Warwick et al. 2000]
- *Camelina sativa* [Pachagounder et al. 1998; Soroka et al. 2003; Henderson et al. 2004]
- *Capsella bursa-pastoris* [Prakash and Bhat 2007]
- *Crambe abyssinica* [Anderson et al. 1992; Soroka et al. 2003; Henderson et al. 2004]
- *Crambe hispanica*, *C. glabrata* [Soroka et al. 2003]
- *Sinapis alba* [Lamb 1980; Bodnaryk and Lamb 1991; Bodnaryk 1997; Gavloski et al. 2000; Henderson et al. 2004]
- *Thlaspi arvense* [Gavloski et al. 2000]

### *Phyllotreta nemorum*, a Europe flea beetle

- *Barbarea vulgaris* [Renwick 2002]

### *Meligethes aeneus* - Pollen beetle

- *Barbarea verna* [Börjesdotter 1999]

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### 12.2 Lepidopterous pests:

#### Diamond-back moth (*Plutella xylostella*)

- *Barbarea vulgaris* [Renwick 2002; Lu et al. 2004; Badenes-Perez et al. 2005]
- *Brassica juncea* [Ruwandi and Gillott 1998]
- *Brassica oleracea* [Stoner 1990; Ramachandran et al. 1998 ; Sarfraz et al. 2007]
- *Brassica napus* [Ramachandran et al. 1998; Sarfraz et al. 2007]
- *Crambe abyssinica* [Kmec et al. 1998]
- *Raphanus raphanistrum* [Lehtila and Strauss 1999]

#### Cabbage butterfly - *Pieris* spp.

##### *Pieris rapae*

- *Erysimum cheiranthoides* (cardenolides) [Renwick 2002]
- *Iberis amara* (cucurbitacin glycosides) [Renwick 2002]

##### *Pieris napi oleracea*

- *Alliaria petiolata* [Renwick 2002]  
(flavone glycoside/unique butenenitrile glycoside)
- *Barbarea vulgaris* [Renwick 2002]

### 12.3 Aphids

#### Cabbage aphid - *Brevicoryne brassicae*

- *Brassica fruticulosa*, *B. spinescens* [Cole 1994; Ellis and Farrell 1995; Singh et al. 1994]
- *Brassica* wild C genome: [Kift et al. 2000]  
*B. cretica*, *B. incana*, *B. macrocarpa*, *B. villosa*
- *Eruca vesicaria* subsp. *sativa* [Singh et al. 1994]
- *Sinapis alba* [Thompson 1963]

#### Mustard aphid - *Lipaphis erysimi* (Kalt.)

- *Brassica carinata*, *B. nigra*, *B. juncea* [Rana et al. 1995; Lal et al. 1997; Chander and Bakhetia 1998]
- *Brassica* spp. [Amjad and Peters 1992]
- *Eruca vesicaria* subsp. *sativa* [Rana et al. 1995; Chander and Bakhetia 1998]

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### 12.4 Cabbage white fly - *Aleyrodes proletella*

- *Brassica cretica*, *B. fruticulosa*, *B. incana*, [Ramsey and Ellis 1994]  
*B. insularis*, *B. spinosa*, *B. villosa*

### 12.5 Cabbage root fly or Cabbage maggot - *Delia radicum*

- *Brassica fruticulosa*, *B. incana*, *B. macrocarpa*, [Ellis et al. 1999]  
*B. spinescens*, *B. villosa*
- *Camelina sativa* [Soroka et al. 2003]
- *Sinapis alba* [Jyoti et al. 2001]

### 12.6 Cabbage seedpod weevil - *Ceutorhynchus obstrictus* (Marsham) (= *C. assimilis* Payk.) (Coleoptera)

- *B. juncea*, *B. nigra*, *B. tournefortii*, *Sinapis alba* [Ulmer and Dosdall 2006; Carcamo et al. 2007]

### 12.7 Mustard sawfly - *Athalia proxima* (Hymenoptera)

- *Camelina sativa* [Singh and Sachan 1997]

## 13. NEMATODE RESISTANCE

### 13.1 Beet cyst nematode - *Heterodera schachtii*

- *Raphanus sativus* [Thierfelder et al. 1991; Lelivelt and Krens 1992; Voss et al. 2000]
- *Sinapis alba* [Thierfelder et al. 1991; Lelivelt et al. 1993]

### 13.2 Root-knot nematode (*Meloidogyne* spp.)

- *Eruca sativa* [Curto et al. 2005]
- *Raphanus sativus* [Buente et al. 1997; Curto et al. 2005; Pattison et al. 2006]
- *Rapistrum rugosum* [Curto et al. 2005]
- *Sinapis alba* [Pattison et al. 2006]

## 14. CROP DIVERSIFICATION [Specht and Diederichsen 2001]

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### 14.1 Source for forage, fodder, green manure, cover crops

- *Brassica* spp. (cover crop for saline soils) [Mitchell et al. 1999; Mihailović et al. 2008]
- *Brassicoraphanus* (raparadish) [Lange et al. 1989]
- *Eruca sativa* (cover crop) [Liébanas and Castillo 2004]
- *Moricandia moricandioides* (cover crop) [Liébanas and Castillo 2004]
- *Orychophragmus violaceus* (Chinese fodder crop) [Luo et al. 1998b]
- *Raphanus sativus* (oilseed radish)
- *Raphanus sativus* “var. *raphanistroides*” (soil reclamation) [Wang et al. 1999]
- *Sinapis alba* [Mihailović et al. 2008; Mikić et al. 2009]

### 14.2 Biocidal Use/Biofumigant

- *Brassica* spp. [Bellostas et al. 2007; Larkin and Griffin 2007]
- *Crambe abyssinica* meal insecticide [[Mohiuddin et al. 1990; Peterson et al. 2000]

### 14.3 Specialty oils/value added molecular farming host system

- *Armoracia rusticana* (horseradish)
- *Camelina sativa* – industrial oil [Plessers et al. 1962; Hebard 1998; Leonard 1998; Putnam et al. 1993; Angelini et al. 1997; Zubr 1997; Mueller et al. 1999; Matthäus and Zubr 2000; Zubr and Matthäus 2002; Matthäus and Angelini 2005; Gehringer et al. 2006; Gugel and Falk 2006]
- *Crambe abyssinica* - industrial oil [Erickson and Bassin 1990; Kmec et al. 1998; Lechner et al. 1999; Warwick and Gugel 2003]
- *Crambe abyssinica* - value-added protein source [Massoura et al. 1996]
- *Crambe hispanica* - industrial oil [Mulder and Mastebroek 1996]
- *Descurainia sophia* - linolenic acid [Luo et al. 1999; Guan et al. 2007a]
- *Eruca vesicaria* subsp. *sativa* - industrial oil [Sun et al. 1991; Yaniv et al. 1998; Warwick et al. 2007]

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- *Lepidium sativum* - linolenic acid [Angelini et al. 1997]
- *Lesquerella fenderli* - hydroxy fatty acids [Angelini et al. 1997]
- *Lesquerella mendocina* -potential new oil crop [Ravetta and Soriano 1998]
- *Lesquerella spp.* - industrial oil [Dierig et al. 1998, 2001b, 2004, 2006; Dierig et al. 2004; Lechner et al. 1999; Salywon et al. 2005; Ploschuk et al. 2005]
  
- *Lesquerella grandiflora* - industrial oil [Marvin et al. 2000]
- *Lunaria annua* - industrial oil, nervonic acid [Cromack 1998; Marvin et al. 2000; Mastebroek and Marvin 2000; Walker et al. 2003]
  
- *Malcolmia crenulata, Matthiola livida, Sinapis alba, Sisymbrium irio, Lepidium spinosum* - industrial oil [Yaniv et al. 1995]
- *Matthiola incana* - potential new oil crop, acid omega-3-linolenic [Ecker et al. 1992]
- *Orychophragmus violaceus* - industrial oil [Yaniv et al. 1997]
- *Orychophragmus violaceus* - industrial oil [Luo et al. 1994; Li et al. 1995; Huang et al. 1999a; Wang et al. 1999]
- *Raphanus sativus* (oilseed radish) [Li et al. 1995]
- *Thlaspi arvense* – biofuel crop [Anonymous 2009]

## Protein crops/Seed meal

- *Brassica carinata* [Warwick et al. 2006b]
- *Crambe abyssinica* [Carlson and Tookey 1983]
- *Eruca sativa* [Fagbenro 2004]
- *Lesquerella fendleri* [Wu and Hojilla-Evangelista 2005]

## Medicinal, Functional Food Health Properties

- *Lepidium sativum* [Mathews et al. 1993; Gokavi et al. 2004]

## 14.4 Condiments

- *Armoracia rusticana* - horseradish
- *Brassica juncea* - Indian mustard

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- *Brassica nigra* - black Indian mustard
- *Eutrema wasabi* - wasabi
- *Sinapis alba* - white mustard

### 14.5 Vegetables

- *Brassica fruticulosa* - shoots and leaves [Branca et al. 1994; Branca 1995; Branca and lapichino 1997]
- *Brassica juncea* - mustard greens
- *Brassica napus* – rutabaga
- *Brassica nigra* - leaves, shoots [Branca 1995; Branca and lapichino 1997]
- *Brassica oleracea* - cole crops [Farnham et al. 2008]
- *Brassica rapa* - turnip, mustard greens, Chinese cabbage, etc.
- *Cakile maritima* - leaves [Branca and lapichino 1997; Guil-Guerrero et al. 1999]
- *Diplotaxis* spp. - rocket [Branca et al. 1994; Branca 1995; Branca and lapichino 1997]
- *Eruca vesicaria* subsp. *sativa* - arugula or rocket [Branca and lapichino 1997; Yaniv et al. 1998; Yadav 2002; Misra et al. 2003]
- *Lepidium sativum* - cress [Branca and lapichino 1997; Özeke and Esiyok 1999]
- *Nasturtium officinale* - water cress
- *Orychophragmus violaceus* - flower stalks (China) [Luo et al. 1998a]
- *Raphanus raphanistrum* – leaves, flowers, roots [Branca and lapichino 1997]
- *Raphanus sativus* - radish
- *Sinapis* spp. - shoots and leaves [Branca et al. 1994; Branca 1995; Branca and lapichino 1997]

### 14.6 Ornamentals

- *Alyssum* spp. - madwort
- *Arabis* spp. - rock cress
- *Aubrieta deltoidea* - purple rock cress
- *Aurinia saxatilis* - golden tuft

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- *Brassica oleracea* - ornamental cabbage
- *Draba* spp. - whitlow grass
- *Erysimum cheiri* - wallflower
- *Hesperis matronalis* - dame's rocket
- *Iberis* spp. - candytuft
- *Isatis tinctoria* - woad
- *Lobularia maritima* - sweet alyssum -(\*most widely cultivated)
- *Lunaria annua* - honesty or money plant
- *Matthiola incana* - stock
- *Orychophragmus violaceus* - ornamental China
- *Vella* spp. - garden shrubs or hedges

### **14.7 Phytoremediation [See Section 7.2] [Palmer et al. 2001; Prasad and Freitas 2003]**

## Brassicaceae: Wild Crucifer Species as Sources of Traits

### References to Brassicaceae: Wild Crucifer Species as Sources of Agronomic Traits

- Adhami, F., Müller, S. and Hauser, M-T 1999. Nonradioactive labeling of large DNA fragments for Genome Walking, RFLP and Northern Blot analysis. *BioTechniques* 27: 314-320.
- Adkins, S.W., Wills, D., Boersma, M., Walker, S.R., Robinson, G., McLeod, R.J. and Einam, J.P. 1997. Weeds resistant to chlorsulfuron and atrazine from the north-east grain region of Australia. *Weed Res.* 37: 343-349.
- Agerbirk, N., Warwick, S.I., Hansen, P.R. and C.E. Olsen, C.E. 2008. *Sinapis* phylogeny and evolution of glucosinolates and specific nitrile degrading enzymes. *Phytochemistry* 69: 2937-2949.
- Agnihotri, A., Shivanni, K.R., Lakshmikumaran, M.S. and Jagannathan, V. 1991. Micropropagation and DNA analysis of wide hybrids of cultivated *Brassica*. Proc. GCIRC 8<sup>th</sup> Rapeseed Congr. , Abstr. pp: 151.
- Aguinagalde, I. and Gómez-Campo, C. 1984. The phylogenetic significance of flavonoids in *Crambe* (Cruciferae). *Bot. J. Linn. Soc.* 89: 277-288.
- Ahuja I., Malik, C.P., Raheja, R.K. and Bhatia, D.S. 1998. Physiological and biochemical changes in fruit development of *Brassica oxyrrhina* and *Brassica tournefortii*. *Phytomorphology* 48: 399-404.
- Ali, A., McLaren, R.D. and Souza-Machado, V. 1986. Chloroplastic resistance to triazine herbicides in *Sinapis arvensis* (wild mustard). *Weed Res.* 26: 39-44.
- Ali, H., Ali, Z., Ali, H., Mehmood, S. and Ali, W. 2007. In vitro regeneration of *Brassica napus* L., cultivars (Star, Cyclone and Westar) from hypocotyls and cotyledonary leaves. *Pakistan J. Bot.* 39: 1251-1256.
- Al-Shehbaz, I.A. 1984. The tribes of Cruciferae (Brassicaceae) in the southeastern United States. *J. Arnold Arbor.* 65: 343-373.
- Al-Shehbaz, I.A. 1985. The genera of Brassiceae (Cruciferae: Brassiceae) in the southwestern United States. *J. Arnold Arbor.* 66: 279-351.
- Al-Shehbaz, I.A. and Al-Shammary, K.I. 1987. Distribution and chemotaxonomic significance of glucosinolates in certain Middle-Eastern Cruciferae. *Biochem. System. Ecol.* 15: 559-569.
- Aminidehaghi, M., Rezaeinodehi, A. and Khangholi, S. 2006. Allelopathic potential of *Alliaria petiolata* and *Lepidium perfoliatum*, two weeds of the Cruciferae family. *J. Plant Dis. Prot. Special Issue* 20: 455-462.
- Amjad, M. and Peters, D.C. 1992. Survival, development, and reproduction of turnip aphids (Homoptera: Aphididae) on oilseed brassica. *J. Econ. Entomol.* 85: 2003-2007.
- Anderson, M.D., Peng, C. and Weiss, M.J. 1992. *Crambe*, *Crambe abyssinica* Hochst., as a flea beetle resistant crop (Coleoptera: Chrysomelidae). *J. Econ. Entomol.* 85: 594-600.
- Angelini, L., Lazzeri, L., Galletti, S., Cozzani, A., Macchia, M. and Palmieri, S. 1998. Antigerminative activity of three glucosinolate-derived products generated by myrosinase hydrolysis. *Seed Sci. Technol.* 26: 771-780.
- Angelini, L.G., Moscheni, E., Colonna, G., Belloni, P. and Bonari, E. 1997. Variation in agronomic characteristics and seed oil composition of new oilseed crops in central Italy. *Industr. Crops Prod.* 6: 313-323.



### Brassicaceae: Wild Crucifer Species as Sources of Traits

- Anonymous. 2009. Stinkweed in your fuel tank? Maybe some day. Associated Press. Sept 5, 2008  
<http://www.msnbc.msn.com/id/26547441>
- Apel, P., Hillmer, S., Pfeffer, M. and Muhle, K. 1996. Carbon metabolism type of *Diplotaxis tenuifolia* (L.) DC. (Brassicaceae). *Photosynthetica* (Prague) 32: 237-243.
- Apel, P., Horstmann, C. and Pfeffer, M. 1997. The *Moricandia* syndrome in species of the Brassicaceae - evolutionary aspects. *Photosynthetica* (Prague) 33: 205-215.
- Arnason, T., Hebda, R.J. and Johns, T. 1981. Use of plants for food and medicine by Native Peoples of eastern Canada. *Can. J. Bot.* 59: 2189-2325.
- Arumuganathan, K. and Earle, E.D. 1991. Nuclear DNA content of some important plant species. *Plant Mol. Biol. Rep.* 9: 208-218.
- Ashraf, M. 1994. Organic substances responsible for salt tolerance in *Eruca sativa*. *Biol. Plant.* (Prague) 36: 255-259.
- Ashraf, M. and Noor, R. 1993. Growth and pattern of ion uptake in *Eruca sativa* Mill. under salt stress. *Angew. Bot.* 67: 17-21.
- Assunção, A.G.L., Da Costa Martins, P., De Folter, S., Vooijs, R., Schat, H. and Aarts, M.G.M. 2001. Elevated expression of metal transporter genes in three accessions of the metal hyperaccumulator *Thlaspi caerulescens*. *Plant Cell Environ.* 24: 217-226.
- Assunção, A.G.L., Schat, H. and Aarts, M.G.M. 2003. *Thlaspi caerulescens*, an attractive model species to study heavy metal hyperaccumulation in plants. *New Phytol.* 159: 351-360.
- Atibalentja, N. and Eastburn, D.M. 1998. *Verticillium dahliae* resistance in horseradish germplasm from the University of Illinois collection. *Plant Dis.* 82: 176-180.
- Badenes-Perez, F.R., Shelton, A.M. and Nault, B.A. 2005. Using yellow rocket as a trap crop for diamondback moth (Lepidoptera: Plutellidae). *J. Econ. Entomol.* 98: 884-890.
- Bailey, K. 1935. Cress seed mucilage. *Biochem. J.* 29: 2477-2485.
- Bailey, K. and Norris, F.W. 1932. The nature and composition of the mucilage of the seed of white mustard (*Brassica alba*). *Biochem. J.* 26: 1609-1623.
- Bang, S.W., Mizuno, Y., Kaneko, Y., Matsuzawa, Y., Bang, K.S. 2003. Production of intergeneric hybrids between the C3-C4 intermediate species *Diplotaxis tenuifolia* (L.) DC. and *Raphanus sativus* L. *Breed. Sci.* 53: 231-236.
- Banga, S.S., Banga, S.K., Bhaskar, P.B., Ahuja, I. and Payal, B. 2003a. Alloplasmic line of *Brassica napus* L. with *Erucastrum canariense* cytoplasm is male sterile. *Proc. GCIRC 11th Int. Rapeseed Congr.* 1: 324-325.
- Banga, S.S., Deol, J.S. and Banga, S.K. 2003b. Alloplasmic male-sterile *Brassica juncea* with *Enarthrocarpus lyratus* cytoplasm and the introgression of gene(s) for fertility restoration from cytoplasm donor species. *Theor. Appl. Genet.* 106: 1390-1395.
- Bangle, D.N., Walker, L.R. and Powell, E.A. 2008. Seed germination of the invasive plant *Brassica tournefortii* (Sahara mustard) in the Mojave desert. *Western North Am. Naturalist* 68: 334-342.

### Brassicaceae: Wild Crucifer Species as Sources of Traits

- Bansal, V.K., Tewari, J.P., Tewari, I., Gómez-Campo, C. and Stringam, G.R. 1997. Genus *Eruca*: a potential source of white rust resistance in cultivated brassicas. *Plant Genet. Resour. Newsl.* 109: 25-26.
- Bauwe, H. 1983. Comparative phylogenetic age of C<sub>3</sub>-C<sub>4</sub> intermediate species of *Moricandia* determined by isoelectric focusing and amino acid composition of small subunit of ribulose 1,5-bisphosphate carboxylase/oxygenase. *Photosynthetica* 17: 442-449.
- Beckie, H.J., Hall, L.M., Tardif, F.J. and Seguin-Swartz, G. 2007. Acetolactate synthase inhibitor-resistant stinkweed (*Thlaspi arvense* L.) in Alberta. *Can. J. Plant Sci.* 87: 965-972.
- Belimov, A.A., Safronova, V.I., Demchinskaya, S.V. and Dzyuba, O.O. 2007. Intraspecific variability of cadmium tolerance in hydroponically grown Indian mustard (*Brassica juncea* (L.) Czern.) seedlings. *Acta Physiol. Plant.* 29: 473-478.
- Bellostas, N., Sorensen, J.C. and Sorensen, H. 2007. Profiling glucosinolates in vegetative and reproductive tissues of four *Brassica* species of the U-Triangle for their fumigation potential. *J. Sci. Food Agric.* 87: 1586-1594.
- Ben-Ghnaya, A., Charles, G., and Branchard, M. 2008. Rapid shoot regeneration from thin cell layer explants excised from petioles and hypocotyls in four cultivars of *Brassica napus* L. *Plant Cell Tissue Organ Cult.* 92: 25-30.
- Bennett, M.D. and Leitch I.J. 2004. Angiosperm DNA C-values database (release 5.0, Dec. 2004). <http://www.rbgekew.org.uk/cval/database1.html>
- Bennett, R.N., Carvalho, R., Mellon, F.A., Eagles, J. and Rosa, E.A.S. 2007. Identification and quantification of glucosinolates in sprouts derived from seeds of wild *Eruca sativa* L. (salad rocket) and *Diplotaxis tenuifolia* L. (wild rocket) from diverse geographical locations. *J. Agric. Food Chem.* 55: 67-74.
- Bennett, R.N., Mellon, F.A. and Kroon, P.A. 2004. Screening crucifer seeds as sources of specific intact glucosinolates using ion-pair high-performance liquid chromatography negative ion electrospray mass spectrometry. *J. Agric. Food Chem.* 52: 428-438.
- Bett, K.E. and Lydiate, D.J. 2003. Genetic analysis and genome mapping in *Raphanus*. *Genome* 46: 423-430. 3
- Bhajan, R. 2000. Development of YSMS-6, a genetic male sterile line of yellow sarson (*Brassica campestris* var yellow sarson Prain). *Cruciferae Newsl. Eucarpia* 22: 29-30.
- Bhat, S.R., Pathania, A., Gaikwad, K., Dinesh Kumar, V., Prakash, S., Kirti, P.B. and Chopra, V.L. 2003. Molecular analyses of cytoplasmic male sterility systems of *Brassica juncea*. *Proc. GCIRC 11<sup>th</sup> Int. Rapeseed Congr.* 2: 504-506.
- Bhat, S.R., Prakash, S., Kirti, P.B., Kumar, V.D. and Chopra, V.L. 2005. A unique introgression from *Moricandia arvensis* confers male fertility upon two different cytoplasmic male-sterile lines of *Brassica juncea*. *Plant Breed.* 124: 117-120.
- Bhat, S.R., Kumar, P. and Prakash, S. 2008. An improved cytoplasmic male sterile (*Diplotaxis berthautii*) *Brassica juncea*: identification of restorer and molecular characterization. *Euphytica* 159: 145-152.

### **Brassicaceae: Wild Crucifer Species as Sources of Traits**

- Boaz, M, Plitmann, U. and Heyn, C.C. 1990. The ecogeographic distribution of breeding systems in the Cruciferae (Brassicaceae) of Israel. *Isr. J. Bot.* 39: 31-42.
- Bodnaryk, R.P. 1997. Will low-glucosinolate cultivars of the mustards *Brassica juncea* and *Sinapis alba* be vulnerable to insect pests? *Can. J. Plant Sci.* 77: 283-287.
- Bodnaryk R.P. and Lamb, R.J. 1991. Mechanisms of resistance to the flea beetle, *Phyllotreta cruciferae* (Goeze), in yellow mustard seedlings, *Sinapis alba* L. *Can. J. Plant Sci.* 71: 13-20.
- Boivin, K., Acarkan, A., Mbulu, R.-S., Clarenz, O and Schmidt, R. 2004. The *Arabidopsis* genome sequence as a tool for genome analysis in *Brassicaceae*. A comparison of the *Arabidopsis* and *Capsella rubella* genomes. *Plant Physiol.* 135: 735-744.
- Börjesdotter, D. 1999. Host plant acceptance by the pollen beetle (*Meligethes aeneus*) of a wild Brassicaceae species: *Barbarea verna*. Proc. GCIRC 10th Int. Rapeseed Congr., Contribution 243 on CD ROM; also available at <http://www.regional.org.au/au/gcirc/>
- Bouchereau A., Hamelin, J., Lamour, I., Renard, M. and Larher, F. 1991. Distribution of sinapine and related compounds in seeds of *Brassica* and allied genera. *Phytochemistry* 30: 1873-1881.
- Boutsalis, P. and Powles, S.B. 1995. Resistance of dicot weeds to acetolactate synthase (ALS)-inhibiting herbicides in Australia. *Weed Res.* 35: 149-155.
- Boutsalis, P., Karotam, J. and Powles, S.B. 1999. Molecular basis of resistance to acetolactate synthase-inhibiting herbicides in *Sisymbrium orientale* and *Brassica tournefortii*. *Pesticide Sci.* 55: 507-516.
- Bowers, W.S, Sener, B., Evans, P.H., Bingol, F. and Erdogan, I. 1997. Activity of Turkish medicinal plants against mosquitoes *Aedes aegypti* and *Anopheles gambiae*. *Insect Sci. Appl.* 16: 339-342.
- Boyd, R.S. and Barbour, M.G. 1986. Relative salt tolerance of *Cakile edentula* (Brassicaceae) from lacustrine and marine beaches. *Am. J. Bot.* 73: 236-241.
- Boyd, R.S. and Martens, S.N. 1998. Nickel hyperaccumulation by *Thlaspi montanum* var. *montanum* (Brassicaceae): a constitutive trait. *Am. J. Bot.* 85: 259-265.
- Boyd, R.S., Shaw, J.J. and Martens, S.N. 1994. Nickel hyperaccumulation defends *Streptanthus polygaloides* (Brassicaceae) against pathogens. *Am. J. Bot.* 81: 294-300.
- Branca, F. 1995. Studies on some wild Brassicaceae species utilizable as vegetables in the Mediterranean areas. *Plant Genet. Resour. Newsl.* 104: 6-9.
- Branca, F. and Iapichino, G. 1997. Some wild and cultivated Brassicaceae exploited in Sicily as vegetables. *Plant Genet. Resour. Newsl.* 110: 22-28.
- Branca, F., Iapichino, G. and Noto, G. 1994. On wild and cultivated Brassicaceae exploited as vegetable(s). ISHS Symposium on Brassicas, 9<sup>th</sup> Crucifer Genetics Workshop, Lisbon, Portugal, Abstracts p 160.
- Brown, G.G. 1999. Unique aspects of cytoplasmic male sterility and fertility restoration in *Brassica napus*. *J. Hered.* 90: 351-356.
- Brun, H. and Tribodet, M. 1995. Pathogenicity of *Leptosphaeria maculans* isolates on one ecotype of *Arabidopsis thaliana*. *Cruciferae Newsl. Eucarpia* 17: 74-75.

### **Brassicaceae: Wild Crucifer Species as Sources of Traits**

- Brun H., Pleiss, J. and Renard, M. 1987. Resistance of some crucifers to *Alternaria brassicae* (Berk.) Sacc.. Proc. GCIRC 7th Int. Rapeseed Congr. Poznan 11-14 May 1987, pp: 1222-1227.
- Budin, J.T., Breene, W.M. and Putnam, D.H. 1995. Some compositional properties of camelina (*Camelina sativa* L. Crantz) seeds and oils. J. Am. Oil Chem. Soc. 72: 309-315.
- Buente, R., Mueller, J. and Friedt, W. 1997. Genetic variation and response to selection for resistance to root-knot nematodes in oil radish (*Raphanus sativus* ssp. *oleiferus*) Plant Breed. 116: 263-266.
- Carcamo, H., Olfert, O., Dosdall, L., Herle, C., Beres, B. and Soroka, J. 2007. Resistance to cabbage seedpod weevil among selected Brassicaceae germplasm. Can. Entomol. 139: 658-669.
- Carlson, K.D. and Tookey, H.L. 1983. Crambe meal as a protein source for feeds. J. Am. Oil. Chem. Soc. 60: 1979-1985.
- Chander, H. and Bakheta, D.R.C. 1998. Evaluation of some cruciferous genotypes at seedling stage for resistance to mustard aphid, *Lipaphis erysimi* (Kalt.) under screen house and field conditions. J. Insect Sci. (Ludhiana) 11: 19-25.
- Chen, C.Y. and Séguin-Swartz, G. 1997. A comparative study of the response of wild crucifers to the blackleg fungus, *Phoma lingam*. Can. J. Plant Pathol. 19: 107.
- Chen, C.Y. and Seguin-Swartz, G. 1999. Reaction of wild crucifers to *Leptosphaeria maculans*, the causal agent of blackleg of crucifers. Can. J. Plant Pathol. 21: 361-367.
- Chen, H., Wang, H. and Li, Z. 2007. Intertribal crosses between *Brassica* species and *Capsella bursa-pastoris* for the improvement of oil quality and resistance to *Sclerotinia sclerotiorum* of *Brassica* crops. Proc. GCIRC 12th Int. Rapeseed Congr. 1: 411-413.
- Christoffers, M.J., Nandula, V.K., Howatt, K.A. and Wehking, T.R. 2006. Target-site resistance to acetolactate synthase inhibitors in wild mustard (*Sinapis arvensis*). Weed Sci. 54: 191-197.
- Chrungu, B., Verma, N., Mohanty, A., Pradhan, A. and Shivanna, K.R. 1999. Production and characterization of interspecific hybrids between *Brassica maurorum* and crop brassicas. Theor. Appl. Genet. 98: 608-613.
- Cipollini, D. and Gruner, B. 2007. Cyanide in the chemical arsenal of garlic mustard, *Alliaria petiolata*. J. Chem. Ecol. 33: 85-94.
- Clauss, M.J., Dietel, S., Schubert, G. and Mitchell-Olds, T. 2006. Glucosinolate and trichome defenses in a natural *Arabidopsis lyrata* population. J. Chem. Ecol. 32: 2351-2373.
- Cole, R.A. 1994. Isolation of a chitin-binding lectin with insecticidal activity in chemically-defined synthetic diets from two wild brassica species with resistance to cabbage aphid *Brevicoryne brassicae*. Entomol. Exp. Appl. 72: 181-187.
- Cole, R.A. 1997. The relative importance of glucosinolates and amino acids to the development of two aphid pests *Brevicoryne brassicae* and *Myzus persicae* on wild and cultivated brassica species. Entomol. Exp. Appl. 85: 121-133.
- Compton, D.L., Laszlo, J.A. and Isbell, T.A. 2004. Cinnamoyl esters of lesquerella and castor oil: Novel sunscreen active ingredients. J. Am. Oil Chem. Soc. 81: 945-951.
- Conn, K.L. and Tewari, J.P. 1986. Hypersensitive reaction induced by *Alternaria brassicae* in *Eruca*

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- sativa*, an oil yielding crucifer. Can. J. Plant Pathol. 8: 348.
- Conn, K.L., Tewari, J.P. and Dahiya, J.S. 1988. Resistance to *Alternaria brassicae* and phytoalexin-elicitation in rapeseed and other crucifers. Plant Sci. 56: 21-25.
- Craig, W., Wiegand, A., O'Neill, C.M., Máthias, R.J., Power, J.B. and Davey, M.R. 1997. Somatic embryogenesis and plant regeneration from stem explants of *Moricandia arvensis*. Plant Cell Rep. 17: 27-31.
- Crute I.A., Gray, A.R., Crisp, P. and Buczacki, S.T. 1980. Variation in *Plasmodiophora brassicae* and resistance to clubroot disease in *Brassicaceae* and allied crops. Plant Breed. 50: 91-104.
- Cromack, H.T.H. 1998. The effect of sowing date on the growth and production of *Lunaria annua* in Southern England. Industr. Crops Prod. 7: 217-221.
- Cui, W., Eskin, N.A.M. and Biliaderis, C.G. 1993a. Chemical and physical properties of yellow mustard (*Sinapis alba* L.) mucilage. Food Chem. 46: 169-176.
- Cui, W., Eskin, N.A.M. and Biliaderis, C.G. 1993b. Water-soluble yellow mustard (*Sinapis alba* L.) polysaccharides: partial characterization, molecular size distribution and rheological properties. Carbohydr. Polym. 20: 215-225.
- Curto, G., Dallavalle, E. and Lazzeri, L. 2005. Life cycle duration of *Meloidogyne incognita* and host status of Brassicaceae and Capparaceae selected for glucosinolate content. Nematology 7: 203-212.
- D'Antuono, L.F., Elementi, S., and Neri, R. 2008. Glucosinolates in *Diplotaxis* and *Eruca* leaves: Diversity, taxonomic relations and applied aspects. Phytochemistry (Amsterdam) 69: 187-199.
- Dal-Corso G., Borgato L., Furini, A. 2005. In vitro plant regeneration of the heavy metal tolerant and hyperaccumulator *Arabidopsis halleri* (Brassicaceae). Plant Cell Tissue Organ Cult. 82: 267-270.
- Dart, S., Kron, P. and Mable, B. K. 2004. Characterizing polyploidy in *Arabidopsis lyrata* using chromosome counts and flow cytometry. Can. J. Bot. 82: 185-197.
- Daun, J., Barthet, V. and Scarth, R. 2003. Erucic acid levels in *Sinapis arvensis* L from different parts of the world. Proc GCIRC 11th Int Rapeseed Congr 1: 290-292.
- Davis, A.R., Pylatuik, J.D., Paradis, J.C. and Low, N.H. 1998. Nectar-carbohydrate production and composition vary in relation to nectary anatomy and location within individual flowers of several species of Brassicaceae. Planta 205: 305-318.
- Daxenbichler, M.E., Spencer, G.F., Carlson, D.G., Rose, G.B., Brinker, A.M. and Powell, R.G. 1991. Glucosinolate composition of seeds from 297 species of wild plants. Phytochemistry 30: 2623-2638.
- Deol, J.S., Ahuja, I. and Banga, S.S. 1999. Physiological investigations of male sterility caused by *Enarthrocarpus lyratus* cytoplasm in Brassicas. Crop Improv. 26: 156-162.
- Deol, J.S., Shivanna, K.R., Prakash, S., Banga, S.S. 2003. *Enarthrocarpus lyratus*-based cytoplasmic male sterility and fertility restorer system in *Brassica rapa*. Plant Breed. 122: 438-440.
- Dhawan, A.K., Jain, A., Inderjeet and Singh, J. 2000. An efficient plant regeneration protocol from seedling explants of *Brassica juncea* RH-781, a freeze tolerant cultivar. Cruciferae Newsl. Eucarpia 22: 21-22.

### Brassicaceae: Wild Crucifer Species as Sources of Traits

- Dierig, D.A., Dahlquist, G.H. and Tomasi, P.M. 2006. Registration of WCL-LO3 high oil *Lesquerella fendleri* germplasm. *Crop Sci.* 46: 1832-1833.
- Dierig, D.A., Shannon, M.C. and Grieve, C.M. 2001a. Registration of WCL-SL1 salt tolerant *Lesquerella fendleri* germplasm. *Crop Sci.* 41: 604-605.
- Dierig, D.A., Thompson, A.E. and Coffelt, T.A. 1998. Registration of three *Lesquerella fendleri* germplasm lines selected for improved oil traits. *Crop Sci.* 38: 287.
- Dierig, D.A., Tomasi, P.M. and Dahlquist, G.H. 2001b. Registration of WCL-LY2 high oil *Lesquerella fendleri* germplasm. *Crop Sci.* 41: 604.
- Dierig, D.A., Tomasi, P.M. and Ray, D.T. 2001c. Inheritance of male sterility in *Lesquerella fendleri*. *J. Am. Soc. Hort. Sci.* 126: 738-743.
- Dierig, D.A., Tomasi, P.M., Salywon, A.M. and Ray, D.T. 2004. Improvement in hydroxy fatty acid seed oil content and other traits from interspecific hybrids of three *Lesquerella* species: *Lesquerella fendleri*, *L. pallida*, and *L. lindheimeri*. *Euphytica* 139: 199-206.
- Durka, W., Bossdorf, O., Prati, D. and Auge, H. 2005. Molecular evidence for multiple introductions of garlic mustard (*Alliaria petiolata*, Brassicaceae) to North America. *Mol. Ecol.* 14: 1697-1706.
- Dutta, I., Saha, P. and Das, S. 2008. Efficient *Agrobacterium*-mediated genetic transformation of oilseed mustard [*Brassica juncea* (L.) Czern.] using leaf piece explants. *In Vitro Cellular Developmental Biol. Plant.* 44: 401-411.
- Eapen, S. 2007. Genetic transformation in *Brassica juncea* L. Czern & Coss using wild types and shooter mutants of *Agrobacterium tumefaciens* and the regeneration response. *Plant Cell Biotechnol. Mol. Biol.* 8: 205-208.
- Ecker, R., Yaniv, Z., Zur, M. and Shafferman, D. 1992. Embryonic heterosis in the linolenic acid content of *Matthiola incana* seed oil. *Euphytica* 59: 93-96.
- El-Khatib, A.A. and Abd-Elaah, G.A. 1998. Allelopathic potential of *Zilla spinosa* on growth of associate flowering plants and some rhizosphere fungi. *Biol. Plant. (Prague)* 41: 461-467.
- El-Menshawi, B., Karawya, M., Wassel, G., Reisch, J. and Kjaer, A. 1980. Glucosinolates in the genus *Zilla* (Brassicaceae). *J. Nat. Prod. (Lloydia)* 43: 534-536.
- Ellis, P.R. and Farrell, J.A. 1995. Resistance to cabbage aphid (*Brevicoryne brassicae*) in six brassica accessions in New Zealand. *N. Z. J. Crop Hort. Sci.* 23: 25-29.
- Ellis, P.R., Pink, D.A.C., Barber, N.E. and Mead, A. 1999. Identification of high levels of resistance to cabbage root fly, *Delia radicum*, in wild *Brassica* species. *Euphytica* 110: 207-214.
- Erickson, D.B. and Bassin, P. 1990. Rapeseed and Crambe: alternative crops with potential industrial uses. *Bull. Kansas Agric. Expt. Stn. (Manhattan) No. 656:* 36 pp.
- Fagbenro, O.A. 2004. Soybean meal replacement by roquette (*Eruca sativa* Miller) seed meal as protein feedstuff in diets for African catfish, *Clarias gariepinus* (Burchell 1822), fingerlings. *Aquac. Res.* 35: 917-923.
- Fahey, J.W., Zalcmann, A.T. and Talalay, P. 2001. The chemical diversity and distribution of glucosinolates among plants. *Phytochemistry* 56: 5-51.

### **Brassicaceae: Wild Crucifer Species as Sources of Traits**

- Farnham, M., Davis, E., Morgan, J. and Smith, J.P. 2008. Neglected landraces of collard (*Brassica oleracea* L. var. *viridis*) from the Carolinas (USA) Genet. Resour. Crop Evol. 55: 797-801.
- Francis, A. and Warwick, S.I. 2003. The biology of Canadian weeds 120. *Neslia paniculata* (L.) Desv. Can. J. Plant Sci. 83: 441-451.
- Francis, A. and Warwick, S.I. 2007. The biology of invasive alien plants in Canada. *Lepidium latifolium*. Can. J. Plant Sci. 87: 639-658.
- Francis, A. and Warwick, S.I. 2008. The biology of Canadian weeds. 3. *Lepidium draba* L., *L. chalepense* L., *L. appelianum* Al-Shehbaz (updated). Can. J. Plant Sci. 88: 379-401.
- Francis, A., Cavers, P. and Warwick, S.I. 2009. The biology of Canadian weeds. 138. *Hesperis matronalis* L. Can. J. Plant Sci. 89: "In press".
- Friesen, L.J. and Powles, S.B. 2007. Physiological and molecular characterization of atrazine resistance in a wild radish (*Raphanus raphanistrum*) population. Weed Technol. 21: 910-914.
- Gaj, M.D. 2004. Factors influencing somatic embryogenesis induction and plant regeneration with particular reference to *Arabidopsis thaliana* (L.) Heynh. Plant Growth Regulation 43:27-47.
- Gao, H.L., Li, Y., Song, Y.P., Gao S.Y., Wang, J.J. 2008. In vitro culture and regeneration system of non-heading Chinese cabbage (*Brassica campestris* ssp. *chinensis* Makino). Xibei Zhiwu Xuebao 28: 963-968.
- Gavloski, J.E., Ekuere, U., Keddie, A. Dodsall, L., Kott -L. and Good, A.G. 2000. Identification and evaluation of flea beetle (*Phyllotreta cruciferae*) resistance within Brassicaceae. Can. J. Plant Sci. 80: 881-887.
- Gehring, A., Friedt, W., Lühs, W. and Snowdon, R.J. 2006. Genetic mapping of agronomic traits in false flax (*Camelina sativa* subsp. *sativa*) Genome 49: 1555-1563.
- Ghaderian, S.M., Mohtadi, A., Rahiminejad, R., Reeves, R.D. and Baker, A.J. 2007. Hyperaccumulation of nickel by two *Alyssum* species from the serpentine soils of Iran. Plant Soil 293: 91-97.
- Goffman, F.D., Thies, W. and Velasco, L. 1999. Chemotaxonomic value of tocopherols in Brassicaceae. Phytochemistry 50: 793-798.
- Gokavi, S.S., Malleshi, N.G. and Guo, M. 2004. Chemical composition of garden cress (*Lepidium sativum*) seeds and its fractions and use of bran as a functional ingredient. Plant Foods Hum. Nutr. 59: 105-111. 3
- Gomez, J.M. and Zamora, R. 1996. Wind pollination in high-mountain populations of *Hormathophylla spinosa* (Cruciferae). Am. J. Bot. 83: 580-585.
- Gómez-Campo, C. 1980. Morphology and morphotaxonomy of the Tribe Brassicaceae. In: *Brassica* crops and wild allies. Edited by S. Tsunoda, K. Hinata and C. Gómez-Campo. Japan Science Societies Press, Tokyo. pp: 3-31.
- Gómez-Campo C. and Tortosa, M.E. 1974. The taxonomic and evolutionary significance of some juvenile characters in the Brassicaceae. Bot. J. Linn. Soc. 69: 105-124.
- Gómez-Campo, C., Tortosa, M.E., Tewari, I. and Tewari, J.P. 1999. Epicuticular wax columns in cultivated *Brassica* species and in their close wild relatives. Ann. Bot. 83: 515-519.

### Brassicaceae: Wild Crucifer Species as Sources of Traits

- Gong, Q., Li, P., Ma, S., Indu Rupassara, S. and Bohnert, H.J. 2005. Salinity stress adaptation competence in the extremophile *Thellungiella halophila* in comparison with its relative *Arabidopsis thaliana*. *Plant J.* 44: 826-839.
- Greenhalgh, J.G. and Mitchell, N.D. 1976. The involvement of flavour volatiles in the resistance of downy mildew of wild and cultivated forms of *Brassica oleracea*. *New Phytol.* 77: 391-398.
- Greilhuber, J. and Obermayer, R. 1999. Cryptopolyploidy in *Bunias* (Brassicaceae) revisited - A flow-cytometric and densitometric study. *Plant Syst. Evol.* 218: 1-4.
- Griffith, M., Timonin, M., Wong, A.C.E., Gray, G.R., Akhter, S.R., Saldanha, M., Rogers, M.A., Weretilnyk, E.A. and Moffatt, B. 2007. *Thellungiella*: an *Arabidopsis*-related model plant adapted to cold temperatures. *Plant Cell Environ.* 30: 529-538.
- Griffiths, P.D. and Nickels, J.L. 2001. Association of a molecular polymorphism with black rot resistance derived from Ethiopian mustard. *Cruciferae Newsl. Eucarpia* 23: 57-58.
- Guan, C.Y., Li, F.Q., Li, X., Chen, S.Y., Liu, Z.S., Wang, G.H. and Sun, W.C. 2004. Resistance of rocketsalad (*Eruca sativa* Mill.) to stem rot (*Sclerotinia sclerotiorum*). *Sci. Agric. Sinica* 37: 1138-1143.
- Guan, R., Jiang, S., Xin, R. and Zhang, H. 2007a. Studies on rapeseed germplasm enhancement by use of cruciferous weed *Descurainia sophia*. *Proc. GCIRC 12<sup>th</sup> Int. Rapeseed Congr.* 1: 261-265.
- Guan, R., Jiang, S., Xin, R. and Zhang, H. 2007b. Studies on rapeseed germplasm enhancement by use of cruciferous weed *Rorippa indica*. *Proc. GCIRC 12<sup>th</sup> Int. Rapeseed Congr.* 1: 329-332.
- Guan, Z.Q., Chai, T.Y., Zhang, Yu.X., Xu, J., Wei, W., Han, L., and Cong, L. 2008. Gene manipulation of a heavy metal hyperaccumulator species *Thlaspi caerulescens* L. via *Agrobacterium*-mediated transformation. *Mol. Biotechnol.* 40: 77-86.
- Gugel, R.K. and Falk, K.C. 2006. Agronomic and seed quality evaluation of *Camelina sativa* in western Canada. *Can. J. Plant Sci.* 86: 1047-1058.
- Gugel, R.K. and Séguin-Swartz, G. 1997. Introgression of blackleg resistance from *Sinapis alba* into *Brassica napus*. *Brassica 97, Int Soc Hortic Sci Symp Brassicas/10th Crucifer Genetics Workshop, 23-27 Sept 1997, Rennes, France, Abst pp 222.*
- Gugel, R.K., Séguin-Swartz, G. and Warwick, S.I. 1997. Transfer of blackleg resistance from *Erucastrum gallicum* to *Brassica rapa*. *Can. J. Plant. Pathol.* 19: 109.
- Guil-Guerrero, J.L., Giménez-Martínez, J.J. and Torija-Isasa, M.E. 1999. Nutritional composition of wild edible crucifer species. *J. Food Biochem.* 23: 283-294.
- Gulden, R.H., Warwick, S.I. and Thomas, A.G. 2008. The biology of Canadian weeds. 137. *Brassica napus* L. and *B. rapa* L. *Can. J. Plant Sci.* 88: 951-996.
- Gulati, S.C., Varma, N.S., Mani, N. and Raman, R. 1991. Resistance to white rust (*Albugo candida*) in Indian mustard. *Proc. GCIRC 8<sup>th</sup> Int. Rapeseed Congr.*, pp: 256-261.
- Haddadi, P., Moieni, A., Karimadeh, Gh. and Abdollahi, M.R. 2008. Effects of gibberellin, abscisic acid and embryo desiccation on normal plantlet regeneration, secondary embryogenesis and callogenesis in microspore culture of *Brassica napus* L. cv. PF704. *Int. J. Plant Prod.* 2: 153-162.



### Brassicaceae: Wild Crucifer Species as Sources of Traits

- Hanson, B.D., Park, K.W., Mallory-Smith, C.A. and Thill, D.C. 2004. Resistance of *Camelina microcarpa* to acetolactate synthase inhibiting herbicides. *Weed Res.* 44: 187-194.
- Hashem, A. and Dhammu, H.S. 2002. Cross-resistance to imidazolinone herbicides in chlorsulfuron-resistant *Raphanus raphanistrum*. *Pest Manag. Sci.* 58: 917-919.
- Hashem, A., Bowran, D., Piper, T. and Dhammu, H. 2001. Resistance of wild radish (*Raphanus raphanistrum*) to acetolactate synthase-inhibiting herbicides in the Western Australia wheat belt. *Weed Technol.* 15: 68-74.
- Heap, I.M. 2009. International survey of herbicide-resistant weeds. [[http://www. weedscience.com](http://www.weedscience.com)]
- Heap, I.M. and Morrison, I.N. 1992. Resistance to auxin-type herbicides in wild mustard (*Sinapis arvensis* L.) populations in western Canada. *Weed Sci. Soc. Amer.* 32: 55.
- Hebard, A. 1998. *Camelina sativa*—a pleasurable experience or another false hope? *Lipid Technol.* 10: 81-83.
- Henderson, A.E., Hallett, R.H. and Soroka, J. 2004. Prefeeding behavior of the crucifer flea beetle, *Phyllotreta cruciferae*, on host and nonhost crucifers. *J. Insect Behav* 17: 17-39.
- Hennion, F., Frenot, Y. and Martin-Tanguy, J. 2006. High flexibility in growth and polyamine composition of the crucifer *Pringlea antiscorbutica* in relation to environmental conditions. *Physiol. Plant.* 127: 212-224.
- Hinata, K. and Konno, N. 1979. Studies on a male sterile strain having the *Brassica campestris* nucleus and the *Diplotaxis muralis* cytoplasm I. On the breeding procedure and some characteristics of the male sterile strain. *Jpn. J. Breed.* 29: 305-311.
- Horn, P.J. and Vaughn, J.G. 1983. Seed glucosinolates of fourteen wild *Brassica* species. *Phytochemistry* 22: 465-470.
- Horovitz, A. and Galil, J. 1972. Gynodioecism in east Mediterranean *Hirschfeldia incana*, Cruciferae. *Bot. Gaz.* 133: 127-131.
- Hu, Q., Andersen, S.B. and Hansen, L.N. 1999a. Plant regeneration capacity of mesophyll protoplasts from *Brassica napus* and related species. *Plant Cell Tissue Organ Cult.* 59: 189-196.
- Hu, Q., Andersen, S.B., Laursen, J. and Hansen, L.N. 1999b. Intergeneric hybridization by protoplast fusion aiming at modification of fatty acid composition in *Brassica napus* L. *Proc. GCIRC 10th Int. Rapeseed Congr., Contribution 332 on CD ROM*; also available at <http://www.regional.org.au/au/gcirl/>.
- Huang, B.Q., Luo, P. and Li, Y.W. 1999a. Domestication and cultivation of *Orychophragmus violaceus* as a new oil crop in China. *Cruciferae Newsl. Eucarpia* 21: 13-14.
- Huang, Y.J., Zhao, J.W., Zhao, H.J., He, F.X. and Li, Y.C. 1999b. Studies on new strain selected by intergeneric hybridization between *B. napus* and *C. bursa-pastoris*. *Proc. GCIRC 10th Int. Rapeseed Congr., Contribution 193 on CD ROM*; also available at <http://www.regional.org.au/au/gcirl/>
- Hussiney, H.A., El-Missiry, M.M. and Ismail, S.I. 1998. Flavonoids of *Diplotaxis harra* (Forssk.) Boiss. and *Diplotaxis acris* (Forssk.) Boiss. *Egypt. J. Pharmac. Sci.* 38: 131-136.
- Hylton, C.M., Rawsthorne, S., Smith, A.M., Jones, D.A. and Woolhouse, H.W. 1988. Glycine

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- decarboxylase is confined to the bundle-sheath cells of leaves of C<sub>3</sub>-C<sub>4</sub> intermediate species. *Planta* 175: 452-459.
- Ignatov, A., Kuginuki, Y., Hida, K. 1999. Disease reaction to *Xanthomonas campestris* pv. *campestris* races 1, 4 and 5 in weedy and cultivated *Brassica rapa* L. *Cruciferae Newsl. Eucarpia* 21: 123-124.
- Inan, G., Zhang, Q., Li, P., Wang, Z., Cao, Z., Zhang, H., Zhang, C., Quist, T.M., Goodwin, S.M., Zhu, J., Shi, H., Damsz, B., Charbaji, T., Gong, Q., Ma, S., Fredricksen, M., Galbraith, D.W., Jenks, M.A., Rhodes, D., Hasegawa, P.M., Bohnert, H.J., Joly, R.J., Bressan, R.A. and Zhu, J.-K. 2004. Salt cress. A halophyte and cryophyte *Arabidopsis* relative model system and its applicability to molecular genetic analyses of growth and development of extremophiles. *Plant Physiol.* 135: 1718-1737.
- Ito, W., Ohta, Y., Mukhlesur Rahman, M.D., Hirata, Y., Zhang, M.F. and Chen, L.P. 2004. Characterization and molecular mechanism of cytoplasmic male sterility in *Brassica juncea*. Program and Abstracts, 14th Crucifer Genetics Workshop/4th ISHS Symposium on Brassicas (Brassica 2004), p. 73.
- Jacobson, H.A., Petersen, J.B. and Putnam, D.E. 1988. Evidence of pre-Columbian *Brassica* in the northeastern U.S. *Rhodora* 90: 355-362.
- Janeja, H.S., Banga, S.K., Bhaskar, P.B. and Banga, S.S. 2003. Alloplasmic male sterile *Brassica napus* with *Enarthrocarpus lyratus* cytoplasm: Introgression and molecular mapping of an *E. lyratus* chromosome segment carrying a fertility restoring gene. *Genome* 46: 792-797.
- Jasieniuk, M., Morrison, I.N. and Brule Babel, A.L. 1995. Inheritance of dicamba resistance in wild mustard (*Brassica kaber*). *Weed Sci.* 43: 192-195.
- Jeffers, G.M., O'Donovan, J.T. and Hall, L.M. 1996. Wild mustard (*Brassica kaber*) resistance to ethametsulfuron but not to other herbicides. *Weed Technol.* 10: 847-850.
- Jin, R.G., Liu, Y.B., Tabashnik, B.E. and Borthakur, D. 1999. Tissue culture and *Agrobacterium*-mediated transformation of watercress. *Plant Cell Tissue Organ Cult.* 58: 171-176.
- Johnston, J.S., Pepper, A.E., Hall, A.E., Chen, Z.J., Hodnett, G., Drabek, J., Lopez, R. and Price, H.J. 2005. Evolution of genome size in Brassicaceae. *Ann. Bot.* 95: 229-235.
- Joseph, D.E. and Dube, J.N. 1988. Effect of mycorrhiza on plant growth and phosphorus uptake in mustard and niger. *Acta Bot. Indica* 16: 210-212.
- Jugulam, M., McLean, M.D. and Hall, J.C. 2005. Inheritance of picloram and 2,4-D resistance in wild mustard (*Brassica kaber*). *Weed Sci.* 53: 417-423.
- Jyoti, J.L., Shelton, A. M. and Earle, E.D. 2001. Identifying sources and mechanisms of resistance in crucifers for control of cabbage maggot (Diptera: Anthomyiidae). *J. Econ Entomol.* 94: 942-949.
- Kanada, I. and Kato, M. 1997. Effect of *Brassica oxyrrhina* cytoplasm on *Raphanus sativus*. *Breeding Sci.* 47: 57-65.
- Kapoor, R., Paathak, A., Mago, P. and Mukerji, K.G. 1996. VAM in two crucifers. *Cruciferae Newsl. Eucarpia* 18: 116-117.
- Kift, N.B., Ellis, P.R., Reynolds, K.A., Sime, S. and Pink. D.A.C. 2000. Resistance in wild *Brassica* species to *Brevicoryne brassicae* in the field is not reproduced in the glasshouse, but increases with

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- age. 3<sup>rd</sup> ISHS Int. Symp. Brassicas/12<sup>th</sup> Cruciferae Genet. Workshop, abstract p082.
- Kirti, P.B., Baldev, A., Gaikwad, K., Bhat, S.R., Kumar, V.D., Prakash, S., Chopra, V.L. 1997. Introgression of a gene restoring fertility to CMS (*Trachystoma*) *Brassica juncea* and the genetics of restoration. *Plant Breed* 116: 259-262.
- Kirti, P.B., Prakash, S., Gaikwad, K., Kumar, V.D., Bhat, S.R. and Chopra, V.L. 1998. Chloroplast substitution overcomes leaf chlorosis in a *Moricandia arvensis* - based cytoplasmic male sterile *Brassica juncea*. *Theor. Appl. Genet.* 97: 1179-1182.
- Klewer, A., Scheunemann, R. and Sacristán, M.D. 2003. Incorporation of blackspot resistance from different origins into oilseed rape. *Proc. GCIRC 11th Int. Rapeseed Congr.* 1: 65-67.
- Klimaszewska, K. and Keller, W.A. 1988. Regeneration and characterization of somatic hybrids between *Brassica napus* and *Diplotaxis harra*. *Plant Sci.* 58: 211-222.
- Kmec, P., Weiss, M.J., Milbrath, L.R., Schatz, B.G., Hanzel, J., Hanson, B.K. and Eriksmoen, E.D. 1998. Growth analysis of crambe. *Crop Sci.* 38: 108-112.
- Koch, M.A. and Kiefer, M. 2005. Genome evolution among cruciferous plants: A lecture from the comparison of the genetic maps of three diploid species - *Capsella rubella*, *Arabidopsis lyrata* subsp. *petraea*, and *A. thaliana*. *Am. J. Bot.* 92: 761-767.
- Kolte, S.J., Bordoloi, D.K. and Awasthi, R.P. 1991. The search for resistance to major diseases of rapeseed and mustard in India. *Proc GCIRC 8<sup>th</sup> Int. Rapeseed Congr.*, pp: 219-225.
- Kotova, V.V., Cozari, E.G., Kononkov, P.F. and Shestoporov, A.A. 1999. Use of antagonistic plants against plant-parasite nematodes. *Sel'skokhozyaistvennaya Biol.* 0(3): 24-32.
- Kruckeberg, A.R. and Reeves, R.D. 1995. Nickel accumulation by serpentine species of *Streptanthus* (Brassicaceae): field and greenhouse studies. *Madroño* 42: 458-469.
- Kuittinen, H., de Haan, A.A., Vogl, C., Oikarinen, S., Leppälä, J., Koch, M., Mitchell-Olds, T., Langley, C.H. and Savolainen, O. 2004. Comparing the linkage maps of the close relatives *Arabidopsis lyrata* and *A. thaliana*. *Genetics* 168: 1575-1584.
- Kumar, P.R. and Tsunoda, S. 1980. Variation in oil content of fatty acid composition among seeds from the Cruciferae. In: *Brassica crops and wild allies. Edited by S. Tsunoda, K. Hinata and C. Gómez-Campo.* Japan Scientific Societies Press, Tokyo. pp: 235-252.
- Kushad, M.M., Guidera, M. and Bratsch, A.D. 1999. Distribution of horseradish peroxidase activity in horseradish plants. *Hortscience* 34: 127-129.
- Lagercrantz, U 1998. Comparative mapping between *Arabidopsis thaliana* and *Brassica nigra* indicates that *Brassica* genomes have evolved through extensive genome replication accompanied by chromosome fusions and frequent rearrangements. *Genetics* 150: 1217-1228.
- Lal, M.N., Singh, S.S. and Singh, V.P. 1997. Screening of *Brassica* germplasms for resistance against mustard aphid, *Lipaphis erysimi* (Kalt.) *J. Entomol. Res. (New-Delhi)* 21: 371-375.
- Lamb, R.J. 1980. Hairs protect pods of mustard (*Brassica hirta* 'Gisilba') from flea beetle feeding damage. *Can. J. Plant Sci.* 60: 1439-1440. 3
- Lange, W., Toxopeus, H., Lubberts, J.H., Dolstra, O. and Harrewijn, J.L. 1989. The development of

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- raparadish *Brassicoraphanus* 2n = 38, a new crop in agriculture. *Euphytica* 40: 1-14.
- Larkin, R.P. and Griffin, T.S. 2007. Control of soilborne potato diseases using *Brassica* green manures. *Crop Prot* 26: 1067-1077.
- Laroche, A., Geng, X.-M. and Singh, J. 1992. Differentiation of freezing tolerance and vernalization responses in Cruciferae exposed to a low temperature. *Plant Cell Environ.* 15: 439-445.
- Leadley, E.A. and Heywood, V.H. 1990. The biology and systematics of the genus *Coincya* Porta and Rigo ex Rouy (Cruciferae). *Bot. J. Linn. Soc.* 102: 313-398.
- Lechner, M., Reiter, B. and Lorbeer, E. 1999. Determination of free and esterified sterols in potential new oil seed crops by coupled on-line liquid chromatography-gas-chromatography. *Fett* 101: 171-177.
- Lefol, C., Séguin-Swartz, G. and Morrall, R.A.A. 1996. Resistance to *Sclerotinia sclerotiorum* in a weed related to canola. 67th Annual Meeting, Canadian Phytopathological Society, June 23-26, 1996, Saskatoon, Canada, Abst.
- Lefol, C., Séguin-Swartz, G. and Morrall, R.A.A. 1997. Effect of petal age on infection by *Sclerotinia sclerotiorum* in *Erucastrum gallicum*. *Brassica 97*, Int Soc Hortic Sci Symp Brassicas/10th Crucifer Genetics Workshop, 23-27 Sept. 1997, Rennes, France, Abst.:188.
- Lehtila, K. and Strauss, S.Y. 1999. Effects of foliar herbivory on male and female reproductive traits of wild radish, *Raphanus raphanistrum*. *Ecology* 80: 116-124.
- Lelivelt, C.L. and Krens, F.A. 1992. Transfer of resistance to the beet cyst nematode *Heterodera schachtii* Schm. into the *Brassica napus* L. gene pool through intergeneric somatic hybridization with *Raphanus sativus* L. *Theor. Appl. Genet.* 83: 887-894.
- Lelivelt, C.L.C., Leunissen, E.H.M., Frederiks, H.J., Helsper, J.P.F.G. and Krens, F.A. 1993. Transfer of resistance of the beet cyst nematode (*Heterodera schachtii* Schm.) from *Sinapis alba* L. (white mustard) to the *Brassica napus* L. gene pool by means of sexual and somatic hybridization. *Theor. Appl. Genet.* 85: 688-696.
- Lemke D.E. and Worthington, R.D. 1991. *Brassica* and *Rapistrum* (Brassicaceae) in Texas. *SouthW. Naturalist* 36: 194-197.
- Leonard, E.C. 1998. Camelina oil:  $\alpha$ -linolenic source. *Inform.* 9: 830-838.
- Li, G., Ammermann, U. and Quiros, C.F. 2001. Glucosinolate contents in maca (*Lepidium peruvianum* Chacon) seeds, sprouts, mature plants and several derived commercial products. *Econ. Bot.* 55: 255-262.
- Li, H., Barbetti, M.J. and Sivasithamparam, K. 2005. Hazard from reliance on cruciferous hosts as sources of major gene-based resistance for managing blackleg (*Leptosphaeria maculans*) disease. *Field Crops Res.* 91: 185-198.
- Li, H.Q., Xu, J., Chen, L., Li, M.R. 2007. Establishment of an efficient *Agrobacterium tumefaciens*-mediated leaf disc transformation of *Thellungiella halophila*. *Plant Cell Rep.* 26: 1785-1789.
- Li, X.F., Yang, Y. and Wang, Y.P. 1995. Preliminary assessment of two new cruciferous oil plant germplasms distributed in China. *Chin. J. Bot.* 7: 156-163.
- Liébanas, G. and Castillo, P. 2004. Host suitability of some crucifers for root-knot nematodes in southern

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- Spain. *Nematology* 6: 125-128.
- Lipecki, J. 1988. *Capsella bursa-pastoris* (L.) Med. - another weed resistant to simazine? *Acta Societatis Botanicorum Poloniae*. 1: 187-189.
- Liu, Q. and Rimmer, S.R. 1991. Inheritance of resistance in *Brassica napus* to an Ethiopian isolate of *Albugo candida* from *Brassica carinata*. *Can. J. Plant Pathol.* 13: 197-201.
- Long, M.L., Xing, G.M., Okubo, H. and Fujieda, K. 1992. Cross compatibility between *Brassicoraphanus* (*Brassica oleracea* X *Raphanus sativus*) and cruciferous crops, and rescuing the hybrid embryos through ovary and embryo culture. *J. Fac. Agric. Kyushu Univ.* 37: 29-39.
- Lu, C. and Kang, J. 2008. Generation of transgenic plants of a potential oilseed crop *Camelina sativa* by *Agrobacterium*-mediated transformation. *Plant Cell Rep.* 27: 273-278.
- Lu, J., Liu, S. and Shelton, A.M. 2004. Laboratory evaluations of a wild crucifer *Barbarea vulgaris* as a management tool for the diamondback moth *Plutella xylostella* (Lepidoptera: Plutellidae). *Bull. Entomol Res.* 94: 509-516.
- Luken, J. O., Thieret, J. W. and Kartesz, J. R. 1993. *Erucastrum gallicum* (Brassicaceae): invasion and spread in North America. *Sida Contr. Bot.* 15: 569-582.
- Luo, P., Huang, B.Q., Lan, Z.Q. and Yan, H. 1998a. A study on the vegetable resource *Orychophragmus violaceus*. *Sichuan Daxue Xuebao Ziran Kexueban* 35(4): 638-641. In Chinese.
- Luo, P., Huang, B.Q., Yin, J.M., Chen, Z.L., Chen, Y.H. and Lan, Z.Q. 1998b. A new forage genetic resource *Orychophragmus violaceus* (L.) O.E.Schulz. *Genet. Res. Crop Evol.* 45: 491-494.
- Luo, P., Lan, Z.Q., Gao, H.B. and Ye, D.P. 1999. *Descurainia sophia* - a neglected cruciferous plant resource. *Cruciferae Newsl. Eucarpia* 21: 15-16.
- Luo, P., Lan, Z.Q. and Li, Z.Y. 1994. *Orychophragmus violaceus*, a potential edible-oil crop. *Plant Breed.* 113: 83-85.
- Lysak, M.A. and Lexer, C. 2006. Towards the era of comparative evolutionary genomics in Brassicaceae. *Plant Syst. Evol.* 259: 175-198.
- Lysak, M.A., Koch, M.A., Beaulieu, J.M., Meister, A., Leitch, I.J. 2009. The dynamic ups and downs of genome size evolution in Brassicaceae. *Mol. Biol. Evol.* 26: 85-98.
- Malik, M., Vyas, P.O., Rangaswamy, N.S. and Shivanna, K.R. 1999. Development of two new cytoplasmic male-sterile lines in *Brassica juncea* through wide hybridization. *Plant Breed.* 118: 75-78.
- Maltais, B. and Bouchard, C.J. 1978. Une moutarde des oiseaux (*Brassica rapa* L.) resistente a l'atrazine. *Phytoprotection* 59: 117-119.
- Mamula, D., Juretic, N. and Horvath, J. 1997. Susceptibility of host plants to belladonna mottle and turnip yellow mosaic tymoviruses: multiplication and distribution. *Acta Phytopathol. Entomol. Hungarica* 32: 289-298.
- Mandal, P. and Sikdar, S.R. 2003; Plant regeneration from mesophyll protoplasts of *Rorippa indica* (L.) Hiern, a wild crucifer. *Curr. Sci. (Bangalore)* 85(10): 1451-1454.
- Mandal, S., Yadav, S., Singh, R., Begum, G., Suneja, P. and Singh, M. 2002. Correlation studies on oil

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- content and fatty acid profile of some cruciferous species. *Genet. Resour. Crop Evol.* 49: 551–556.
- Marthe, F., Richter, K., Schrader, O and Ryschka, U. 2004. Cabbage (*Brassica oleracea*) with new resistance to black rot (*Xanthomonas campestris* pv. *campestris*) from black mustard (*Brassica nigra*). *Brassica 2004*, 4th ISHS Symposium Brassicas/Proc. 14th Crucifer Genet. Workshop, p. 175.
- Marvin, H.J.P., Mastebroek, H.D., Becu, D.M.S. and Janssens, R.J.J. 2000. Investigation into the prospects of five novel oilseed crops within Europe. *Outlook on Agriculture* 29: 47-53.
- Massoura, E., Vereijken, J.M., Kolster, P., Derksen, J.T.P. and Janick, J. 1996. Isolation and functional properties of proteins from *Crambe abyssinica* oil seeds. *Proc. 3<sup>rd</sup> Nat. Symp., "Progress in new crops"*, Indianapolis, Indiana, 22-25 Oct., 1996. Pp 322-327.
- Mastebroek, H.D. and Marvin, H.J.P. 2000. Breeding prospects of *Lunaria annua* L. *Industr. Crops Prod.* 11: 139-143.
- Mathews, S., Singhal, R.S. and Kulkarni, P.R. 1993. Some physicochemical characteristics of *Lepidium sativum* (haliv) seeds. *Die Nahrung* 37: 69-71.
- Matsuzawa, Y., Mekiyanon, S., Kaneko, Y., Bang, S.W., Wakui, K., Takahata, Y. 1999. Male sterility in alloplasmic *Brassica rapa* L. carrying *Eruca sativa* cytoplasm. *Plant Breed.* 118: 82-84.
- Matthäus, B. and Angelini, L.G. 2005. Anti-nutritive constituents in oilseed crops from Italy. *Industr. Crops Prod.* 21: 89-99.
- Matthäus, B. and Zubr, J. 2000. Variability of specific components in *Camelina sativa* oilseed cakes. *Ind. Crops Prod.* 12: 9-18.
- McCarthy, B.C. and Hanson, S.L. 1998. An assessment of the allelopathic potential of the invasive weed *Alliaria petiolata* (Brassicaceae). *Castanea* 63: 68-73.
- McVetty, P.B.E., Austin, R.B. and Morgan, C.L. 1989. A comparison of the growth, photosynthesis, stomatal conductance and water use efficiency of *Moricandia* and *Brassica* species. *Ann. Bot.* 64: 87-94.
- Medve, R.J. 1983. The mycorrhizal status of the Cruciferae. *Amer. Midl. Nat.* 109: 406-408.
- Megdiche, W., Ben Amor, N., Debez, A., Hessini, K., Ksouri, R., Zuily-Fodil, Y. and Abdely, C. 2007. Salt tolerance of the annual halophyte *Cakile maritima* as affected by the provenance and the developmental stage. *Acta Physiol. Plant.* 29: 375-384.
- Meng, J., Yan, Z., Tian, Z., Huang, R. and Huang, B. 1999. Somatic hybrids between *Moricandia nitens* and three *Brassica* species. *Proc. GCIRC 10th Inter. Rapeseed Congr., Contribution 6 on CD ROM*; also available at <http://www.regional.org.au/au/gcirc/>.
- Mensuali-Sodi, A., Brea, M., Panizza, M., Serra, G. and Tognoni, F. 1994. In vitro-regeneration of shoots in *Matthiola incana* L. from seedling explants of different age. *Gartenbauwissenschaft* 59: 77-80.
- Mihailović, V., Erić, P., Marinković, R., Čupina, B., Marjanović-Jeromela, A., Mikić<sup>1</sup>, A., Krstić, Đ. and Červenski<sup>1</sup> J. 2008. Potential of some *Brassica* species as forage crops. *Cruciferae Newsl. Eucarpia* Vol. 27: 39-40.
- Mikić, A., Mihailović V., Petrović, S., Dimitrijević, M., Vasiljević, S., Karagić, Đ. and Pataki, I. 2009. Green forage yield components in white mustard (*Sinapis alba* L. subsp. *alba*). *Cruciferae Newsl. Eucarpia*

## Brassicaceae: Wild Crucifer Species as Sources of Traits

28: 20-21.

- Misra, A.K., Ratan, S. and Kumar, A. 2003. Evaluation of rocket (*Eruca sativa*) germplasm. Proc. GCIRC 11th Intr. Rapeseed Congr. 2: 514-516.
- Mishra, R.S., Abdin, M.Z. and Uprety, D.C. 1999. Interactive effects of elevated CO<sub>2</sub> and moisture stress on the photosynthesis, water relation and growth of *Brassica* species. J. Agron. Crop Sci. 182: 223-229.
- Mitchell, J.P., Thomsen, C.D., Graves, W.L. and Shennan, C. 1999. Cover crops for saline soils. J. Agron. Crop Sci. 183: 167-178.
- Mithen, R.F. and Herron, C. 1991. Transfer of disease resistance to oilseed rape from wild *Brassica* species. Proc GCIRC 8<sup>th</sup> Int. Rapeseed Congr., pp: 244-249.
- Mithen, R.F. and Magrath, R. 1992. Glucosinolates and resistance to *Leptosphaeria maculans* in wild and cultivated *Brassica* spp.. Plant Breed. 108: 60-68.
- Mithen, R.F., Lewis, B.G., Heaney, R.K. and Fenwick, G.R. 1987a. Glucosinolates of wild and cultivated *Brassica* species. Phytochemistry 26: 1969-1973.
- Mithen, R.F., Lewis, B.G., Heaney, R.K. and Fenwick, G.R. 1987b. Resistance of leaves of *Brassica* species to *Leptosphaeria maculans*. Trans. Br. Mycol. Soc. 88: 525-531.
- Mithila, J. and Hall J.C. 2007. Production of an auxinic herbicide-resistant microspore-derived doubled haploid wild mustard (*Sinapis arvensis* L.) plant. Crop Prot. 26: 357-362.
- Mohapatra, T., Kirti, P.B., Kumar, V.D., Prakash, S. and Chopra, V.L. 1998. Random chloroplast segregation and mitochondrial genome recombination in somatic hybrid plants of *Diplotaxis catholica* + *Brassica juncea*. Plant Cell Rep. 17: 814-818.
- Mohiuddin, S., Qureshi, R.A., Qureshi, S.A., Nasir, M.K.A. and Khatri, L.M. 1990. Studies on the repellent activity of some indigenous plant oils against *Tribolium castaneum* (Herbst.). Pak. J. Sci. Ind. Res. 33: 326-328.
- Morinaga, S., Nagano, A.J., Miyazaki, S., Kubo, M., Fukuda, T.D.H., Sakai, S., Hasebe, M., Fukuda, H. 2008. Ecogenomics of cleistogamous and chasmogamous flowering: genome wide gene expression patterns from cross-species microarray analysis in *Cardamine kokaiensis* (Brassicaceae). J. Ecol. 96: 1086-1097.
- Morrison, I. N. and Devine, M. D. 1994. Herbicide resistance in the Canadian prairie provinces: Five years after the fact. Phytoprotection 75 (Suppl.): 5-16.
- Mueller, M., Ordon, F. and Friedt, W. 1999. Perspectives for efficient cereal and oilseed production in marginal areas. Z. Kulturtech. Landentwickl. 40: 275-281.
- Mulder, J.H. and Mastebroek, H.D. 1996. Variation for agronomic characteristics in *Crambe hispanica*, a wild relative of *Crambe abyssinica*. Euphytica 89: 267-278.
- Munir, M., Rashid, H., Rauf, M., Chaudhry, Z., Bukhari, M.S. 2008. Callus formation and plantlets regeneration from hypocotyl of *Brassica napus* by using different media combinations. Pakistan J. Bot. 40: 309-315.
- Munshi, M.K., Roy, P.K., Kabir, M.H., and Ahmed, G. 2007. In vitro regeneration of cabbage (*Brassica*

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- oleracea* L. var. *capitata*) through hypocotyl and cotyledon culture. *Plant Tissue Cult. Biotechnol.* 17: 131-136.
- Murayama, K., Yahara, T. and Terachi, T. 2004. Variation of female frequency and cytoplasmic male-sterility gene frequency among natural gynodioecious populations of wild radish (*Raphanus sativus* L.). *Mol. Ecol.* 13: 2459-2464.
- Naumova, T.N., van der Laak, J., Osadtchij, J., Matzk, F., Kravtchenko, A., Bergervoet, J., Ramulu, K.S. and Boutilier, K. 2001. Reproductive development in apomictic populations of *Arabis holboellii* (Brassicaceae). *Sex. Plant Reprod.* 14: 195-200.
- Nieto, F.G. 1991. Breeding systems and related flora traits in several *Erysimum* Cruciferae. *Can. J. Bot.* 69: 2515-2521.
- Ogura, H. 1968. Studies on the new male-sterility in Japanese radish, with special reference to the utilization of this sterility towards the practical raising of hybrid seeds. *Mem. Fac. Agric. Kagoshima Univ.* 6: 39-78.
- Onyilagha, J., Bala, A., Hallett, R., Gruber, M., Soroka, J. and Westcott, N. 2003. Leaf flavonoids of the cruciferous species, *Camelina sativa*, *Crambe* spp., *Thlaspi arvense* and several other genera of the family Brassicaceae. *Biochem. Syst. Ecol.* 31: 1309-1322.
- Orlowska, E., Zubek, Sz., Jurkiewicz, A., Szarek-Lukaszewska, G., Turnau, K., 2002. Influence of restoration on arbuscular mycorrhiza of *Biscutella laevigata* L. (Brassicaceae) and *Plantago lanceolata* L. (Plantaginaceae) from calamine spoil mounds. *Mycorrhiza* 12: 153-160.
- Özeker, E. and Esiyok, D. 1999. Identification of phenolic compounds in seeds of different rocket species (*Eruca sativa* and *Diplotaxis tenuifolia*) and land cress (*Lepidium sativum*). *Cruciferae Newsl. Eucarpia* 21: 21-22.
- Pachagounder, P., Lamb, R.J. and Bodnaryk, R.P. 1998. Resistance to the flea beetle *Phyllotreta cruciferae* (Coleoptera: Chrysomelidae) in false flax, *Camelina sativa* (Brassicaceae). *Can. Entomol.* 130: 235-240.
- Pahwa, R.S., Banga, S.K., Gogna, K.P.S. and Banga, S.S. 2004. Tournefortii male sterility system in *Brassica napus*. Identification, expression and genetic characterization of male fertility restorers. *Plant Breed.* 123: 444-448.
- Palmer, C.E., Warwick, S.I. and Keller, W. 2001. Brassicaceae (Cruciferae) Family, *Plant Biotechnology and Phytoremediation*. *Int. J. Phytoremediation* 3: 245-287.
- Parkin, I.A.P., Gulden, S.M., Sharpe, A.G., Lukens, L, Trick, M., Osborn, T.C. and Lydiate, D.J. 2005. Segmental structure of the *Brassica napus* genome based on comparative analysis with *Arabidopsis thaliana*. *Genetics* 171: 765-781.
- Pathania, A., Bhat, S.R., Kumar, V.D., Ashutosh, Kirti, P.B., Prakash, S., Chopra, V.L. 2003. Cytoplasmic male sterility in alloplasmic *Brassica juncea* carrying *Diplotaxis catholica* cytoplasm: Molecular characterization and genetics of fertility restoration. *Theor. Appl. Genet.* 107: 455-461.
- Pattison, A.B., Versteeg, C., Akiew, S. and Kirkegaard, J. 2006. Resistance of Brassicaceae plants to root-knot nematode (*Meloidogyne* spp.) in northern Australia. *Int. J. Pest Manag.* 52: 53-62.



### Brassicaceae: Wild Crucifer Species as Sources of Traits

- Paunescu, A. 2008. Histological investigation of the secondary somatic embryogenesis of *Alyssum borzaneanum* (Brassicaceae). *Phytologia Balcanica* 14: 111-117.
- Pedras, M.S.C. and Adio, A.M. 2008. Phytoalexins and phytoanticipins from the wild crucifers *Thellungiella halophila* and *Arabidopsis thaliana*: Rapalexin A, wasalexins and camalexin. *Phytochemistry* 69: 889-893.
- Pedras, M.S.C., Chumala, P.B. and Suchy, M. 2003a. Phytoalexins from *Thlaspi arvense*, a wild crucifer resistant to virulent *Leptosphaeria maculans*: Structures, syntheses and antifungal activity. *Phytochemistry (Amsterdam)* 64: 949-956.
- Pedras, M.S.C., Montaut, S., Zaharia, I.L., Gai, Y. and Ward, D.E. 2003b. Transformation of the host-selective toxin destruxin B by wild crucifers: probing a detoxification pathway. *Phytochemistry* 64: 957-963.
- Peisker, M., Heinemann, I. and Pfeffer, M. 1998. A study on the relationship between leaf conductance, CO<sub>2</sub> concentration and carboxylation rate in various species. *Photosynth. Res.* 56: 35-43.
- Peláez, F., Collado, J., Arenal, F., Basilio, A., Cabell, A., Diez-Matas, M.T., Garcia, J.B., Del Val, A., Gonzalez, V., Gorroochategui, J., Hernandez, P., Martin, I., Platas, G. and Vicente, F. 1998. Endophytic fungi from plants living on gypsum soils as a source of secondary metabolites with antimicrobial activity. *Mycol. Res.* 102: 755-761.
- Peterson, C.J., Cosse, A. and Coats, J.R. 2000. Insecticidal components in the meal of *Crambe abyssinica*. *J. Agric. Urban Entomol.* 17: 27-36.
- Plessers, A.G., McGregor, W.G., Carson, R.B. and Nakoneshny, W. 1962. Species trials with oilseed plants II. Camelina. *Can. J. Plant Sci.* 42: 452-459.
- Ploschuk, E.L., Slafer, G.A. and Ravetta, D.A. 2005. Reproductive allocation of biomass and nitrogen in annual and perennial *Lesquerella* crops. *Ann. Bot. (London)* 96: 127-135.
- Ploschuk, E.L., Windauer, L. and Ravetta, D.A. 2001. Potential value of traits associated with perennial habit in the development of new oil-seed crops for arid lands. A comparison of *Lesquerella fendleri* and *L. mendocina* subjected to water stress. *J. Arid Environ.* 47: 373-386.
- Plowman, A.B. and Richards, A.J. 1997. The effect of light and temperature on competition between atrazine susceptible and resistant *Brassica rapa*. *Ann. Bot. (London)* 80: 583-590.
- Plowman, A.B., Richards, A.J. and Tremayne, M.A. 1999. Environmental effects on the fitness of triazine-resistant and triazine-susceptible *Brassica rapa* and *Chenopodium album* in the absence of herbicide. *New Phytol.* 141: 471-485.
- Pollard, A.J. and Baker, A.J.M. 1996. Quantitative genetics of zinc hyperaccumulation in *Thlaspi caerulescens*. *New Phytol.* 132: 113-118.
- Pollard, A.J. and Baker, A.J.M. 1997. Deterrence of herbivory by zinc hyperaccumulation in *Thlaspi caerulescens* (Brassicaceae). *New Phytol.* 135: 655-658.
- Popova, O.V., Yang, O., Dietz, K.J. Gollack, D. 2008. Differential transcript regulation in *Arabidopsis thaliana* and the halotolerant *Lobularia maritima* indicates genes with potential function in plant salt adaptation. *Gene (Amsterdam)* 423: 142-148.

### **Brassicaceae: Wild Crucifer Species as Sources of Traits**

- Pradhan, A.K., Mukopadhyay, A. and Pental, D. 1991. Identification of the putative cytoplasmic donor of a cms system in *Brassica juncea*. *Plant Breed.* 106: 204-208.
- Prakash, S. and Bhat, S.R. 2007. Contribution of wild crucifers in *Brassica* improvement : past accomplishment and future perspectives. *Proc. GCIRC 12th Int. Rapeseed Congr.* 1: 213-215.
- Prakash, S. and Chopra, V.L. 1988a. Introgression of resistance to pod shatter in *Brassica napus* from *Brassica juncea* through non-homologous recombination. *Plant Breed.* 101: 167-168.
- Prakash, S. and Chopra, V.L. 1988b. Synthesis of alloplasmic *Brassica campestris* and induction of cytoplasmic male sterility. *Plant Breed.* 101: 253-255.
- Prakash, S., Ahuja, I. Upreti, H.C., Kumar, V.D., Bhat, S.R., Kirti, P.B., Chopra, V.L. 2001. Expression of male sterility in alloplasmic *Brassica juncea* with *Erucastrum canariense* cytoplasm and the development of a fertility restoration system. *Plant Breed.* 120: 479-482.
- Prakash, S., Kirti, P.B., Bhat, S.R., Gaikwad, K., Kumar, V.D. and Chopra, V.L. 1998. A *Moricandia arvensis*-based cytoplasmic male sterility and fertility restoration system in *Brassica juncea*. *Theor. Appl. Genet.* 97: 488-492.
- Prasad, M.N.V. and Freitas, H.M.O. 2003. Metal hyperaccumulation in plants - Biodiversity prospecting for phytoremediation technology. *Electronic Journal of Biotechnol.* [http://www.ejbiotechnology.info/content/vol6/issue\\_3/index.html](http://www.ejbiotechnology.info/content/vol6/issue_3/index.html)
- Prem, D., Gupta, K., Sarkar, G. and Agnihotri, A. 2008. Activated charcoal induced high frequency microspore embryogenesis and efficient doubled haploid production in *Brassica juncea*. *Plant Cell Tissue Organ Cult.* 93: 269-282.
- Przedpelska, E. and Wierzbicka, M. 2007. *Arabidopsis arenosa* (Brassicaceae) from lead-zinc waste heap in southern Poland – a plant with high tolerance to heavy metals. *Plant Soil* 299: 43-53.
- Putnam, D.H., Budin, J.T., Field, L.A. and Breene, W.M. 1993. Camelina: a promising low-input oilseed. Pages 314–322 in J. Janick and J. E. Simon, eds. *New crops: Exploration, research, and commercialization*. John Wiley & Sons, New York, NY.
- Pysek, P. 1998. Is there a taxonomic pattern to plant invasions? *Oikos* 82: 282-294.
- Ramachandran, S., Buntin, G.D., All, J.N. and Raymer, P.L. 1998. Diamondback moth (Lepidoptera: Plutellidae) resistance of *Brassica napus* and *B. oleracea* lines with differing leaf characteristics. *J. Econ. Entomol.* 91: 987-992.
- Ramsey, A.D. and Ellis, P.R. 1994. Resistance in wild brassicas to the cabbage whitefly, *Aleyrodes proletella*. ISHS Symposium on Brassicas, 9<sup>th</sup> Crucifer Genetics Workshop, Lisbon, Portugal, Abstracts p 32.
- Rana, J.S., Khokhar, K.S. and Singh, H. 1995. Relative susceptibility of *Brassica* species to mustard aphid, *Lipaphis erysimi* (Kalt.). *J. Insect Sci.* 8: 96-97.
- Rao, G.U. and Shivanna, K.R. 1996. Development of a new alloplasmic CMS *Brassica napus* in the cytoplasmic background of *Diplotaxis siifolia*. *Cruciferae Newsl. Eucarpia* 18: 68-69.
- Rao, G.U., Batra-Sarup, V., Prakash, S. and Shivanna, K.R. 1994. Development of new cytoplasmic male-sterility system in *Brassica juncea* through wide hybridization. *Plant Breed.* 112: 171-174.

### **Brassicaceae: Wild Crucifer Species as Sources of Traits**

- Rao, G.U., Pradhan, A.K. and Shivanna, K.R. 1998. Isolation of useful variants in alloplasmic crop brassicas in the cytoplasmic background of *Erucastrum gallicum*. *Euphytica* 103: 301-306.
- Rashid, H., Toriyama, K. and Hinata, K. 1996. Transgenic plant production from leaf disc of *Moricandia arvensis* using *Agrobacterium tumefaciens*. *Plant Cell Rep.* 15: 799-803.
- Ravetta, D.A. and Soriano, A. 1998. Alternatives for the development of new industrial crops for Patagonia. *Ecol. Austral.* 8: 297-307.
- Razmjoo, K., Toriyama, K., Ishii, R. and Hinata, K. 1996. Photosynthetic properties of hybrids between *Diplotaxis muralis* DC, a C3 species, and *Moricandia arvensis* (L.) DC, a C3-C4 intermediate species in Brassicaceae. *Genes Genet. Syst.* 71: 189-192.
- Reeves, R.D. and Adiguzel, N. 2008. The nickel hyperaccumulating plants of the serpentines of Turkey and adjacent areas: A review with new data. *Turkish J. Biol.* 32: 143-153.
- Rehn, F., Arbeiter, A. and Siemens, J. 2004. The gene RPB1 confers resistance of *Arabidopsis thaliana* to the obligate biotrophic parasite *Plasmodiophora brassicae*. *Brassica 2004, 4th ISHS Symposium Brassicas/14th Crucifer Genet Workshop*, Abst p. 137.
- Renwick, J.A.A. 2002. The chemical world of crucivores: Lures, treats and traps. *Entomol. Exp. Appl.* 104: 35-42.
- Rimmer, S.R. and van den Berg, C.J.G. 1992. Resistance of oilseed *Brassica* spp. to blackleg caused by *Leptosphaeria maculans*. *Can. J. Plant Pathol.* 14: 56-66.
- Riungu, T.C. and McVetty, P.B.E. 2000. *Diplotaxis muralis* (mur) cytoplasmic male sterility system maintainer occurrence and frequency in summer rape. *Can. J. Plant Sci.* 80: 587-589.
- Riungu, T.C. and McVetty, P.B.E. 2003a. Development and evaluation of *Diplotaxis muralis* (mur) cytoplasmic male sterility system in summer rape. *Can. J. Plant Sci.* 83: 261-269.
- Riungu, T.C. and McVetty, P.B.E. 2003b. Inheritance of maintenance and restoration of the *Diplotaxis muralis* (mur) cytoplasmic male sterility system in summer rape. *Can. J. Plant Sci.* 83: 515-518.
- Roberts, K.J. and Anderson, R.C. 2001. Effect of garlic mustard (*Alliaria petiolata* (Beib. Cavara and Grande)) extracts on plants and arbuscular mycorrhizal (AM) fungi. *Am. Midl. Nat.* 146: 146-152.
- Robinson, B., Duwig, C., Bolan, N., Kannathasan, M. and Saravanan, A. 2003. Uptake of arsenic by New Zealand watercress (*Lepidium sativum*). *Science Total Environ.* 301: 67-73.
- Rodman, J.E. 1974. Systematics and evolution of the genus *Cakile* (Cruciferae). *Contr. Gray Herb.* 205: 3-146.
- Rodman, J.E. 1976. Differentiation and migration of *Cakile* (Cruciferae): seed glucosinolate evidence. *Syst. Bot.* 1: 137-148.
- Rollins, R.C. 1993. *The Cruciferae of Continental North America*. Stanford University Press, Stanford, Calif.
- Roux, F., Matejicek, A. and Reboud, X. 2005a. Response of *Arabidopsis thaliana* to 22 ALS inhibitors: baseline toxicity and cross-resistance of *csr1-1* and *csr1-2* resistant mutants. *Weed Res.* 45: 220-227.

### Brassicaceae: Wild Crucifer Species as Sources of Traits

- Roux, F., Matejcek, A., Gasquez, J. and Reboud, X. 2005b. Dominance variation across six herbicides of the *Arabidopsis thaliana* csr1-1 and csr1-2 resistance alleles. *Pest Manag. Sci.* 61: 1089-1095.
- Roy, B.A. 1995. The breeding systems of six species of *Arabis* (Brassicaceae). *Am. J. Bot.* 82: 869-877.
- Roy, B.A. and Rieseberg, L.H. 1989. Evidence for apomixis in *Arabis*. *J. Hered.* 80: 506-508.
- Ruwandi, A. and Gillott, C. 1998. Resistance of *Brassica*, especially *B. juncea* (L.) Czern, genotypes to the diamondback moth, *Plutella xylostella* (L.). *Crop Prot.* 17: 85-94.
- Rygulla, W., Friedt, W., Seyis, F., Luehs, W., Eynck, C., von Tiedemann, A. and Snowdon, R.J., 2007a. Combination of resistance to *Verticillium longisporum* from zero erucic acid *Brassica oleracea* and oilseed *Brassica rapa* genotypes in resynthesized rapeseed (*Brassica napus*) lines. *Plant Breed.* 126: 596-602.
- Rygulla, W., Snowdon, R.J., Eynck, C., Koopmann, B., von-Tiedemann, A., Luehs, W. and Friedt, W. 2007b. Broadening the genetic basis of *Verticillium longisporum* resistance in *Brassica napus* by interspecific hybridization. *Phytopathology* 97: 1391-1396.
- Rylott, E.L., Metzloff, K., and Rawsthorne, S. 1998. Developmental and environmental effects on the expression of the C<sub>3</sub>-C<sub>4</sub> intermediate phenotype in *Moricandia arvensis*. *Plant Physiol.* 118: 1277-1284.
- Salisbury, P.A. 1987. Blackleg resistance in weedy crucifers. *Cruciferae Newsl. Eucarpia* 12: 90.
- Salisbury, P.A. 1989. Potential utilization of wild crucifer germplasm in oilseed *Brassica* breeding. *Proc. 7th Austral. Rapeseed Agron. Breeders Workshop*, pp: 51-53.
- Salywon, A. M.; Dierig, D.A.; Rebman, J.P.; de Rodriguez, D.J. 2005. Evaluation of new *Lesquerella* and *Physaria* (Brassicaceae) oilseed germplasm. *Am. J. Bot.* 92: 53-62.
- Sánchez-Yélamo, M.D. 1994. A chemosystematic survey of flavonoids in the Brassicinae: *Diplotaxis*. *Bot. J. Linn. Soc.* 115: 9-18.
- Sánchez-Yélamo, M.D. 2000. Occurrence of phenolic compounds in *Erucastrum* and *Brassica* (Brassicinae). *Cruciferae Newsl. Eucarpia* 22: 9-10.
- Sánchez-Yélamo, M.D. 2001. Study of flavonoid patterns in some species of *Erucastrum* (Brassicinae). *Cruciferae Newsl. Eucarpia* 23: 5-6.
- Sánchez-Yélamo, M.D. 2002. Comparative analysis of phenolic compounds among some species of the genus *Brassica* from Sect. *Sinapistrum* and Sect. *Micropodium*. *Eucarpia Cruciferae Newsl.* 24: 19-20.
- Sánchez-Yélamo, M.D. 2004. Taxonomic relationships among *Erucastrum* and *Brassica* species based on flavonoid compounds. *Cruciferae Newsl. Eucarpia* 25:13-14.
- Sang, J.P., Minchinton, I.R., Johnstone, P.K. and Truscott, R.J.W. 1984. Glucosinolate profiles in the seed, root and leaf tissue of cabbage, mustard, rapeseed, radish and swede. *Can. J. Plant Sci.* 64: 77-93.
- Sarfraz, M., Dossdall, L.M. and Keddie, B.A. 2007. Resistance of some cultivated Brassicaceae to infestations by *Plutella xylostella* (Lepidoptera: Plutellidae). *J. Econ. Entomol.* 100: 215-224.

### **Brassicaceae: Wild Crucifer Species as Sources of Traits**

- Schranz, M.E., Dobes, C., Koch, M.A., and Mitchell-Olds, T. 2005. Sexual reproduction, hybridization, apomixis, and polyploidization in the genus *Boechea* (Brassicaceae). *Am. J. Bot.* 92: 1797-1810.
- Schranz, M.E., Lysak, M.A. and Mitchell-Olds, T. 2006a. The ABC's of comparative genomics in the *Brassicaceae*: building blocks of crucifer genomes. *Trends Plant Sci.* 11: 535-542.
- Schranz, M.E., Kantama, L., de-Jong, H., and Mitchell-Olds, T. 2006b. Asexual reproduction in a close relative of *Arabidopsis*: a genetic investigation of apomixis in *Boechea* (Brassicaceae). *New Phytol.* 171: 425-438.
- Schranz, M.E., Song, B.-H., Windsor, A.J., Lawton-Rauh, A., and Mitchell-Olds, T. 2007a. Comparative genomics in the Brassicaceae: a family-wide perspective. *Curr. Opin. Plant Biol.* 10: 168-175.
- Schranz, M.E., Windsor, A.J., Song, B.-H., Lawton-Rauh, A., and Mitchell-Olds, T. 2007b. Comparative genetic mapping in *Boechea stricta*, a close relative of *Arabidopsis*. *Plant Physiol. (Rockville)* 144: 286-298.
- Schroder-Pontoppidan, M., Skarzhinskaya, M., Dixelius, C., Stymne, S. and Glimelius, K. 1999. Very long chain and hydroxylated fatty acids in offspring of somatic hybrids between *Brassica napus* and *Lesquerella fendleri*. *Theor. Appl. Genet.* 99: 108-114.
- Schuster, A. and Friedt, W. 1998. Glucosinolate content and composition as parameters of quality of *Camelina* seed. *Industr. Crops Prod.* 7: 297-302.
- Séguin-Swartz, G, Warwick, S.I. and R. Scarth, R. 1997. Cruciferae: Compendium of Trait Genetics. Agriculture and Agri-Food Research Branch Tech. Bull. No. 1997-3E. and pdf file; <http://www.brassica.info>.
- Sharma T.R. and Singh, B.M. 1992. Transfer of resistance to *Alternaria brassicae* in *Brassica juncea* through interspecific hybridization among *Brassica*. *J. Genet. Breed.* 46: 373-378.
- Sharma, G., Kumar, V.D., Haque, A., Bhat, S.R., Prakash, S., Chopra, V.L. 2002. *Brassica* coenospecies: A rich reservoir for genetic resistance to leaf spot caused by *Alternaria brassicae* *Euphytica* 125: 411-417.
- Sharma, N., Cram, D., Huebert, T., Zhou, N. and Parkin, I.A.P. 2007. Exploiting the wild crucifer *Thlaspi arvense* to identify conserved and novel genes expressed during a plant's response to cold stress. *Plant Mol. Biol.* 63: 171-184.
- Shukla, V.K.S., Dutta, P.C. and Artz, W.E. 2002. Camelina oil and its unusual cholesterol content. *J. Am. Oil Chem. Soc.* 79: 965-969.
- Siemens, J. 2002. Interspecific hybridisation between wild relatives and *Brassica napus* to introduce new resistance traits into the oilseed rape gene pool. *Czechoslov J. Genet. Plant Breed.* 38: 155-157.
- Siemens, J., Köhn, C., and Sacristán, M.D. 1995. Plant regeneration from root explants of *Matthiola incana* (L.) R.Br. and transformation attempts. *Cruciferae Newsl. Eucarpia* 17: 42-43.
- Sigareva, M.A., Ren, J.P. and Earle, E.D. 2000. Introgression of resistance to *Alternaria* leaf spot from *Sinapis alba* to *Brassica oleracea* via somatic hybridization and backcrosses. 3<sup>rd</sup> ISHS Int. Symp. Brassicas/12<sup>th</sup> Cruciferae Genet. Workshop, abstract p074.
- Sikdar, S.R., Chatterjee, G., Das, S. and Sen, S.K. 1987. Regeneration of plants from mesophyll

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- protoplasts of the wild crucifer *Eruca sativa* Lam. Plant Cell Rep. 8: 722-725.
- Sikdar, S.R., Sengupta, S., Das, S. and Sen, S.K. 1990. Plant regeneration from mesophyll protoplasts of *Diplotaxis muralis*, a wild crucifer. Plant Cell Rep. 6: 486-489.
- Singh, K.H., Gupta, M.C. and Srivastava, K.K. 2003. Agro-morphological characterization of different CMS systems in Indian mustard (*Brassica juncea* (L.) Czern & Coss). Proc. GCIRC 11th Int. Rapeseed Congr. 2: 507.
- Singh, M.P. and Kolte, S.J. 1999. Differential reactions of various crucifer host species against isolates of *Peronospora parasitica*. J. Mycol. Plant Pathol. 29: 118-121.
- Singh, R., Ellis, P.R., Pink, D.A.C. and Phelps, K. 1994. An investigation of the resistance to cabbage aphid in brassica species. Ann. Appl. Biol. 125: 457-465.
- Singh, S.P. and Sachan, G.C. 1997. Effect of different temperatures and host plants on the developmental behaviour of mustard sawfly, *Athalia proxima*. Indian J. Entomol. 59: 34-40.
- Skarjinskaia, M., Svab, Z. and Maliga, P. 2003. Plastid transformation in *Lesquerella fendleri*, an oilseed Brassicaceae. Transgenic Res. 12: 115-122.
- Smisek, A., Doucet, C., Jones, M., and Weaver, S. 1998. Paraquat resistance in horseweed (*Conyza canadensis*) and Virginia pepperweed (*Lepidium virginicum*) from Essex County, Ontario. Weed Sci. 46: 200-204.
- Smit, J.J. and Cairns, A.L.P. 2001. Resistance of *Raphanus raphanistrum* to chlorsulfuron in the Republic of South Africa. Weed Res. 41: 41-47.
- Sodhi, Y.S., Chandra, A., Verma, J.K., Arumugam, N., Mukhopadhyay, A., Gupta, V., Pental, D., Pradhan, A.K. 2006. A new cytoplasmic male sterility system for hybrid seed production in Indian oilseed mustard *Brassica juncea*. Theor. Appl. Genet. 114: 93-99.
- Soltis, J., Medrano, G. and Ghislain, M. 2007. Inhibitory effect of a defensin gene from the Andean crop maca (*Lepidium meyenii*) against *Phytophthora infestans*. J. Plant Physiol. 164: 1071-1082.
- Sonntag, K. and Gramenz, J. 2004. In vitro regeneration system in *Crambe* via protoplast culture. Cruciferae Newsl. Eucarpia 25:101-102.
- Sonntag, K. and Rudloff, E. 2001. Preliminary studies on genetic transformation of *Crambe abyssinica*. Cruciferae Newsl. Eucarpia 23: 33-34.
- Soroka, J., Gugel, R., Elliott, R., Rakow, G. and Raney, J.P. 2003. Resistance of crucifer species to insect pests. Proc. GCIRC 11<sup>th</sup> Int. Rapeseed Congr. 3: 1031-1033.
- Specht, C.E. and Diederichsen, A. 2001. Cruciferae In: Hanelt, P. (ed.) Mansfeld's Encyclopedia of Agricultural and Horticultural Crops. Springer-Verlag, Berlin, Germany Vol. 3: 1413-1481.
- Stanek, R. and Lipecki, J. 1991. Resistance to triazines of *Capsella bursa-pastoris* (L.) Med. is located in chloroplast. Resistant Pest Management 3: 27.
- Stobbs, L.W. and Stirling, A. 1990. Susceptibility of Ontario weed species to turnip mosaic virus. Canad. J. Plant Pathol. 12: 255-262.
- Stoner, K. 1990. Glossy leaf wax and plant resistance to insects in *Brassica oleracea* under natural

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- infestation. Environm. Entomol. 19: 730-739.
- Sun, W.C., Pan, Q.Y., An, X.H. and Yang, Y.P. 1991. *Brassica* and *Brassica*-related oilseed crops in Gansu, China. Proc. GCIRC 8<sup>th</sup> Int. Rapeseed Congr. pp: 1130-1135.
- Sun, W.C., Yang, Q., Zhang, J., Zhang, T. and Yun, Z. 1999. Assessment on drought tolerance of *Eruca sativa* genotypes from northwestern China. Proc GCIRC 10th Int Rapeseed Congr, Contribution 628 on CD ROM; also available at <http://www.regional.org.au/au/gcirc>
- Suwabe, K., Tsukazaki, H., Iketani, H., Hatakeyama, K., Fujimura, M., Kondo, M., Nunome, T., Fukuoka, H., Hirai, M. and Matsumoto, S. 2004. Synteny analysis of clubroot resistance loci between *Brassica rapa* and *Arabidopsis*. Program and Abstracts, 14th Crucifer Genetics Workshop/4th ISHS Symposium on Brassicas (Brassica 2004), p. 143.
- Taji, T., Seki, M., Satou, M., Sakurai, T., Kobayashi, M., Ishiyama, K., Narusaka, Y., Narusaka, M., Zhu, J.K., and Shinozaki, K. 2004. Comparative genomics in salt tolerance between *Arabidopsis* and *Arabidopsis* -related halophyte salt cress using *Arabidopsis* microarray. Plant Physiol. 135: 1697-1709.
- Tan, M.K. and Medd R. W. 2002. Characterisation of the acetolactate synthase (ALS) gene of *Raphanus raphanistrum* L. and the molecular assay of mutations associated with herbicide resistance. Plant Sci. 163: 195-205.
- Taskin, K.M., Turgut, K. and Scott, R.J. 2004. Apomictic development in *Arabis gunnisoniana*. Isr. J. Plant Sci. 52: 155-160.
- Tatsuzawa, F., Saito, N., Shinoda, K., Shigihara, A., and Honda, T. 2006. Acylated cyanidin 3-sambubioside-5-glucosides in three garden plants of the Cruciferae. Phytochemistry (Amsterdam) 67: 1287-1295.
- Tattersall, A. and Millam, S. 1999. Establishment and in vitro regeneration studies of the potential oil crop species *Camelina sativa*. Plant Cell Tissue Organ Cult. 55: 147-149.
- Tewari, J.P. 1991. Current understanding of resistance to *Alternaria brassiceae* in Cruciferae. Proc. GCIRC 8<sup>th</sup> Int. Rapeseed Congr., pp: 471-476.
- Tewari, J.P., Bansal, V.K., Tewari, I., Gómez-Campo, C., Stringam, G.R. and Thiagarajah, M.R. 1996. Reactions of some wild and cultivated accessions of *Eruca* against *Leptosphaeria maculans*. Cruciferae Newsl. Eucarpia 18: 130-131.
- Thierfelder, A., Hackenberg, E., Nichterlein, K. and Friedt, W. 1991. Development of nematode-resistant rapeseed genotypes via interspecific hybridization. Proc. GCIRC 8<sup>th</sup> Int. Rapeseed Congr., pp: 269-273.
- Thompson, K.F. 1963. Resistance to the cabbage aphid (*Brevicoryne brassicae*) in brassica plants. Nature 198: 209.
- Tian, Z.H. and Meng, J.L. 1998. Plant regeneration from cultured protoplasts of *Moricandia nitens*. Plant Cell Tissue Organ Cult. 55: 217-221.
- Turk, M.A., and Tawaha, A.M. 2003. Allelopathic effect of black mustard (*Brassica nigra* L.) on germination and growth of wild oat (*Avena fatua* L.). Crop Prot. 22: 673-677.

### Brassicaceae: Wild Crucifer Species as Sources of Traits

- Ueno, O., Bang, S.W., Wada, Y., Kondo, A., Ishihara, K., Kaneko, Y., and Matsuzawa, Y. 2003. Structural and biochemical dissection of photorespiration in hybrids differing in genome constitution between *Diplotaxis tenuifolia* (C3-C4) and radish (C3). *Plant Physiology* (Rockville) 132: 1550-1559.
- Ulmer, B.J., and Dossdall, L.M. 2006. Glucosinolate profile and oviposition behavior in relation to the susceptibilities of Brassicaceae to the cabbage seedpod weevil. *Entomol. Exp. Appl.* 12: 203-213.
- Upreti, D.C., Shyam-Prakash, P., Abrol, Y.P. and Prakash, S. 1995. Variability for photosynthesis in *Brassica* and allied genera. *Indian J. Plant Physiol.* 38: 207-213.
- Vaughn, S.F. and Berhow, M.A. 2005. Glucosinolate hydrolysis products from various plant sources: pH effects, isolation, and purification. *Industr. Crops Prod.* 21: 193-202.
- Velasco, L. and Becker, H.C. 2000. Variability for seed glucosinolates in a germplasm collection of the genus *Brassica*. *Genet. Resour. Crop Evol.* 47: 231-238.
- Velasco, L., Goffman, F., and Becker, H.C. 1998. Variability for the fatty acid composition of the seed oil in a germplasm collection of the genus *Brassica*. *Genet. Resour. Crop Evol.* 45: 371-382.
- Veldhuis, L.J., Hall, L.M., O'Donovan, J.T., Dyer, W. and Hall, J.C. 2000. Metabolism-based resistance of a wild mustard (*Sinapis arvensis* L.) biotype to ethametsulfuron-methyl. *J. Agric. Food Chem.* 48: 2986-2990.
- Verma, S.S., Chiinnusamy, V., Bansal, K.C. 2008. A simplified floral dip method for transformation of *Brassica napus* and *B. carinata*. *J. Plant Biochem. Biotechnol.* 17: 197-200.
- Vicente, J.G., Conway, J., King, G.J. and Taylor, J.D. 2000. Resistance to *Xanthomonas campestris* pv. *campestris* in *Brassica* spp. *Acta Hort.* 539: 61-68.
- Vinterhalter, B., Savic, J., Platisa, J., Raspor, M., Ninkovic, S., Mitic, N., and Vinterhalter, D. 2008. Nickel tolerance and hyperaccumulation in shoot cultures regenerated from hairy root cultures of *Alyssum murale* Waldst. & Kit. *Plant Cell Tissue Organ Cult.* 94: 299-303.
- Vioque, J., Pastor, J. and Vioque, E. 1990. Analysis of the fatty acids and sterols of the oils of four *Brassica* species. *Lagasalia* 16: 95-103.
- Voss, A., Snowdon, R.J., Lühs, W. and Friedt, W. 2000. Intergeneric transfer of nematode resistance from *Raphanus sativus* into the *Brassica napus* genome. *Acta Hort.* 539: 129-134.
- Walker, R.L., Walker, K.C. and Booth, E.J. 2003. Adaptation potential of the novel oilseed crop, Honesty (*Lunaria annua* L.), to the Scottish climate. *Ind. Crops Prod.* 18: 7-15.
- Walsh, M.J., Duane, R.D., and Powles, S.B. 2001. High frequency of chlorsulfuron-resistant wild radish (*Raphanus raphanistrum*) populations across the Western Australian wheatbelt. *Weed Technol.* 15: 199-203.
- Walsh, M.J., Powles, S.B., Beard, B.R., Parkin, B.T., and Porter, S.A. 2004. Multiple-herbicide resistance across four modes of action in wild radish (*Raphanus raphanistrum*). *Weed Sci.* 52: 8-13.
- Walsh, M.J., Owen, M.J. and Powles, S.B. 2007. Frequency and distribution of herbicide resistance in *Raphanus raphanistrum* populations randomly collected across the Western Australian wheatbelt. *Weed Res.* 47: 542-550.
- Wan, Z., Fu, T., Tu, J., Ma, C., Shen, J. and Yi, B. 2007. Genetic classification of a newly identified



## Brassicaceae: Wild Crucifer Species as Sources of Traits

- cytoplasmic male sterility *hau* CMS system in *Brassica napus* L. Proc. GCIRC 12<sup>th</sup> Int. Rapeseed Congr. 1: 18-24.
- Wan, Z., Jing, B., Tu, J., Ma, C., Shen, J., Yi, B., Wen, J., Huang, T., Wang, X. and Fu, T. 2008. Genetic characterization of a new cytoplasmic male sterility system (*hau*) in *Brassica juncea* and its transfer to *B. napus*. Theor. Appl. Genet. 116: 355-362.
- Wang, J., Li, Y. and Liang, C. 2008a. Recovery of transgenic plants by pollen-mediated transformation in *Brassica juncea*. Transgenic Res. 17: 417-424.
- Wang, X., Ping, L., Bonnema, G., Baojun, Y., Heyan, H., Hangjun, H., Yanguo, Z. and Zhiyuan, F. 2004. Chromosome mapping of a dominant male sterility gene Ms-cd1 in *Brassica oleracea*. Program and Abstracts, 14th Crucifer Genetics Workshop/4th ISHS Symposium on Brassicas (Brassica 2004), p. 93.
- Wang, Y.P., Lan, L.F., Li, X.F. and Luo, P. 1999. A preliminary assessment of some wild cruciferous oil plant[s] in the western Sichuan of China and their utilization. Cruciferae Newsl. Eucarpia 21: 29-30.
- Wang, W., Wang, C., Huang, B.L. and Huang, B. 2008b. Agrobacterium tumefaciens-mediated transformation of *Lesquerella fendleri* L., a potential new oil crop with rich lesquerolic acid. Plant Cell Tissue Organ Cult. 92: 165-171.
- Warwick, S.I. 1991. Herbicide resistance in weedy plants: physiology and population biology. Ann. Rev. Ecol. Syst. 22: 95-114.
- Warwick, S.I. and Al-Shehbaz, I.A. 2006. Brassicaceae: Chromosome number index and database on CD-Rom. Plant Syst. Evol. 259: 237-248.
- Warwick, S.I. and Black, L.D. 1993. Electrophoretic variation in triazine-resistant and susceptible populations of the allogamous weed *Brassica rapa*. Weed Res. 33: 105-114.
- Warwick, S.I. and Francis, A. 2005. The Biology of Canadian Weeds 132. *Raphanus raphanistrum*. Can. J. Plant Sci. 85: 709-733.
- Warwick, S.I. and Francis, A. 2006. The Biology of Invasive Alien Plants in Canada. *Berteroa incana*. Can. J. Plant Sci. 86:1297-1309.
- Warwick, S.I. and Gugel, R. 2003. Genetic variation in the *Crambe abyssinica* - *C. hispanica* - *C. glabrata* complex. Genet. Resour. Crop Evol. 50: 291-305.
- Warwick, S.I. and Wall, D.A. 1998. Biology of Canadian Weeds: *Erucastrum gallicum*. Can. J. Plant Sci. 78: 155-165.
- Warwick, S.I., Beckie, H., Thomas, G. and McDonald, T.A. 2000. Biology of Canadian Weeds 8. *Sinapis arvensis* L. (updated). Can. J. Plant Sci. 80: 939-961.
- Warwick, S.I., Francis, A. and Al-Shehbaz, I.A. 2006a. Brassicaceae: Species checklist and database on CD-Rom. Plant Syst. Evol. 259: 249-258.
- Warwick, S.I., Francis, A. and Mulligan, G.A. 1999. Brassicaceae of Canada. Agric. and Agri-Food Canada, Electronic publication. [<http://res.agr.ca/ecorc/cwmt/crucican>]
- Warwick, S.I., Francis, A., and La Fleche, J. 2000. Guide to Wild Germplasm of Brassica and Allied Crops (tribe Brassiceae, Brassicaceae. 2nd Edition. Agriculture and Agri-food Research Branch Publication,

## Brassicaceae: Wild Crucifer Species as Sources of Traits

- ECORC Ottawa, Canada. Contribution No. 991475. [<http://www.brassica.info>]
- Warwick, S.I., Francis, A., and Susko, D.J. 2002. The biology of Canadian weeds 9. *Thlaspi arvense* L. (updated), Can. J. Plant Sci. 82: 803-823.
- Warwick, S.I., Gugel, R.K., Gómez-Campo, C. and James, T. 2007. Genetic variation in the *Eruca vesicaria* (L.) Cav. Plant Genet. Resour. Charact. Util. 5: 142-153.
- Warwick, S.I., Gugel, R., McDonald T. and Falk, K. 2006b. Genetic variation and agronomic potential of Ethiopian mustard (*Brassica carinata*) in western Canada. Genetic Resour. Crop Evol. 53: 297-312.
- Warwick, S. I., Sauder, C. and Beckie, H.J. 2005. Resistance in Canadian biotypes of wild mustard (*Sinapis arvensis* L.) to acetolactate synthase (ALS)-inhibiting herbicides. Weed Sci. 53: 631-639.
- Wechter, W.P., Farnham, M.W., Smith, J.P., and Keinath, A.P. 2007. Identification of resistance to peppery leaf spot among *Brassica juncea* and *Brassica rapa* plant introductions. HortScience 42:1140-1143.
- Westman, A.L. and Dickson, M.H. 1998. Disease reaction to *Alternaria brassicicola* and *Xanthomonas campestris* pv. *campestris* in *Brassica nigra* and other weedy crucifers. Cruciferae Newsl. Eucarpia 20: 87-88.
- Westman, A.L., Kresovich, S., and Dickson, M.H. 1999. Regional variation in *Brassica nigra* and other weedy crucifers for disease reaction to *Alternaria brassicicola* and *Xanthomonas campestris* pv. *campestris*. Euphytica 106: 253-259.
- Williams, P.H. and Pound, G.S. 1963. Nature and inheritance of resistance to *Albugo candida* in radish. Phytopathology 53: 1150-1154.
- Winter, H., Gaertig, S., Diestel, A. and Sacristán, M.D. 1999. Blackleg resistance of different origin transferred into *Brassica napus*. Proc GCIRC 10th Int Rapeseed Congr., Contribution 593 on CD ROM; also available at <http://www.regional.org.au/au/gcirt>
- Winter, H., Snowdon, R.J., Bellin, U., Krone, N. and Sacristán, M.D. 2002. Blackleg resistance gene transfer into *Brassica napus* from related species. 13th Crucifer Genet. Workshop, Davis, California, USA. Abst p. 15.
- Winter, H., Diestel, A., Gärtig, S., Krone, N., Sterenberg, K. and Sacristán, M.D. 2003. Transfer of new blackleg resistances into oilseed rape. Proc. GCIRC 11th Int. Rapeseed Congr. 1:19-21.
- Wong, C.E., Li, Y., Whitty, B.R., Diaz-Camino, C., Akhter, S.R., Brandle, J.E., Golding, G.B., Weretilnyk, E.A., Moffatt, B.A., and Griffith, M. 2005. Expressed sequence tags from the Yukon ecotype of *Thellungiella* reveal that gene expression in response to cold, drought and salinity shows little overlap Plant Mol. Biol. 58: 561-574.
- Wu, Y.-V. and Hojilla-Evangelista, M.P. 2005. *Lesquerella fendleri* protein fractionation and characterization. J. Am. Oil Chem. Soc. 82: 53-56.
- Wu, Y.-Y., Li, P.P., Zhao Y.G., Wang, J.Z. and Wu, X.M. 2007. Study on photosynthetic characteristics of *Orychophragmus violaceus* related to shade-tolerance. Scientia Horticulturae 113: 173-176.
- Xu, T.F., Zhang, L., Sun, X.F. Zhang, H., and Tang, K. 2004. Production and analysis of organic acids in hairy-root cultures of *Isatis indigotica* Fort. Biotechnol. Appl. Biochem. 39: 123.

### Brassicaceae: Wild Crucifer Species as Sources of Traits

- Yadav, Y.P. 2002. Lb siliqua mutant in taramira (*Eruca sativa* Mill.). *Cruciferae Newsl. Eucarpia* 24: 21-22.
- Yajima, W., Hall, J.C., and Kav, N.N.V. 2004. Proteome-level differences between auxinic-herbicide-susceptible and -resistant wild mustard (*Sinapis arvensis* L.). *J. Agric. Food Chem.* 52: 5063-5070.
- Yamagishi, H. 1998. Distribution and allelism of restorer genes for Ogura cytoplasmic male sterility in wild and cultivated radishes. *Genes Genet. Syst.* 73: 79-83.
- Yan, Z., Tian, Z. Huang, B., Huang, R. and Meng, J. 1999. Production of somatic hybrids between *Brassica oleracea* and the C<sub>3</sub>-C<sub>4</sub> intermediate species *Moricandia nitens*. *Theor. Appl. Genet.* 99: 1281-1286.
- Yang C. and Mu, X. 2006. Allelopathic effects of companion weed *Descurainia sophia* on wheat. *Yingyong Shengtai Xuebao* 17: 2389-2393.
- Yang, T.-J., Kim, J.-S., Lim, K.-B., Kwon, S.-J., Kim, J.-A., Jin, M., Park, J.Y., Lim, M.-H., Kim, H.-I., Kim, S.Y., Lim, Y.P., and Park, B.-S. 2005. The Korea *Brassica* Genome Project: a glimpse of the *Brassica* genome based on comparative genome analysis with *Arabidopsis*. *Comp. Funct. Genomics* 6: 138-146.
- Yaniv, Z, Elber, Y., Zur, M. and Schafferman, D. 1991. Differences in fatty acid composition of oils of wild cruciferae seed. *Phytochemistry* 30: 841-843.
- Yaniv, Z., Elber, Y., Schafferman, D., Ben-Moshe, E. and Zur, M. 1995. A survey of crucifers native to Israel, as a source of oils. *Plant Genet. Resour. Newsl.* 101: 1-5.
- Yaniv, Z., Schafferman, D., and Amar, Z. 1998. Tradition, uses and biodiversity of rocket (*Eruca sativa*, Brassicaceae in Israel. *Econ. Bot.* 52: 394-400.
- Yaniv, Z., Schafferman, D., Elber, Y., Ben-Moshe, E. and Zur, M. 1994. Evaluation of *Sinapis alba*, native to Israel, as a rich source of erucic acid in seed oil. *J. Industr. Crops* 2: 137-142.
- Yaniv, Z., Schafferman, D., Zur, M. and Shamir, I. 1997. Evaluation of *Matthiola incana* as a source of omega-3-linolenic acid. *Industr. Crops Prod.* 6: 285-289.
- Yu, Q., Zhang, X.-Q., Hashem, A., Walsh, M.J. and Powles, S.B. 2003. ALS gene proline 197) mutations confer ALS herbicide resistance in eight separated wild radish (*Raphanus raphanistrum*) populations. *Weed Sci.* 51: 831-838.
- Zhang, L., Wei, Y.-T., and Li, X.-Y. 2002. A preliminary study on the restoring-maintaining relationship in radish (*Raphanus sativus* L.) *Cruciferae Newsl. Eucarpia* 24: 57-58.
- Zhang, L., Xu, T.F., Sun, X.F. Zhang, H., Tang, T., and Tang, K. 2003. Factors influencing shoot regeneration from cotyledons of tetraploid *Isatis indigotica* Fort. *In Vitro Cell Dev. Biol. Plant.* 39: 459-462.
- Zhang, T., Cao, Z.Y. and Wang, X.Y. 2005. Induction of somatic embryogenesis and plant regeneration from cotyledon and hypocotyl explants of *Eruca sativa* Mill. *In Vitro Cell. Dev. Biol. Plant.* 41: 655-657.
- Zhang, W., Fu, Q., Dai, X., and Bao, M. 2008. The culture of isolated microspores of ornamental kale (*Brassica oleracea* var. *acephala*) and the importance of genotype to embryo regeneration. *Sci. Hort. (Amsterdam)* 117: 69-72.

### **Brassicaceae: Wild Crucifer Species as Sources of Traits**

- Zheng, H.-G. and Hall, J.C. 2001. Understanding auxinic herbicide resistance in wild mustard: physiological, biochemical, and molecular genetic approaches. *Weed Sci.* 49: 276-281.
- Zhou, N., Robinson, S.J., Huebert, T., Bate, N.J., and Parkin, I.A.P. 2007. Comparative genome organization reveals a single copy of CBF in the freezing tolerant crucifer *Thlaspi arvense*. *Plant Mol. Biol.* 65: 693-705.
- Ziolkowski, P.A., Kaczmarek, M., Babula, D., and Sadowski, J. 2006. Genome evolution in *Arabidopsis/Brassica*: conservation and divergence of ancient rearranged segments and their breakpoints. *Plant J.* 47: 63-74.
- Zubr, J. 1997. Oil-seed crop: *Camelina sativa*. *Industr. Crops Prod.* 6: 113-119.
- Zubr, J. and Matthäus, B. 2002. Effects of growth conditions on fatty acids and tocopherols in *Camelina sativa* oil. *Industr. Crops Prod.* 15: 155-162.