Resource Book

CrGC

Crucifer Genetics Cooperative

Dept. of Plant Pathology, 1630 Linden Dr., University of Wisconsin, Madison, WI 53706

Nomenclature

- *Biology*
- *Production*
- *Utilization*

CrGC

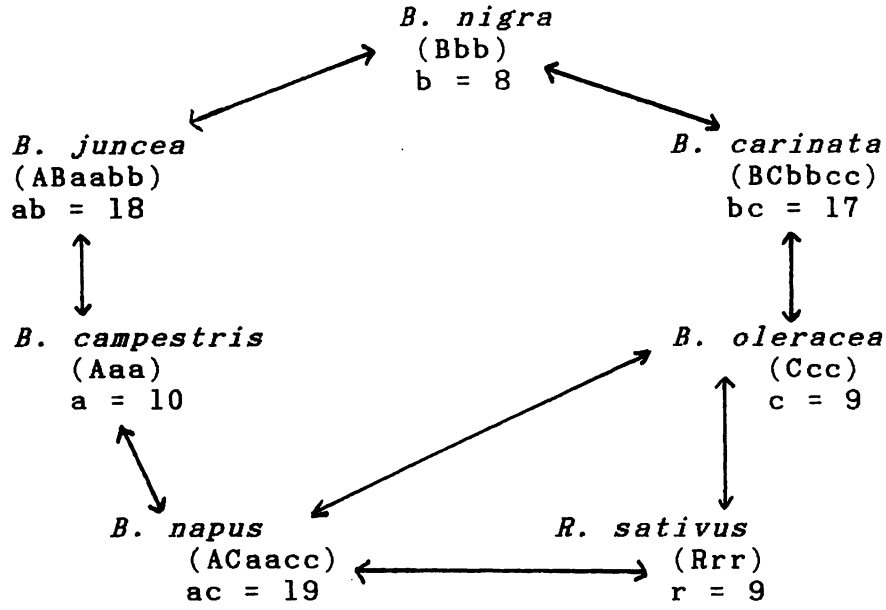
Crucifer Genetics Cooperative
Dept. of Plant Pathology, 1630 Linden Dr., University of Wisconsin, Madison, WI 53706
(608-262-6496)

CRUCIFER GENETICS COOPERATIVE
DEPT. OF PLANT PATHOLOGY, 1630 LINDEN DR., UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN 53706 (608-262-6496)

NBP 06-15-87 WILPAU

BIOLOGY, TAXONOMY, PRODUCTION AND USES OF CULTIVATED BRASSICAS AND RAPHANUS

Cultivated brassicas are represented by six interrelated species, three of which are diploids, *B. nigra*, bb (n = 8), *B. oleracea*, cc (n = 9) and *B. campestris*, aa (n = 10) and three of which are the amphidiploid derivatives of the diploid species, *B. carinata*, bbcc (n = 17), *B. juncea*, aabb (n = 18) and *B. napus*, aacc (n = 19).



Many of the *Brassica* species consist of numerous subspecies or varieties representing a diverse range of morphotypes and utilization, from oils and condiments to vegetables and animal fodders. (see CrGC-ID #, NG 05-11-85 WILPAU). Brassica oil (rapeseed oil) ranks 5th in world commerce as a major edible and industrial oil, kales, rapes, turnips and swedes are important sheep and cattle fodder in climates too cool for maize or soybeans whereas the cole crops and oriental brassica greens are a primary dietary vitamin source for over half of the world's population.

The cytogenetic interrelationships of the six *Brassica* sp. were first described by Morinaga (1934) and U (1935) and since then numerous studies have been made on the interspecific transfer of genes among various species of brassicas, Yarnell (1956), McNaughton and Ross (1978). More recently intergeneric relationships between various brassicas and radish *Raphanus sativus*, rr (n = 9) have demonstrated the transfer of

potentially useful characters such as disease resistance and high dry matter content and have resulted in the development of the new crop genus *Raphanobrassica* (McNaughton and Ross, 1978).

The three diploid species of *Brassica* are insect pollinated and strongly outbreeding with self incompatibility controlled by a multiple allelic series of genes at the S-locus and under sporophytic phenotypic expression. Occasionally genetic self compatibility can be found and is predominant in cauliflower and sarson (yellow mustard). Selfing of incompatible plants can be accomplished by bud pollination; the placing of "self" pollen on the immature stigmas, 1-2 days prior to anthesis. Selfing in the diploid species normally results in inbreeding depression. Amphidiploid species are predominantly self pollinating (75% in oil seed rape) though S-alleles do exist in some populations of amphidiploids.

BRASSICA AND RAPHANUS SEED PRODUCTION

Full development of ovules in the various brassicas results in 20-30 seeds per silique.

The reproductive forms of different brassicas range from biennial and winter annuals which may require from a few days to several months of cool temperatures (< 5 C) to induce flowering, to annual and ephemeral types which flower without vernalization. Seed production of most brassicas occurs in regions with cool (mild) winter climates where vernalization of the biennial forms takes place. Following late summer and fall sowings, flowering occurs from April through June with seed harvest in July and August.

VEGETABLE BRASSICA AND RAPHANUS SEED PRODUCTION AREAS

North America - U.S.A.
- Washington State (Puget Sound Area), Oregon and California
- all are preferred regions because dry summers minimize the seed borne diseases caused by *Xanthomonas campestris, Leptosphaeria maculans,* and *Alternaria brassicicola.*

Europe - S. England, Holland, Denmark, Central France, Italy

South Africa, Japan, Korea, China, India, New Zealand, and S.E. Australia

HYBRID PRODUCTION

Incompatibility

Many vegetable brassicas and radishes are produced as F1 hybrids using S-allele incompatibility. Selfing is accomplished by bud pollination. Selfing may also be achieved by exposure of plants to increased CO_2 levels for a few hours prior to pollination. Immature buds, 2 days prior to anthesis, are carefully opened with forceps and pollen from mature flowers

is placed on the immature stigmas. F2 and F3 and later selfed generations are tested for homozygosity and homogeneity of S-alleles via diallel analysis. Self- and sib-incompatible inbreds having different S-alleles are interplanted in F1 hybrid seed production. Depending on the degree of S-allele control in the particular breeding program, one-, two-, three-, and four-way hybrids can be made.

1. S1S1 X SxSy (open pollinated inbred)

↓

(Top cross hybrid)

2. S1S1 X S2S2

↓

(2-way cross hybrid) S1S2 → X S3S3

↓

S1S3 } → (3-way cross hybrid)
S2S3 }

3. S1S1 X S2S2 S3S3 X S4S4

↓ ↓

S1S2 → X ← S3S4

↓

S1S3 }
S1S4 } → (4-way cross hybrid)
S2S3 }
S2S4 }

Male sterility controlled by recessive *ms* genes may be used to produce F1 hybrids. Fertiles, occurring at approximately the 50% level in the stocks, are rogued from inbreds which are maintained through backcrossing.

Inbred A

ms/ms X *ms/+*

↓

Inbred B

ms/ms → X ← +/+

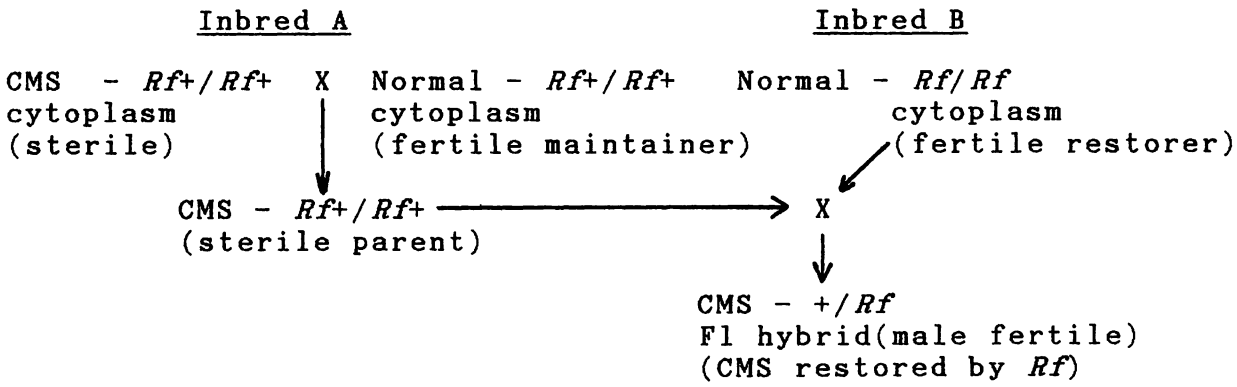
(fertile rogues or used as maintainer) → *ms/+*

↓

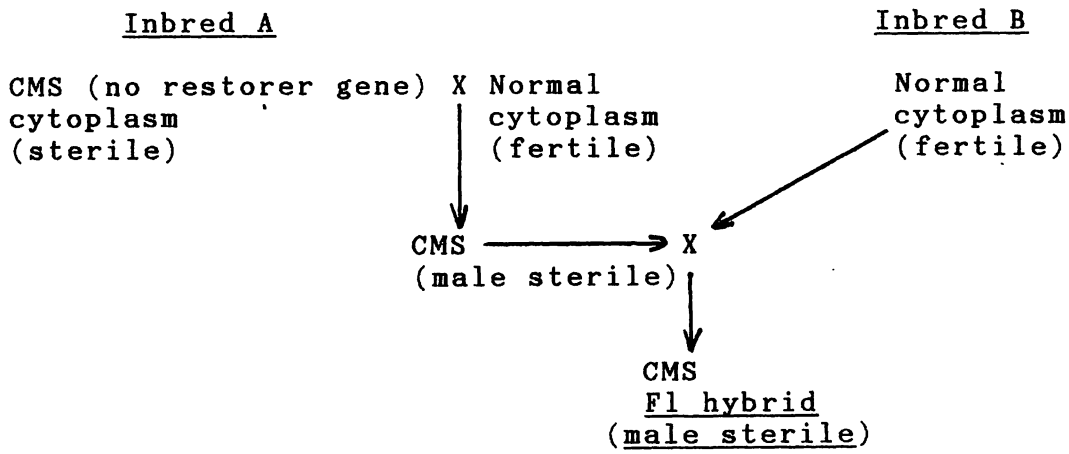
ms/+ (F1 fertile hybrid)

Cytoplasmically controlled male sterility (CMS) may be used in F1 hybrid production. This form of hybrid production has greatest utility when nuclear genes capable of restoration of the CMS are available. Fertility restoration is essential for crops whose seed is the commercial product. In the case of cytoplasmic-genic systems of pollen control, selection for bee attraction (nectary function), is very important to insure F1 hybrid production.

1. Cytoplasmic-genic



2. Cytoplasmic



In the development of CMS inbreds, in addition to adequate selection for bee attraction, care must be taken to insure that S-allele incompatibility does not impair the development of the CMS inbred or prevent the production of desireable F1 combinations. Development of CMS parents is greatly facilitated by selecting with self compatible lines for recurrent parents.

CRUCIFER GENETICS COOPERATIVE
DEPT. OF PLANT PATHOLOGY, 1630 LINDEN DR., UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN 53706 (608-262-6496)

NBPR 06-15-87 WILPAU

BIOLOGY TAXONOMY PRODUCTION AND USES OF CULTIVATED *BRASSICAS* AND *RAPHANUS*

References

Crisp, P. 1976. Trends in the breeding and cultivation of cruciferous crops. In J.G. Vaughan, A. J. MacLeod and B. M. G. Jones Eds. The Biology and Chemistry of the Cruciferae. Academic Press, London 355 p.

Harapiak, J. T. ed. 1975. Oilseed and pulse crops in Western Canada - A symposium. Western Coop. Fertilizers Inc. Calgary, 703 pp.

Li, C.W. 1980. Classification and evolution of mustard crops (*Brassica juncea*) in China. pp. 33-35. In Cruciferous Newsletter No. 5. EUCARPIA.

McFarlane-Smith, W. H. and Hodgkin, T. eds. 1984. Better Brassicas '84, Proceedings, Scottish. Crop Res. Inst. Invergowrie, 252 pp.

McNaughton, I. H. and Ross, C. L. 1978. Interspecific and intergeneric hybridization in the *Brassicae* with special emphasis on the improvement of forage crops. Scottish Plant Br. Sta. 57th Ann. Rept. Invergowrie, pp. 75-100.

Morinaga, T. 1934. Interspecific hybridization in Brassica VI. The cytology of F_1 hybrids of *B. juncea* and *B. nigra*. Cytology 6:62-67.

Nieuwhof, M. 1969. Cole Crops, CRC Press, Cleveland, 353 pp.

Shinohara, S. 1984. Vegetable Seed Production Technology of Japan Elucidated with Respective Variety Development Histories, Particulars. Shinohara's AACEO, 4-7-7 Ni Shiooi, Shinagawa-ku, Tokyo, 432 pp.

Talekar, N. S. and Griggs, T. D. eds. 1981. Chinese Cabbage. Asian Veg. Res. and Dev. Center, Shanhau. 489 pp.

Tsunoda, S. K. Hinata and Gomez-Campo, C. eds. 1980. Brassica crops and wild allies. Japan Sci. Soc. Press. Tokyo. 354 pp.

U., N. 1935. Genomic analysis in Brassica with special reference to the experimental formation of B. napus and peculiar mode of fertilization. Japan. J. Bot. 7:3890452.

Vaughan, J. G., MacLeod, A. J. and Jones, B. M. G. eds. 1976. The Biology and Chemistry of the Cruciferae. Academic Press, London. 355 pp.

Yarnell, S.H. 1956. Cytogenetics of the vegetable crops. II. Crucifers. Bot. Rev. 22:81-166.

CRUCIFER GENETICS COOPERATIVE
DEPT. OF PLANT PATHOLOGY, 1630 LINDEN DR., UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN 53706 (608-262-6496)

NG 05-11-85 WILPAU

GENOMIC DESIGNATIONS OF VARIETAL OR SUBSPECIFIC TAXA OF AGRICULTURALLY IMPORTANT BRASSICAS AND RADISH.

Brassica sp. (n)	ssp. or var.	2N genome descriptor	Common name
nigra (8)	---	bb	black mustard
oleracea (9)	---	cc	cole crops
	acephala	cc.a	kales
	alboglabra	cc.al	Chinese kale, Kailan
	botrytis	cc.b	cauliflower, heading broccoli
	capitata	cc.c	cabbage
	costata	cc.co	Portuguese cabbage
	gemmifera	cc.g	brussel sprouts
	gongylodes	cc.go	kohl rabi
	italica	cc.i	broccoli, calabrese
	medullosa	cc.m	marrow stem kale
	palmifolia	cc.p	kale (Jersey kale)
	ramosa	cc.ra	thousand-head kale
	sabauda	cc.s	savoy cabbage
	sabellica	cc.sa	collards
	selensia	cc.se	borecole
campestris (10) syn. *rapa*	---	aa	---
	chinensis	aa.c	pak choi
	narinosa	aa.na	---
	nipposinica	aa.n	---
	oleifera	aa.o	turnip rape, toria
	parachinensis	aa.pa	choy sum
	pekinensis	aa.p	Chinese cabbage, petsai
	perviridis	aa.pe	tendergreen, komatsuna, mustard spinach
	rapifera	aa.r	turnip
	trilocularis	aa.t	sarson
	utilis	aa.u	---
carinata (17)	---	bbcc	Ethiopian mustard
juncea (18)	---	aa.bb	---
	capitata	aabb.c	head mustard
	crispifolia	aabb.cr	cut leaf mustard
	faciliflora	aabb.f	broccoli mustard
	lapitata	aabb.l	large petiole mustard
	multiceps	aabb.m	multishoot mustard

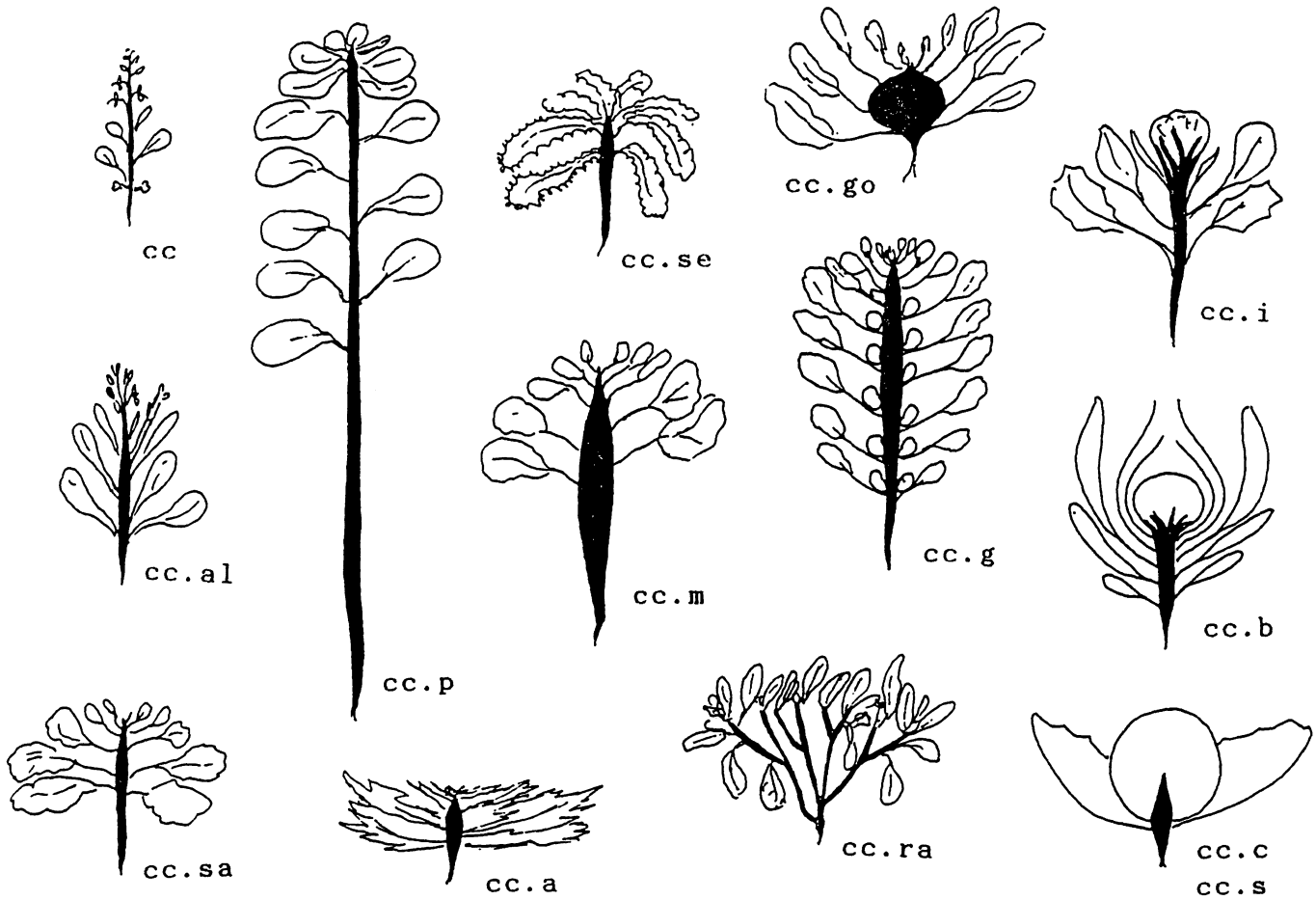
	oleifera	aabb.o	oil seed mustard, raya
	rapifera	aabb.r	root mustard
	rugosa	aabb.ru	leaf mustard
	spicea	aabb.sp	mustard
	tsa-tsai	aabb.t	big stem mustard
napus (19)	---	aacc	fodder rape
	oleifera	aacc.o	oil rape
	rapifera	aacc.r	swede, rutabaga
Raphanus	---	rr	radish
sativus (9)	*radicola*	rr.r	radish, dikon
	oleifera	rr.o	oil radish
	caudatus	rr.c	rat tail radish

CRUCIFER GENETICS COOPERATIVE
DEPT. OF PLANT PATHOLOGY, 1630 LINDEN DR., UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN 53706 (608-262-6496)

NMC 05-20-85 WILPAU

MORPHOTYPES OF VARIETAL TAXA OF *BRASSICA OLERACEA* (Ccc)

Variety	Genome	Common Name
acephala	cc.a	kales
alboglabra	cc.al	Chinese kale, Kailan
botrytis	cc.b	cauliflower, heading broccoli
capitata	cc.c	cabbage
costata	cc.co	Portuguese cabbage
gemmifera	cc.g	brussel sprouts
gongylodes	cc.go	kohl rabi
italica	cc.i	broccoli, calabrese
medullosa	cc.m	marrow stem kale
oleracea	cc	CrGC-3 base population, RC
palmifolia	cc.p	kale (Jersey kale)
ramosa	cc.ra	thousand-head kale
sabauda	cc.s	savoy cabbage
sabellica	cc.sa	collards
selensia	cc.se	borecole



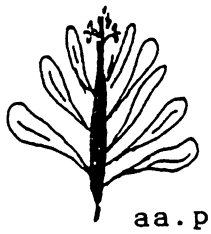
CRUCIFER GENETICS COOPERATIVE
DEPT. OF PLANT PATHOLOGY, 1630 LINDEN DR., UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN 53706 (608-262-6496)

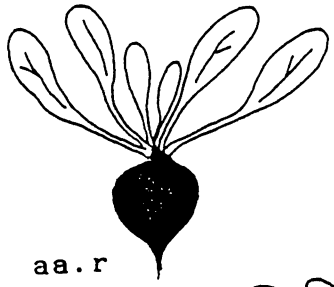
NSSA 05-20-85 WILPAU

MORPHOTYPES OF SUBSPECIFIC TAXA OF *BRASSICA CAMPESTRIS* (Aaa) (SYN. *RAPA*)

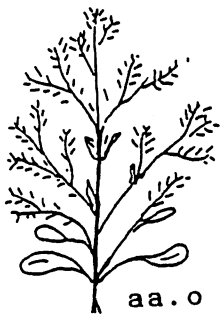
Subspecies	Genome	Common Name
campestris	aa	CrGC-1, rapid cycling base population
chinensis	aa.c	pak choi
narinosa	aa.na	---
nipposinica	aa.n	---
oleifera	aa.o	turnip rape, toria
parachinensis	aa.pa	choy sum
pekinensis	aa.p	Chinese cabbage, petsai
perviridis	aa.pe	tendergreen, komatsuna, mustard spinach
rapifera	aa.r	turnip
trilocularis	aa.t	sarson
utilis	aa.u	---

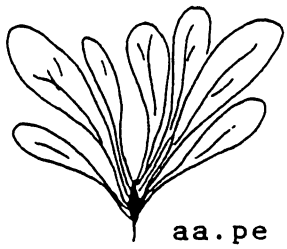

aa

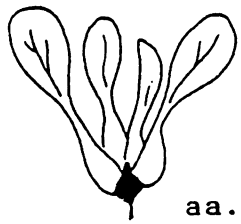

aa.pa

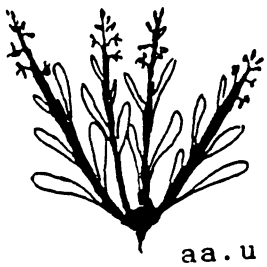

aa.r

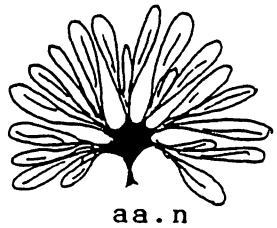

aa.na

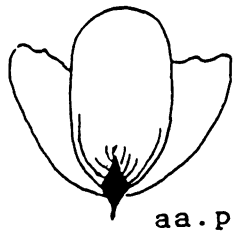

aa.o
aa.t


aa.pe


aa.c


aa.u


aa.n


aa.p