In and out:

Challenges and opportunities to use favorable genes from different subgenomes in Brassica Paradise

Jinling Meng

Huazhong Agricultural University, Wuhan, China

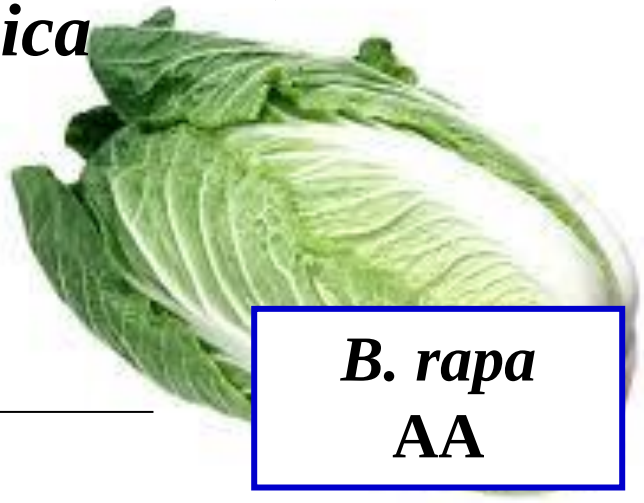
U’s triangle of *Brassica*

U's triangle of *Brassica*

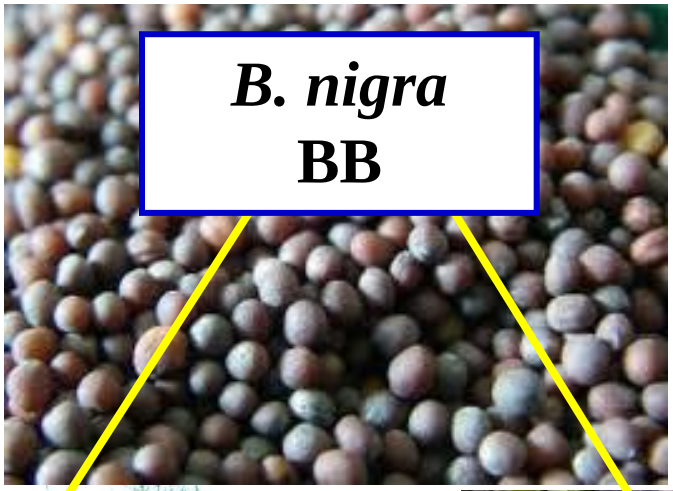
B. nigra
BB

U's triangle of *Brassica*

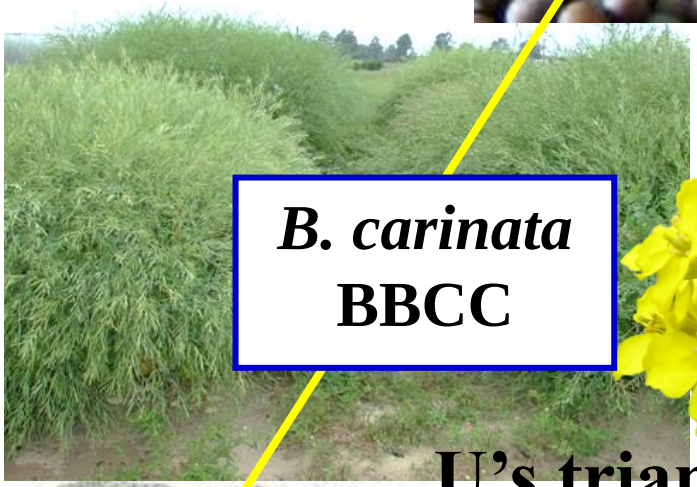
B. oleracea
CC



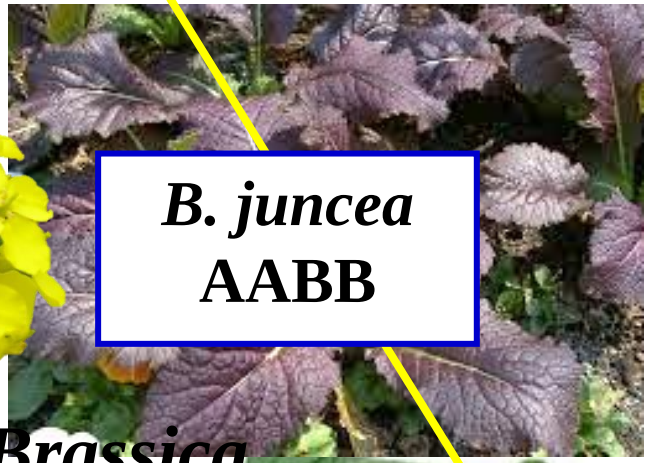
B. rapa
AA



B. nigra
BB

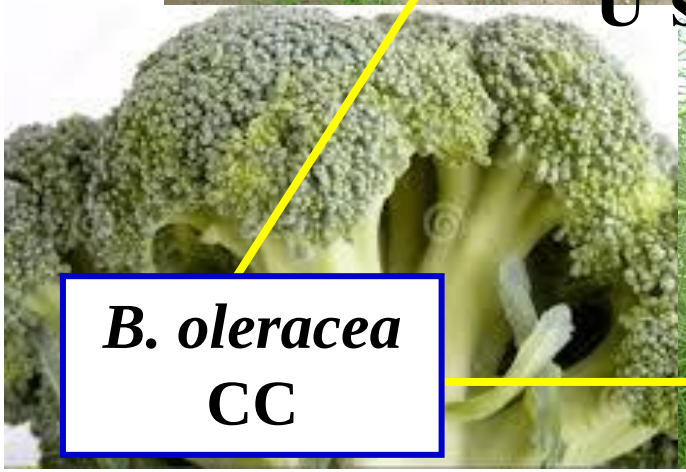


B. carinata
BBCC

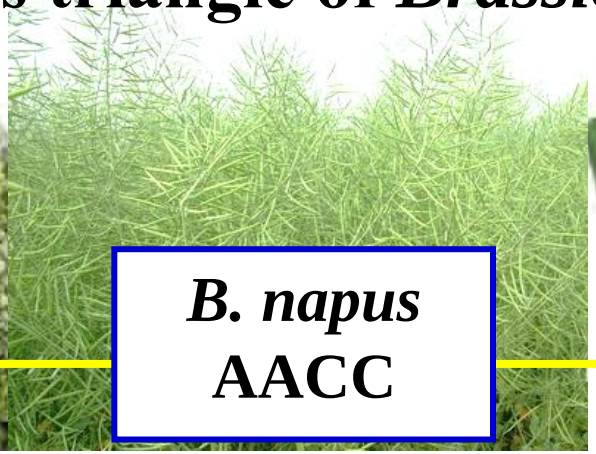


B. juncea
AABB

U's triangle of *Brassica*



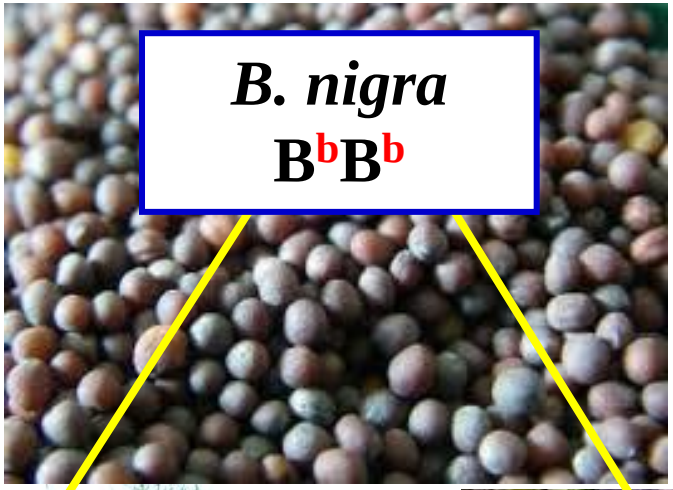
B. oleracea
CC



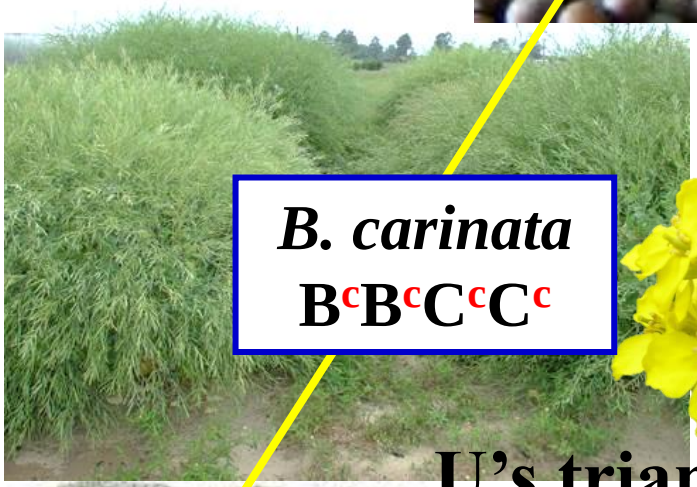
B. napus
AACC

B. rapa
AA

Subgenomes



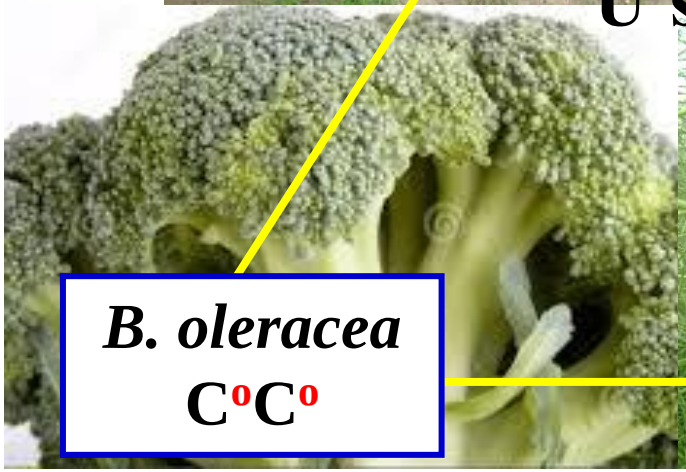
B. nigra
B^bB^b



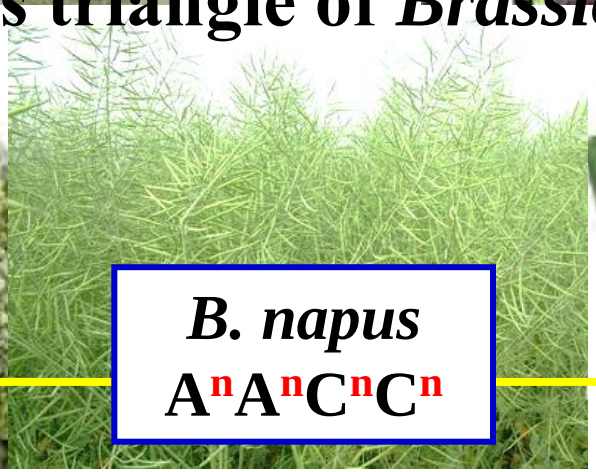
B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^jB^j$

U's triangle of *Brassica*



B. oleracea
C^oC^o



B. napus
$A^nA^nC^nC^n$

B. rapa
A^rA^r

Great diversity !

Pan-genomics

B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^jB^j$

B. oleracea
C^oC^o

B. napus
$A^nA^nC^nC^n$

B. rapa
A^rA^r

Pan-genomics

Thousands of different genes and numerous alleles there!

B. nig
B^bB^b

?

B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^jB^j$

B. napus
$A^nA^nC^nC^n$

B. rapa
A^rA^r

Chen S et al., 2011: Critical Reviews in Plant Science

Can we put different subgenomes from various species into **one** along with their specific genes?

B. nigra
B^bB^b

B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^jB^j$

Brassica hexaploid
$A^jA^jB^jB^jC^oC^o$

B. oleracea
C^oC^o

B. napus
$A^nA^nC^nC^n$

B. rapa
A^rA^r

Chen S et al., 2011: Critical Reviews in Plant Science

Can we put different subgenomes from various species into **one** along with their specific genes?

B. nigra
B^bB^b

B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^jB^j$

Brassica hexaploid
$A^nA^nB^bB^bC^nC^n$

B. oleracea
C^oC^o

B. napus
$A^nA^nC^nC^n$

B. rapa
A^rA^r

Chen S et al., 2011: Critical Reviews in Plant Science

Can we put different subgenomes from various species into **one** along with their specific genes?

B. nigra
B^bB^b

B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^jB^j$

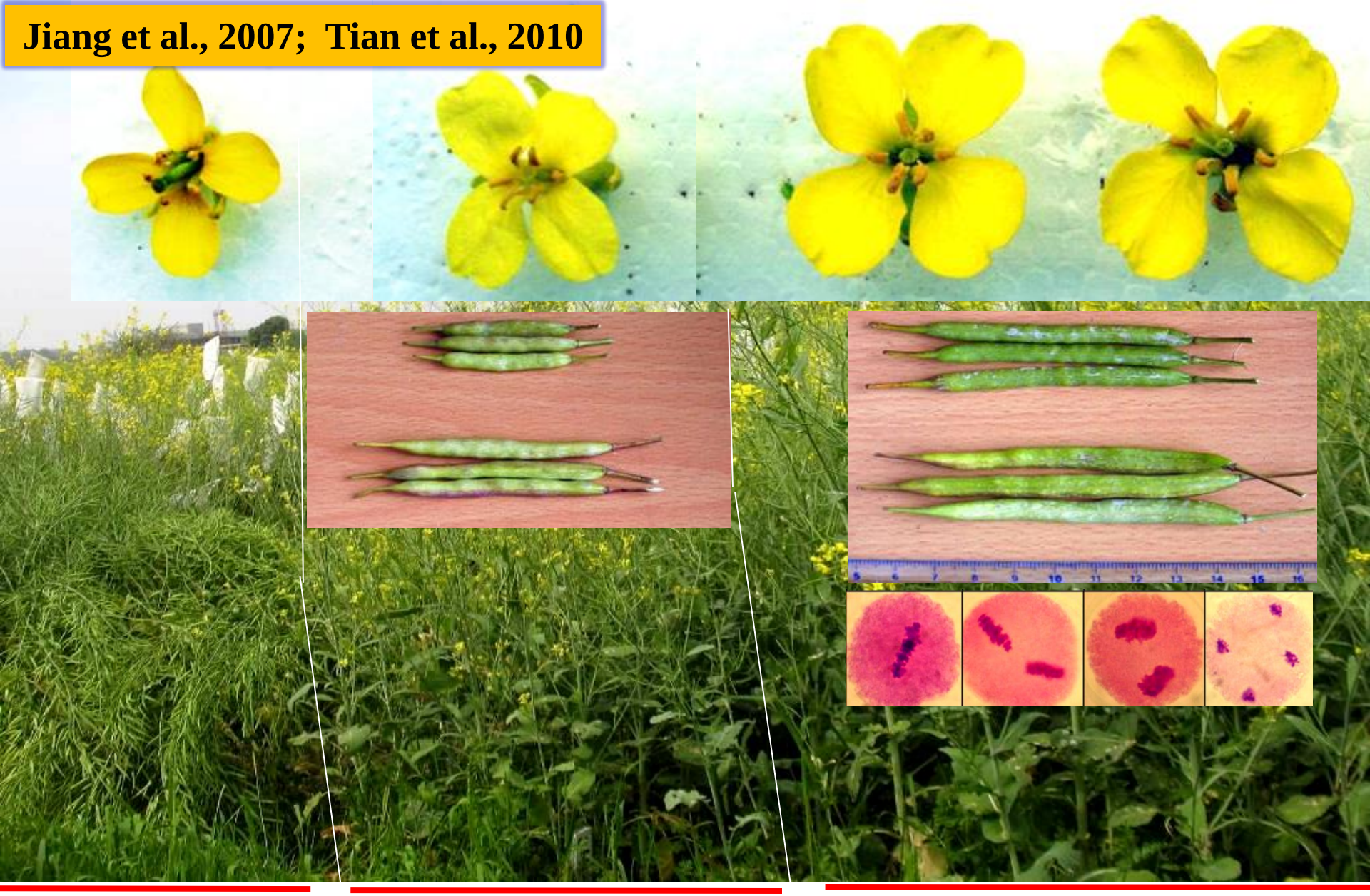
Brassica hexaploid
$A^rA^rB^cB^cC^cC^c$

B. oleracea
C^oC^o

B. napus
$A^nA^nC^nC^n$

B. rapa
A^rA^r

Jiang et al., 2007; Tian et al., 2010



B. rapa

A^rA^r

B. carinata

$B^cB^cC^cC^c$

Hexaploid

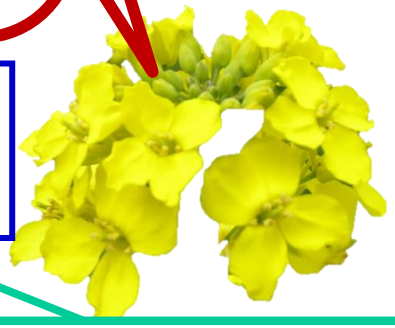
$A^rA^rB^cB^cC^cC^c$

Geng et al., 2013

A mapping population has been established from a hexaploid hybrid derived from four species

B. nigra
B^bB^b

B. carinata
$B^cB^cC^cC^c$



B. juncea
$A^jA^jB^jB^j$

Brassica hexaploid
$A^rA^jB^cB^jC^cC^o$

B. oleracea
C^oC^o

B. napus
$A^nA^nC^nC^n$

B. rapa
A^rA^r

B. nigra
B^bB^b

Different subgenomes could be also put into a existed species

B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^jB^j$

B. napus
$A^nA^nC^nC^n$

B. oleracea
C^oC^o

B. rapa
A^rA^r

B. nigra
B^bB^b

Different subgenomes could be also put into a existed species

B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^jB^j$

B. napus
$A^nA^nC^nC^n$

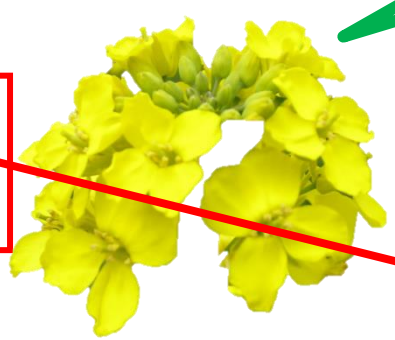
B. oleracea
C^oC^o

B. rapa
A^rA^r

B. nigra
B^bB^b

Different subgenomes could be also put into a existed species

B. carinata
$B^cB^cC^cC^c$



B. juncea
$A^jA^jB^jB^j$

B. napus
$A^nA^nC^nC^n$
$A^rA^rC^cC^c$

B. oleracea
C^oC^o

B. rapa
A^rA^r

B. carinata
$B^cB^cC^cC^c$

×

B. rapa
A^rA^r

↓

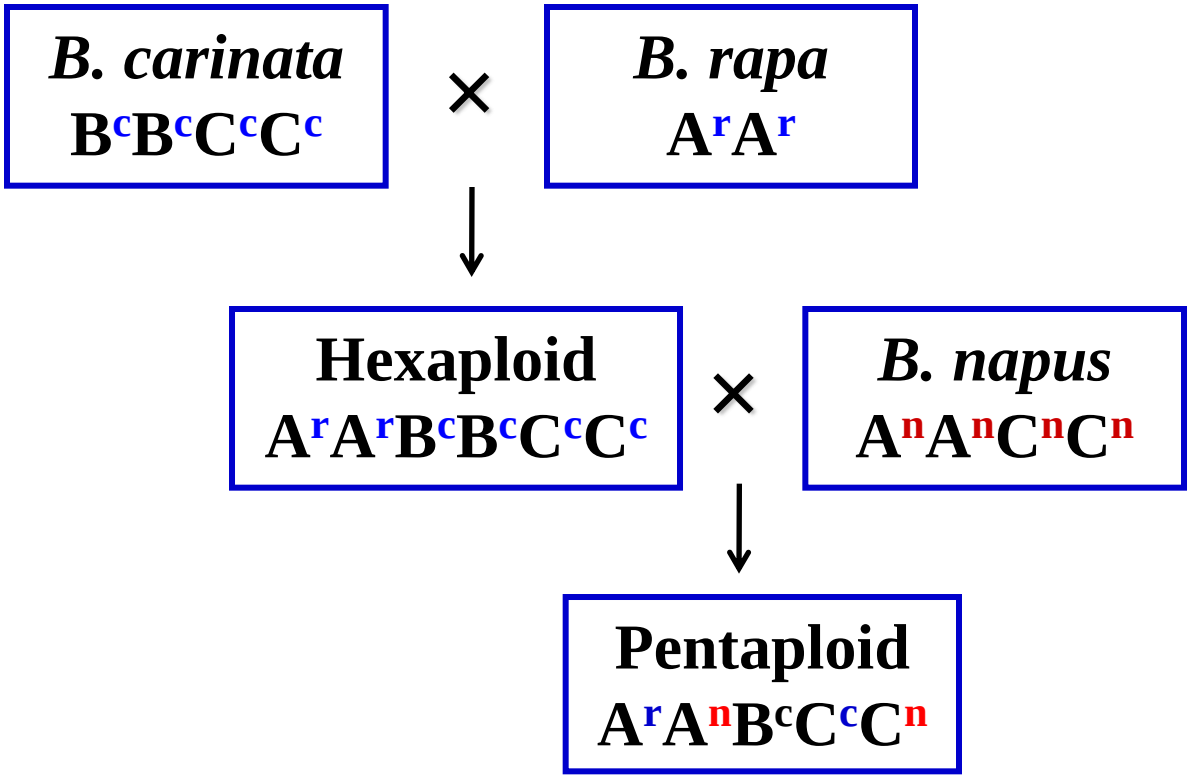
Hexaploid
$A^rA^rB^cB^cC^cC^c$

×

B. napus
$A^nA^nC^nC^n$

Hybrid ***B.rapa*** ***B.carinata***

Li et al., 2004


B. carinata
$B^cB^cC^cC^c$
×
B. rapa
A^rA^r
Hexaploid
$A^rA^rB^cB^cC^cC^c$
×
B. napus
$A^nA^nC^nC^n$
Pentaploid
$A^rA^nB^cC^cC^n$

Li et al., 2004

B. carinata
$B^cB^cC^cC^c$

×

B. rapa
A^rA^r

↓

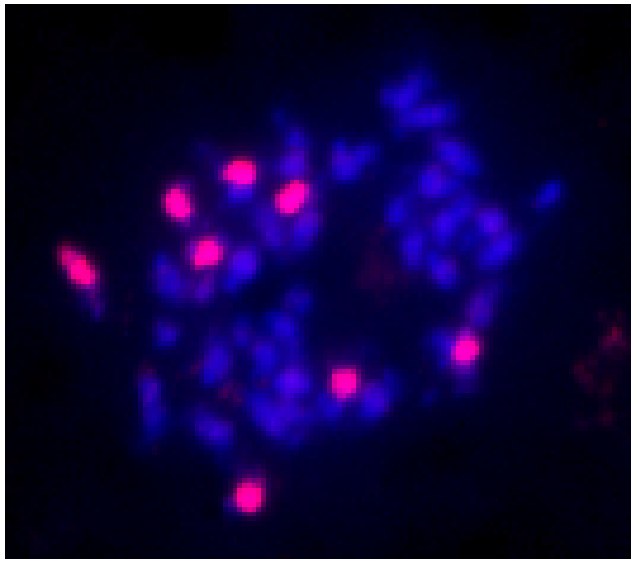
Hexaploid
$A^rA^rB^cB^cC^cC^c$

×

B. napus
$A^nA^nC^nC^n$

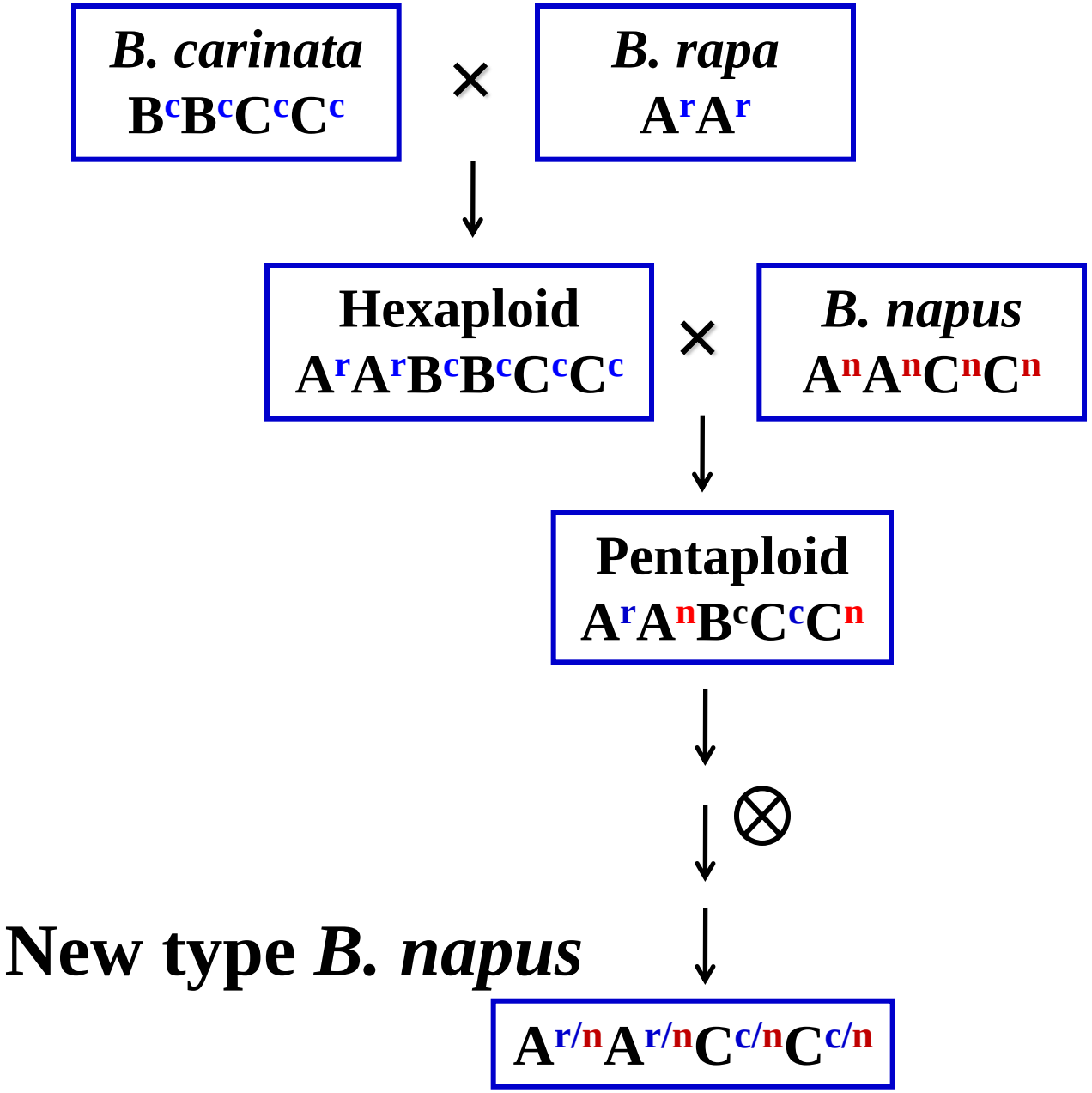
↓

Pentaploid
$A^rA^nB^cC^cC^n$

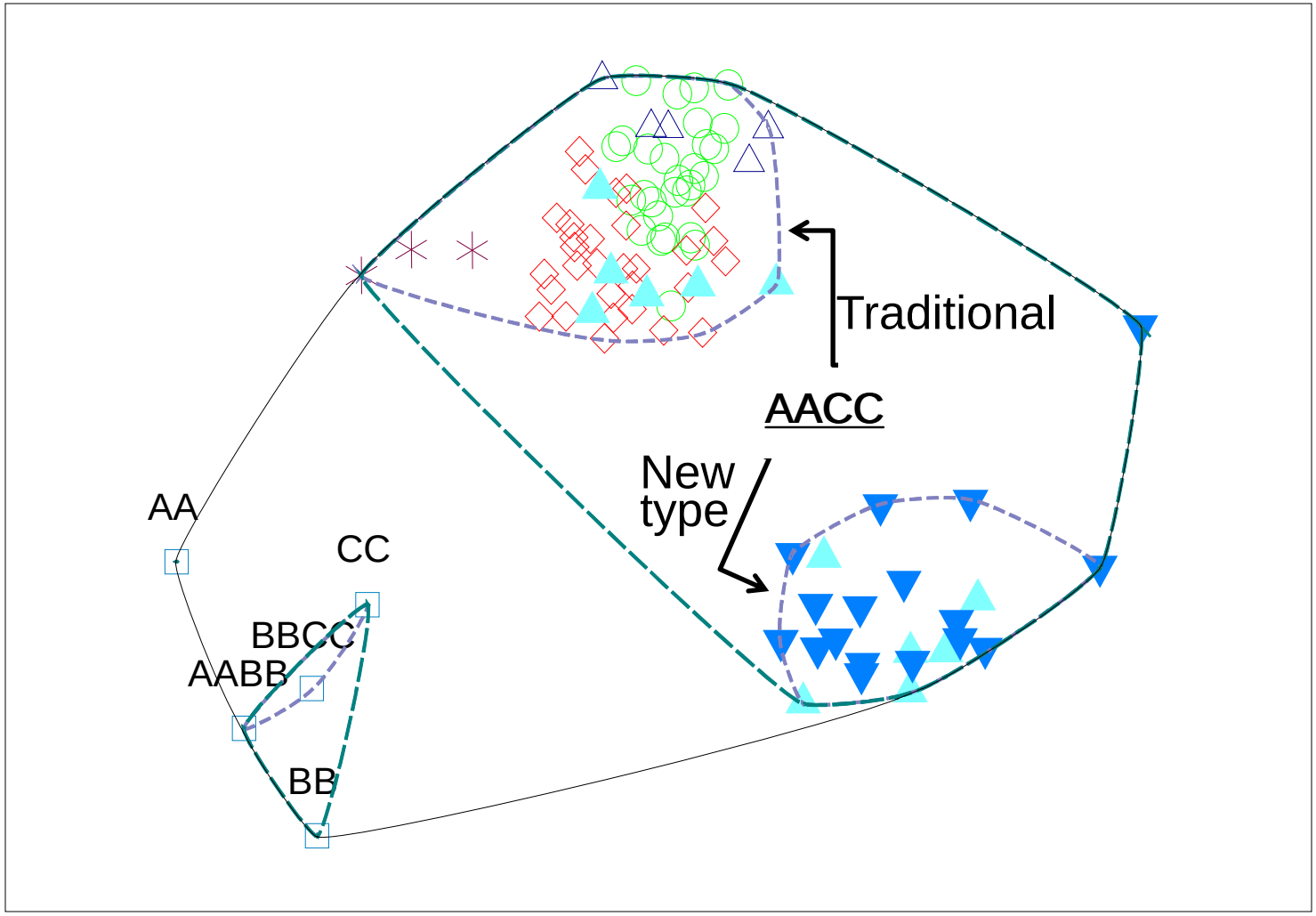


8 red chromosomes were from B genome

Li et al., 2004


B. carinata
$B^cB^cC^cC^c$
×
B. rapa
A^rA^r
Hexaploid
$A^rA^rB^cB^cC^cC^c$
×
B. napus
$A^nA^nC^nC^n$
Pentaploid
$A^rA^nB^cC^cC^n$
⊗
New type *B. napus*
$A^{r/n}A^{r/n}C^{c/n}C^{c/n}$

Li et al., 2004



New type *B. napus*:

Traditional *B. napus*:

- Australia
- China
- Europe
- India

Other species:

Analysis on genetic diversity on *B. napus* accessions and other Brassica species

Chen et al., 2010, Crop & Pasture Science

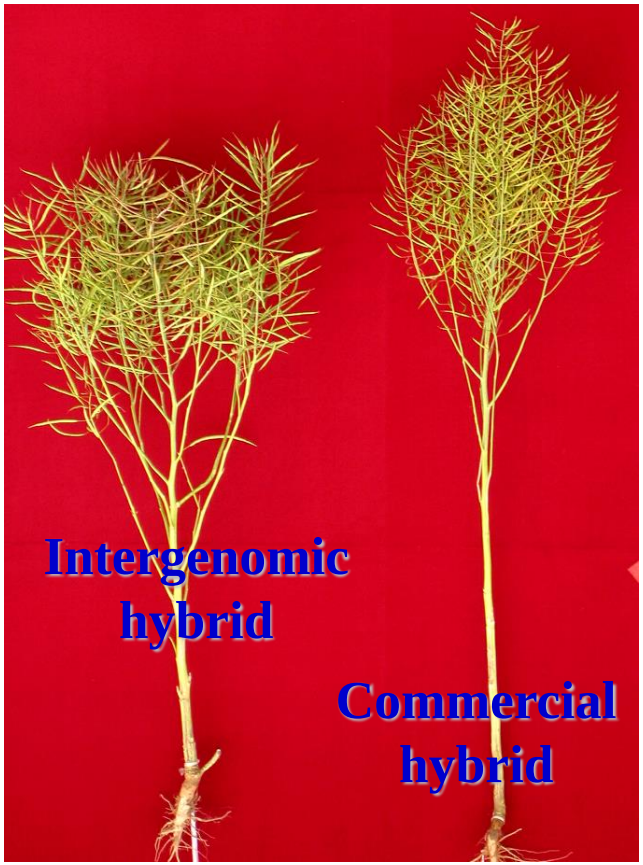
Partial new type *B. napus*

$A^{r/n}A^{r/n}C^{c/n}C^{c/n}$ X $A^{n}A^{n}C^{n}C^{n}$

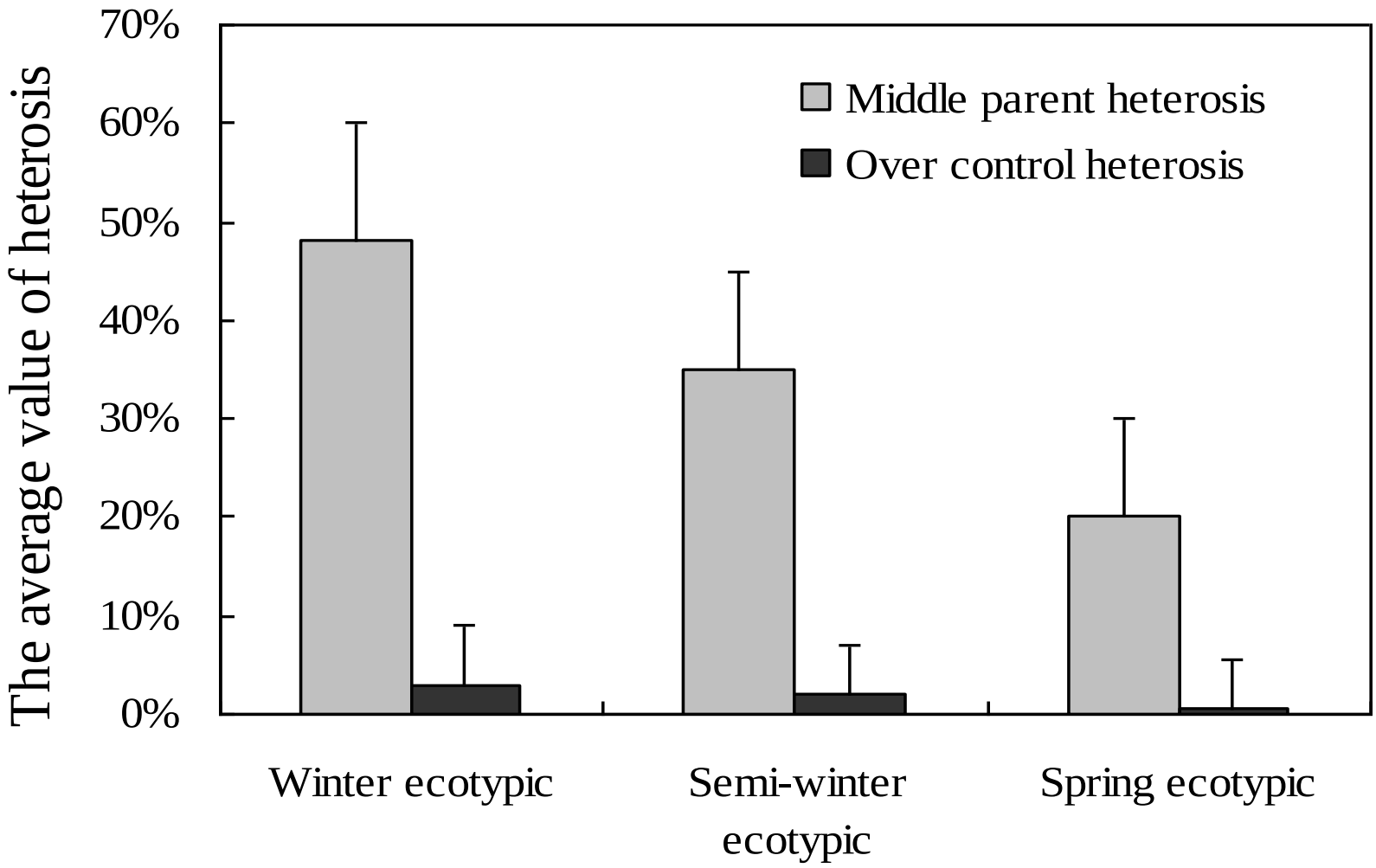
↓

$$\frac{A^{n}C^{n}}{A^{r/n}C^{c/n}}$$

Intersubgenomic hybrids



Li et al., 2006, Crop Science



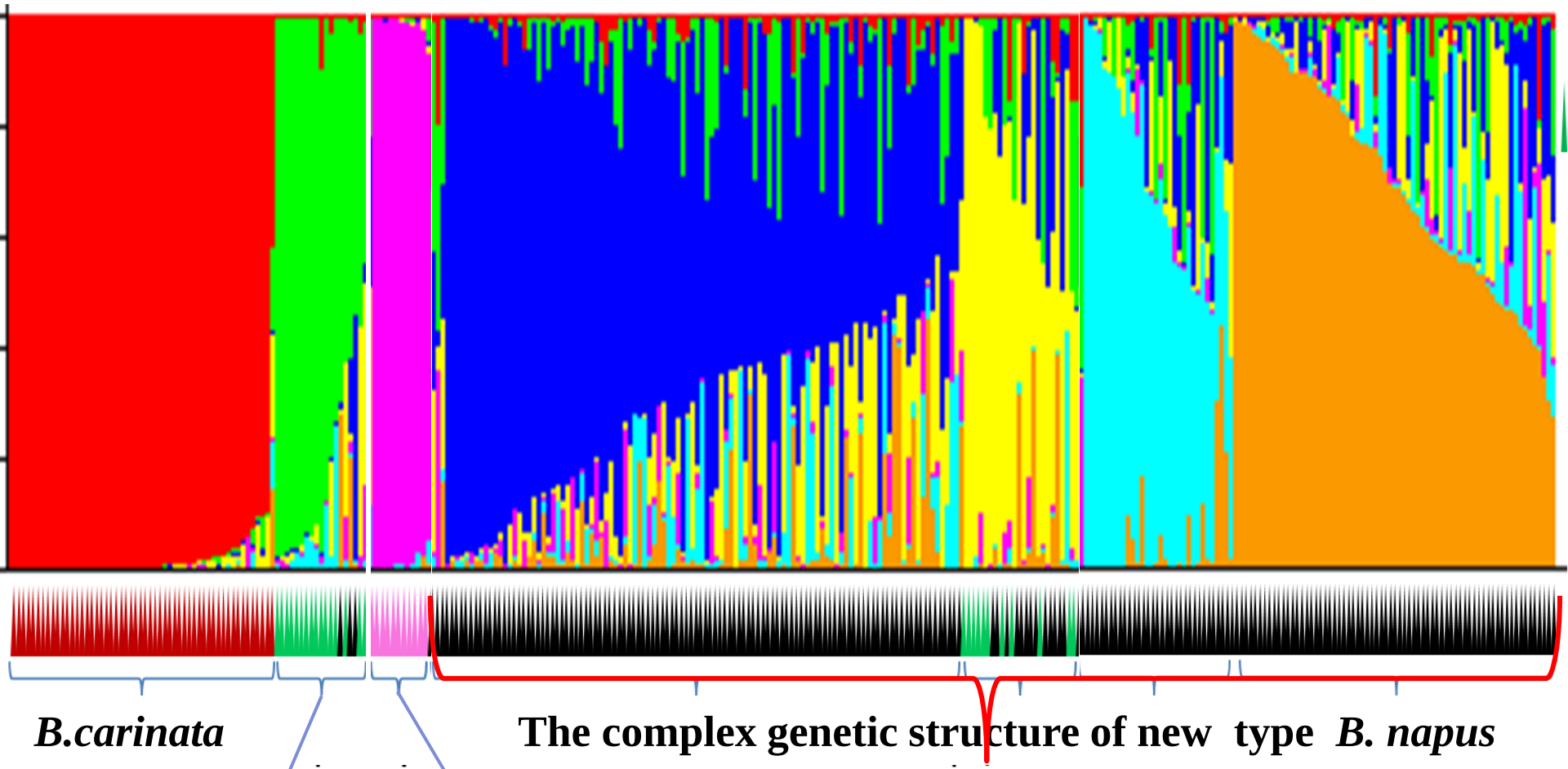
Heterosis overview on partial intersubgenomic hybrids in three ecotypic regions of rapeseed production

Qian eat al., 2009

Construct a A^r/C^c genepool of new type *B. napus*

Xiao et al. TAG, 2010

Genetic structure of the population is distinguished from traditional *B. napus* and its parental species



B.carinata

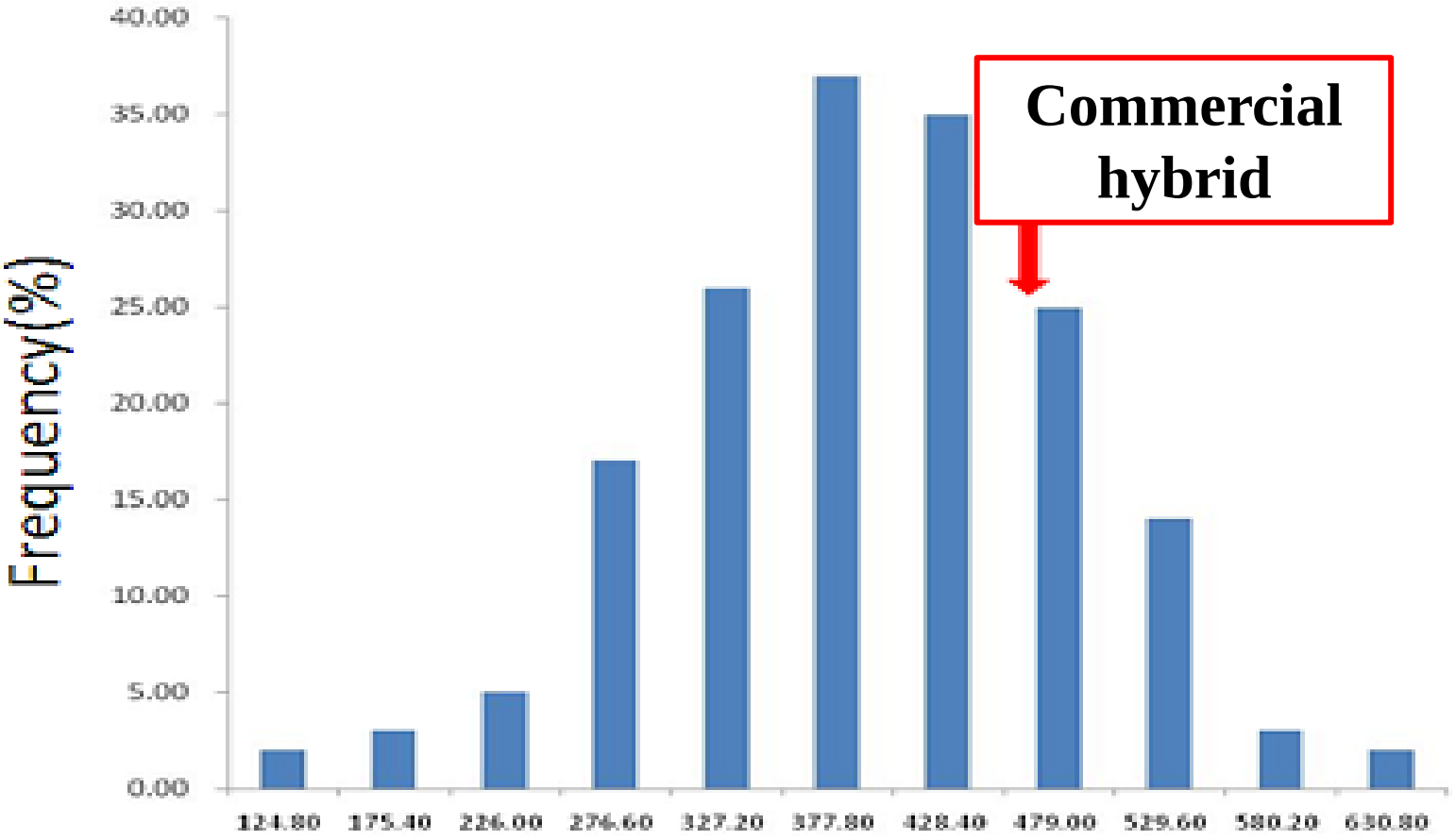
The complex genetic structure of new type *B. napus*

B. napus

B. rapa

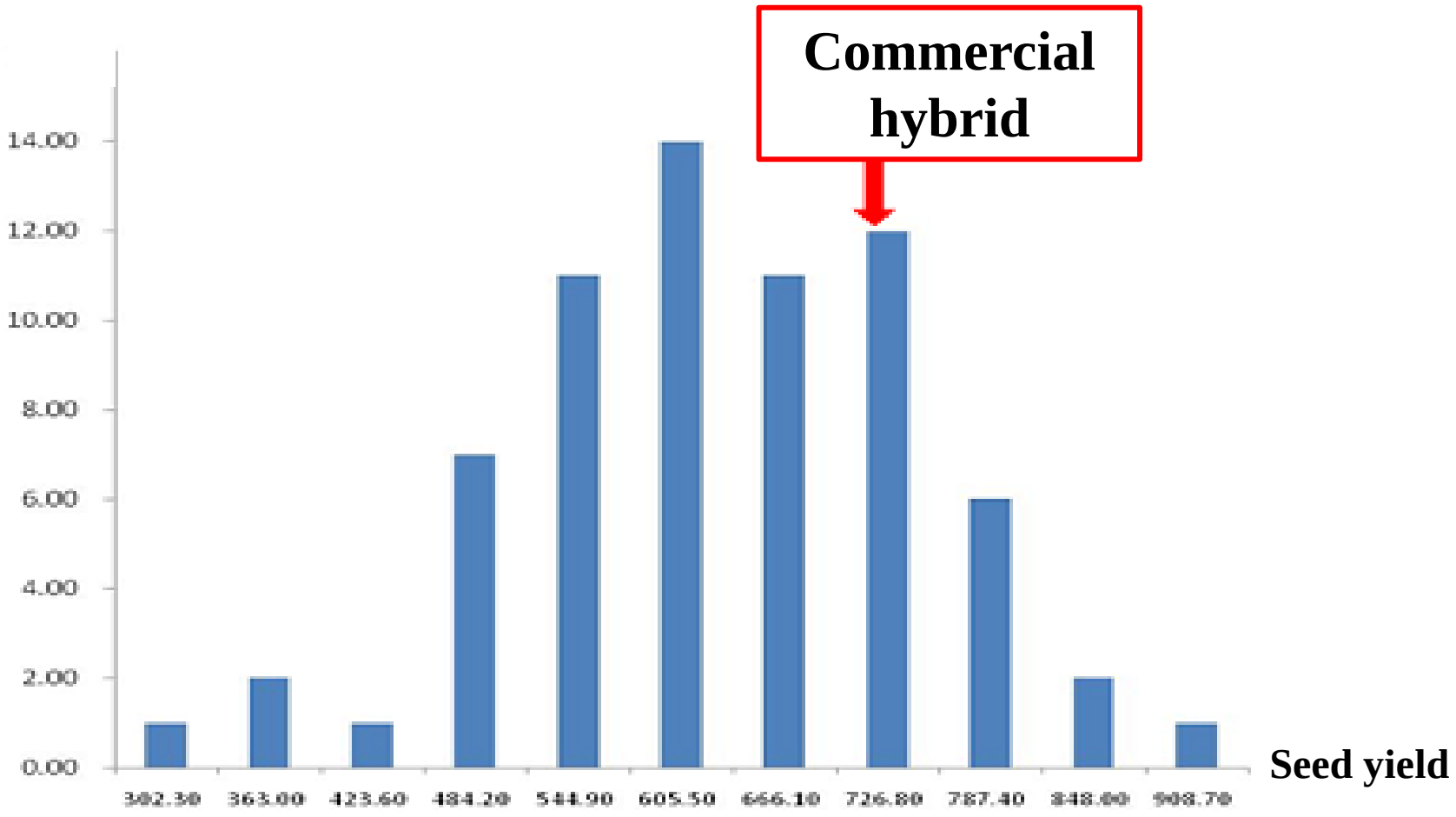
Genomic constitution: A^rC^c (90%)

The heterosis potential of selected inbred lines of new type *B. napus* was evaluated with four testers



Grown in Wuhan, 2012

The heterosis potential of selected inbred lines of new type *B. napus* was evaluated with four testers



Grown in south-east of Wuhan, 2012

Construct a A^r/C^c genepool of new type *B. napus*

Founder parents:

78 cultivars

B. carinata ($B^cB^cC^cC^c$)

×

135 cultivars

B. rapa (A^rA^r)

Hexaploid ($A^rA^rB^cB^cC^cC^c$)

Selected lines of new type *B. napus*

×

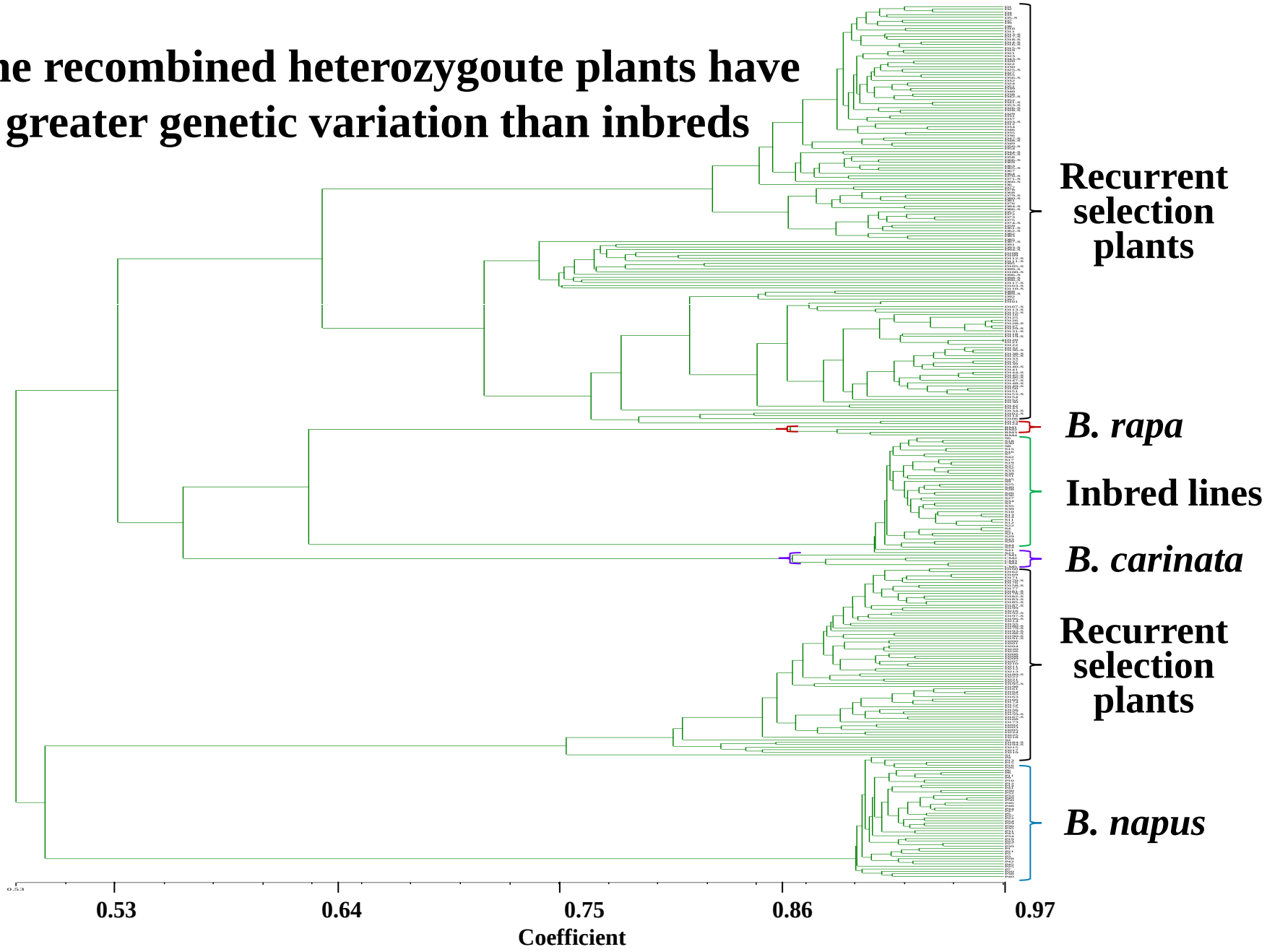
Introduce Dominant genic male sterility

A^r/C^c genepool of new type *B. napus* ~10,000 plants

Inbred lines

Recombined heterozygote plants for recurrent selection

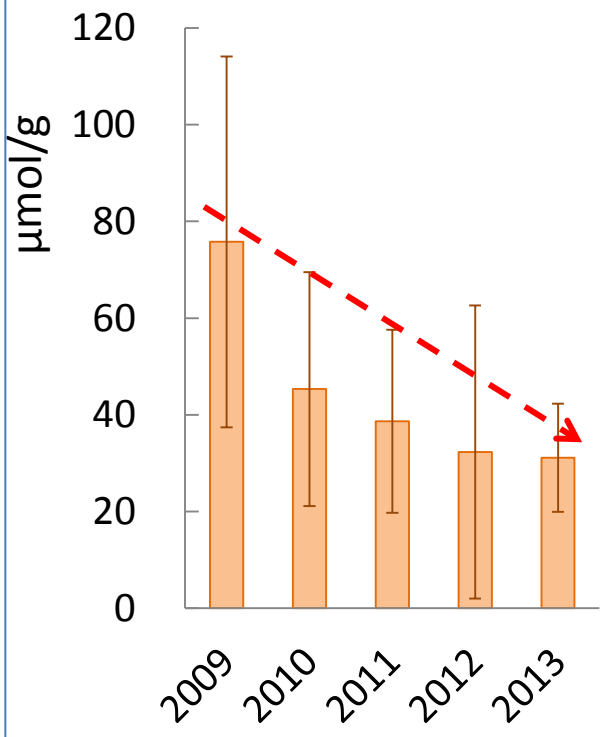
The recombined heterozygoute plants have greater genetic variation than inbreds



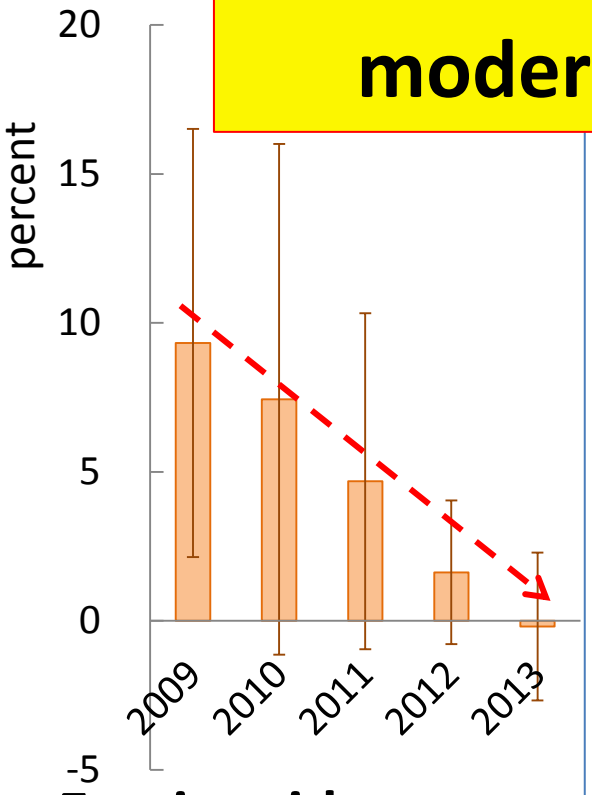
Genetic similarity in lines of new type *B. napus* and their parental species

Traits in the population have been greatly improved by recurrent selection

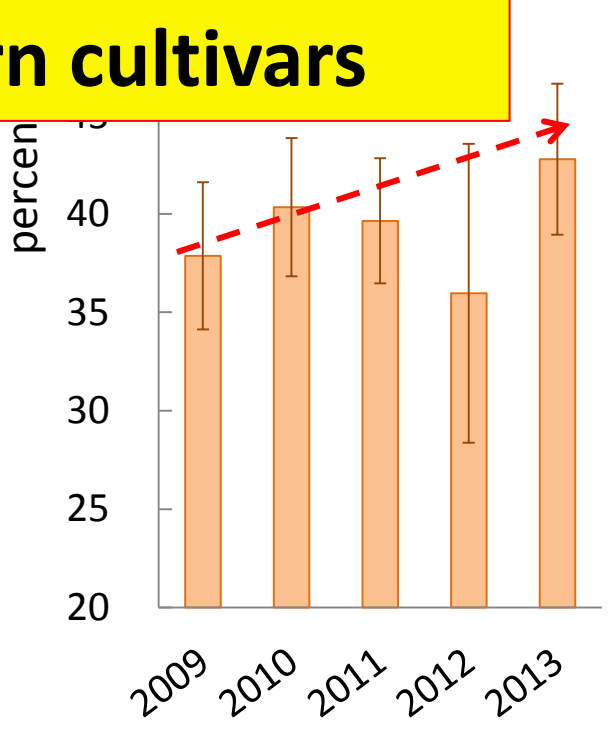
The agronomical traits are also as good as modern cultivars



Glucosinolate content



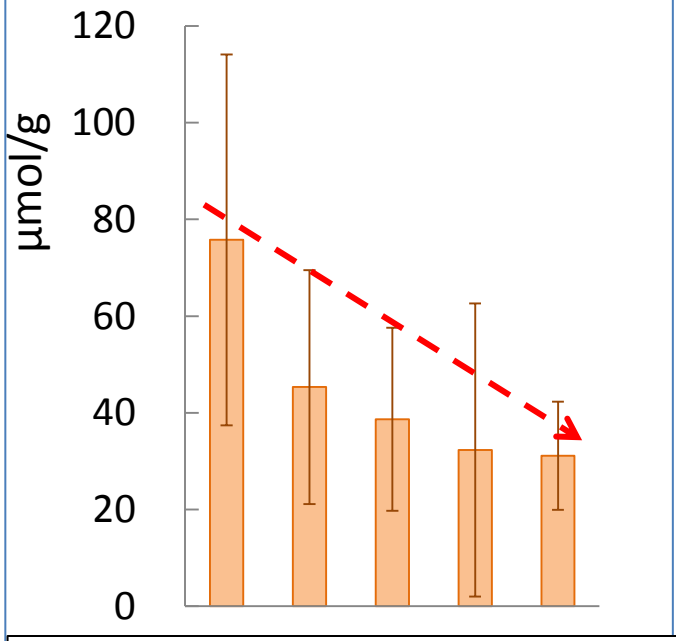
Erucic acid content

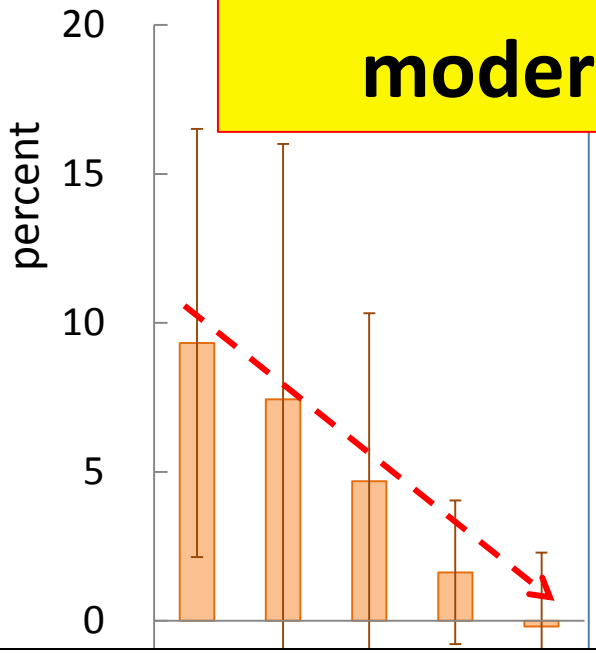


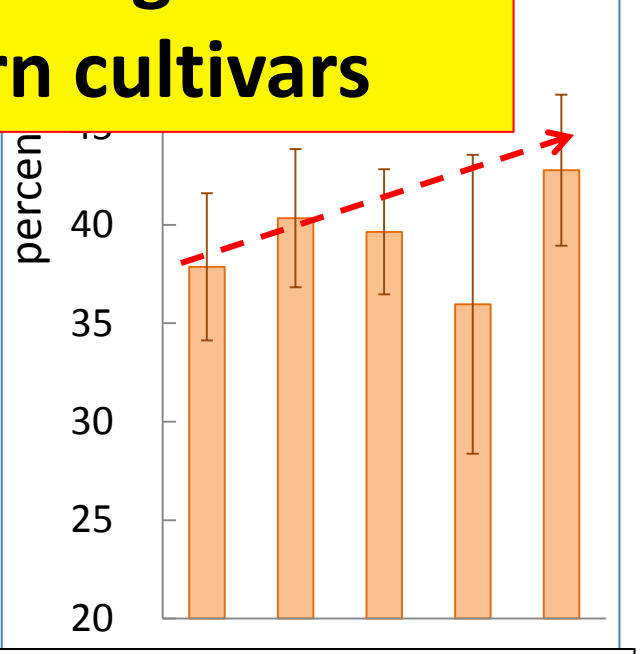
Oil content

Traits in the population have been greatly improved by recurrent selection

The agronomical traits are also as good as modern cultivars







Bring A^r/C^c subgenomes in *B. napus*

Shift-out the dross by recurrent selection

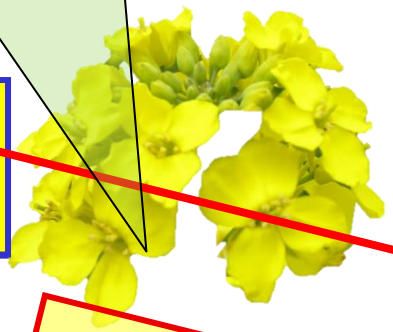
去粗取精

In and out:

Bring A/C subgenomes from all of Brassica oilseed crops in one

Shift-out the dross by recurrent selection

去粗取精



B. carinata $B^cB^cC^cC^c$

B. juncea $A^jA^jB^jB^j$

New type of *B. napus* $A^rA^rC^cC^c$

B. oleracea C^oC^o

B. napus $A^nA^nC^nC^n$

B. rapa A^rA^r

In and out:

Bring A/C subgenomes from all of Brassica oilseed crops in one

Shift-out the dross by recurrent selection

去粗取精

B. carinata $B^cB^cC^cC^c$

B. juncea $A^jA^jB^jB^j$

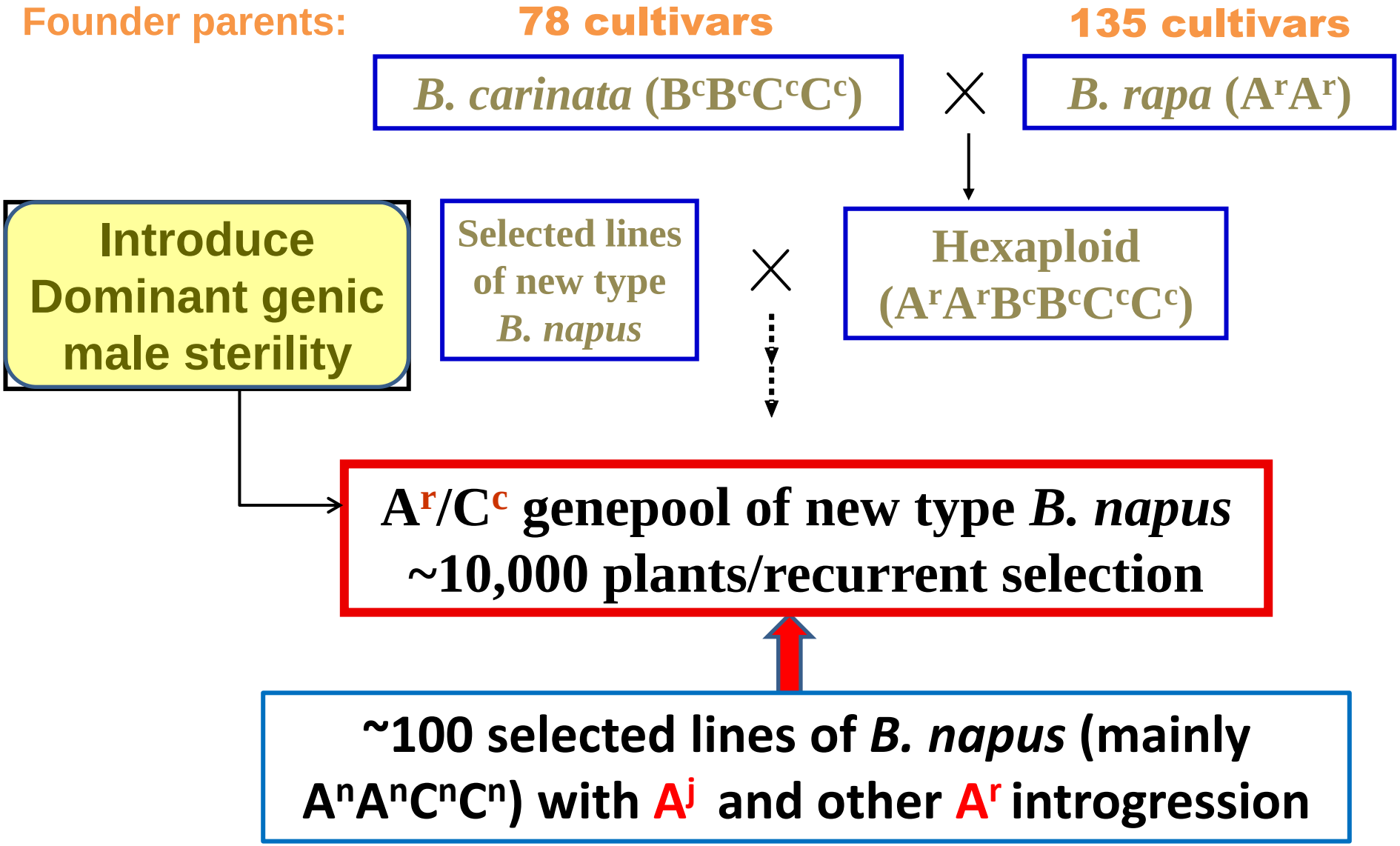
New type of *B. napus* with renewed A/C subgenomes

B. oleracea C^oC^o

B. napus $A^nA^nC^nC^n$

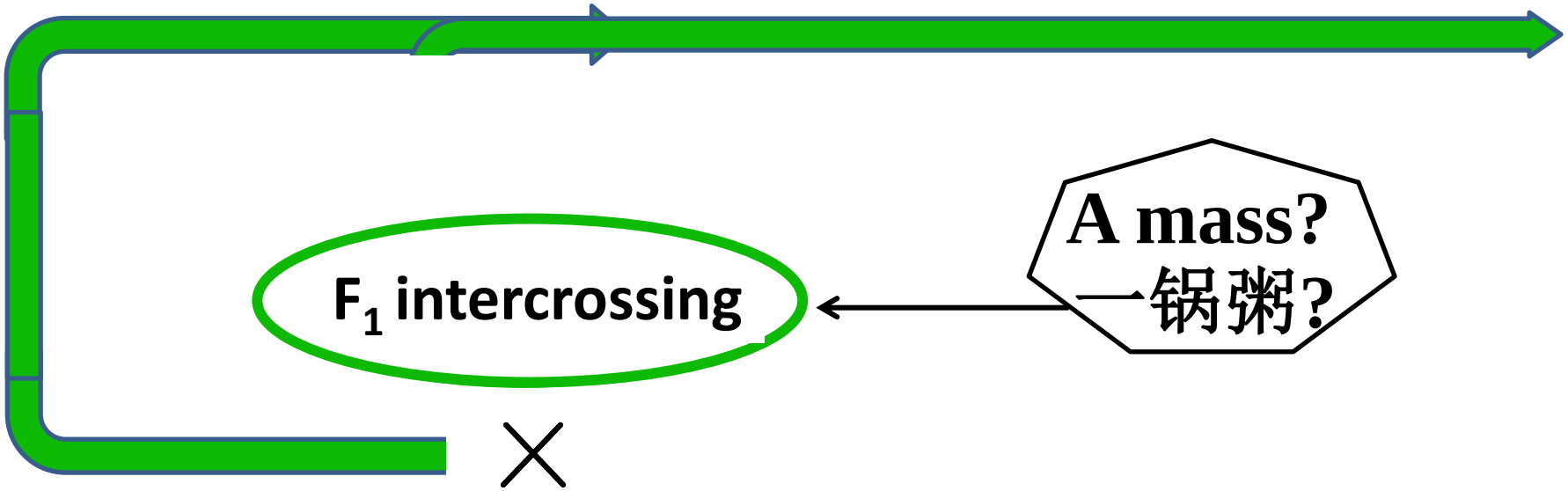
B. rapa A^rA^r

Construct a A^r/C^c genepool of new type *B. napus*



Shift-out the dross by recurrent selection

and by genomic selection with genomic knowledge



A^r/C^c genepool of new type *B. napus*
~10,000 plants/recurrent selection

~100 selected lines of *B. napus* (mainly $A^nA^nC^nC^n$) with A^j and other A^r introgression

Shift-out the dross by recurrent selection

and by genomic selection with genomic knowledge

B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^j$

Next four years?

New type of *B. napus* with renewed A/C subgenomes

B. napus
$A^nA^nC^nC^n$

B. rapa
A^rA^r

B. nigra
B^bB^b

B. carinata
$B^cB^cC^cC^c$

B. juncea
$A^jA^jB^jB^j$

B. napus
$A^nA^nC^nC^n$

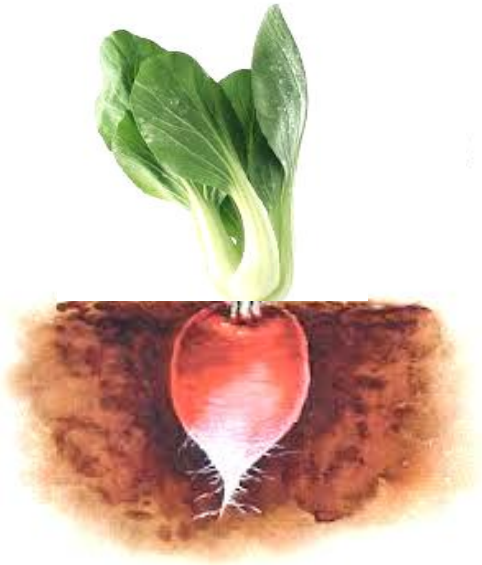
B. oleracea
C^oC^o

B. rapa
A^rA^r

B. nigra
BB

B. carinata
BBCC

B. juncea
AABB



B. oleracea
CC

B. napus
AACC

B. rapa
AA

Brassicaceae 芸薹科 ***Crucifer*** 十字花科

Brassiceae 芸薹族

Brassica 芸苔属

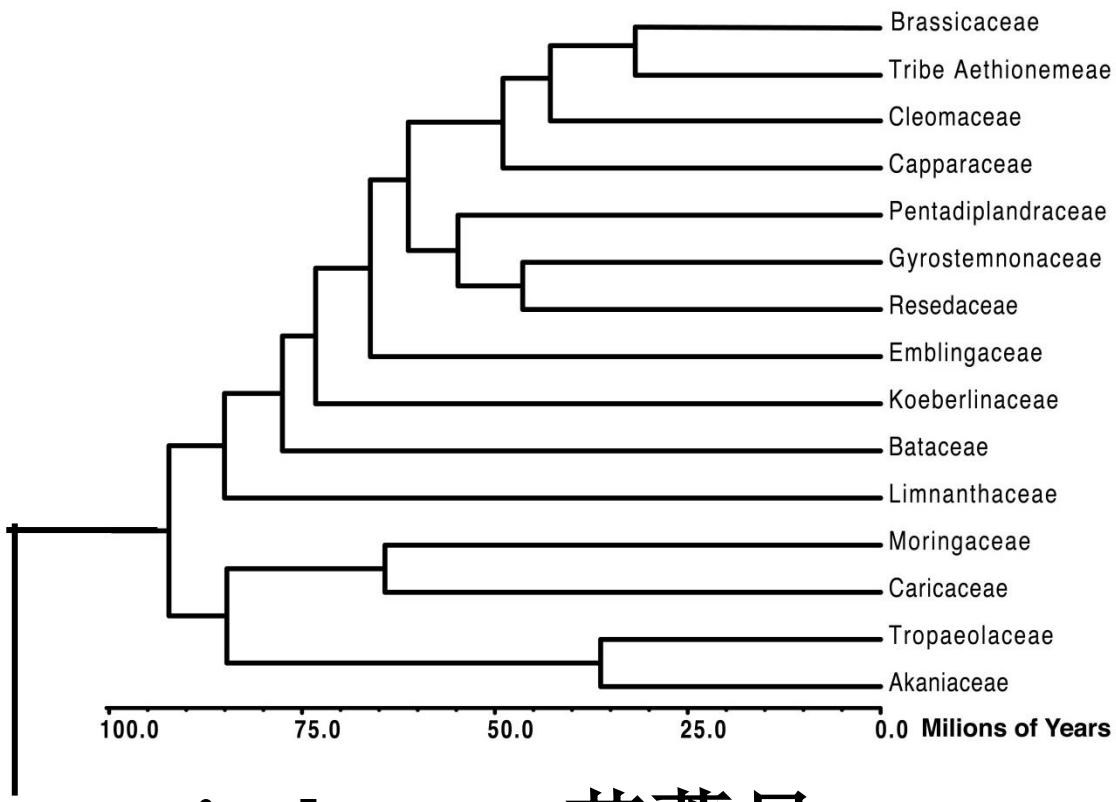
Brassicales 芸薹目

Brassicaceae 芸薹科

Brassiceae 芸薹族

Brassica 芸苔属

Camelina sativa



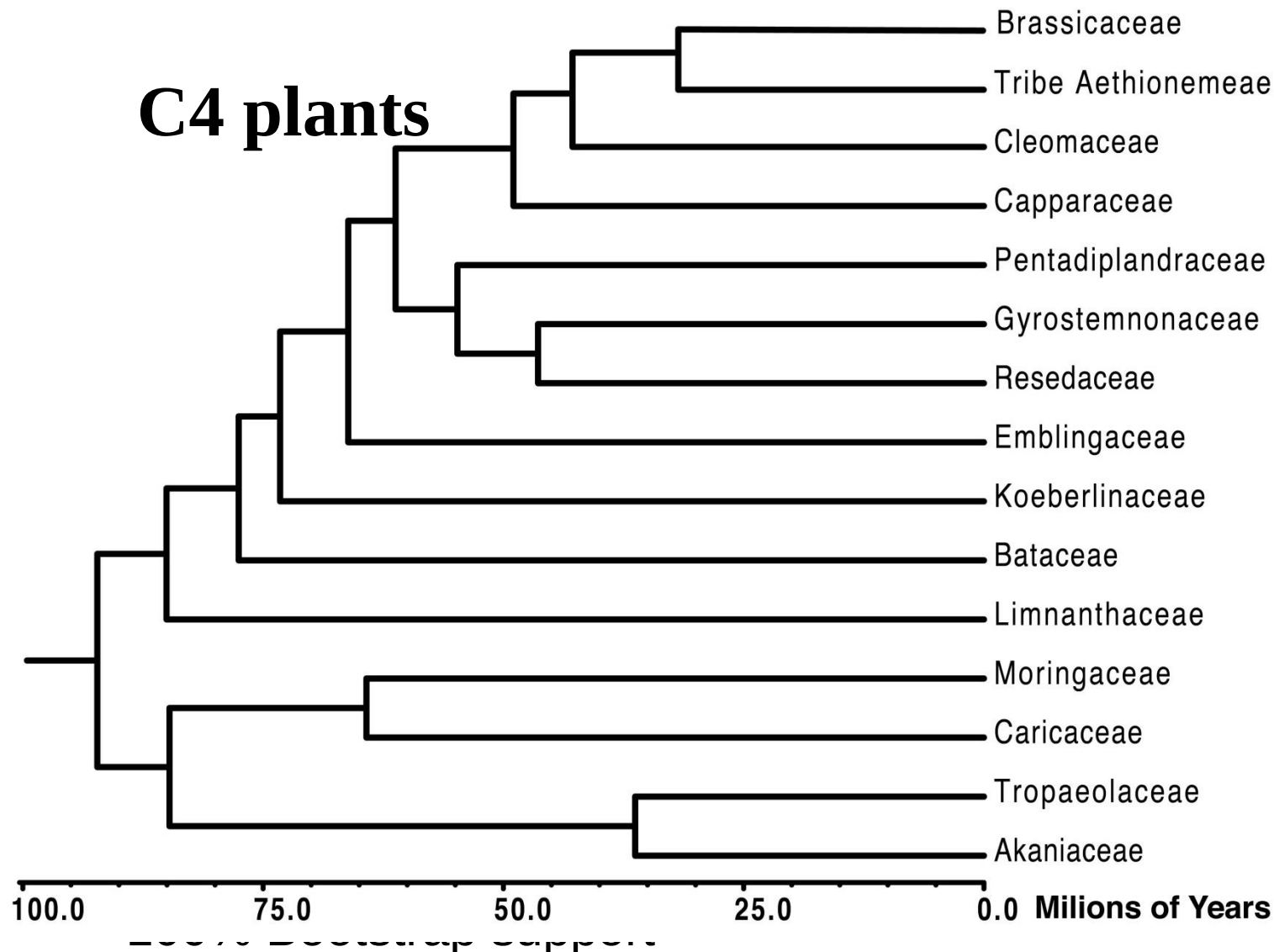
Brassicales 芸薹目

Brassicaceae 芸薹科

Brassiceae 芸薹族

Brassica 芸苔属

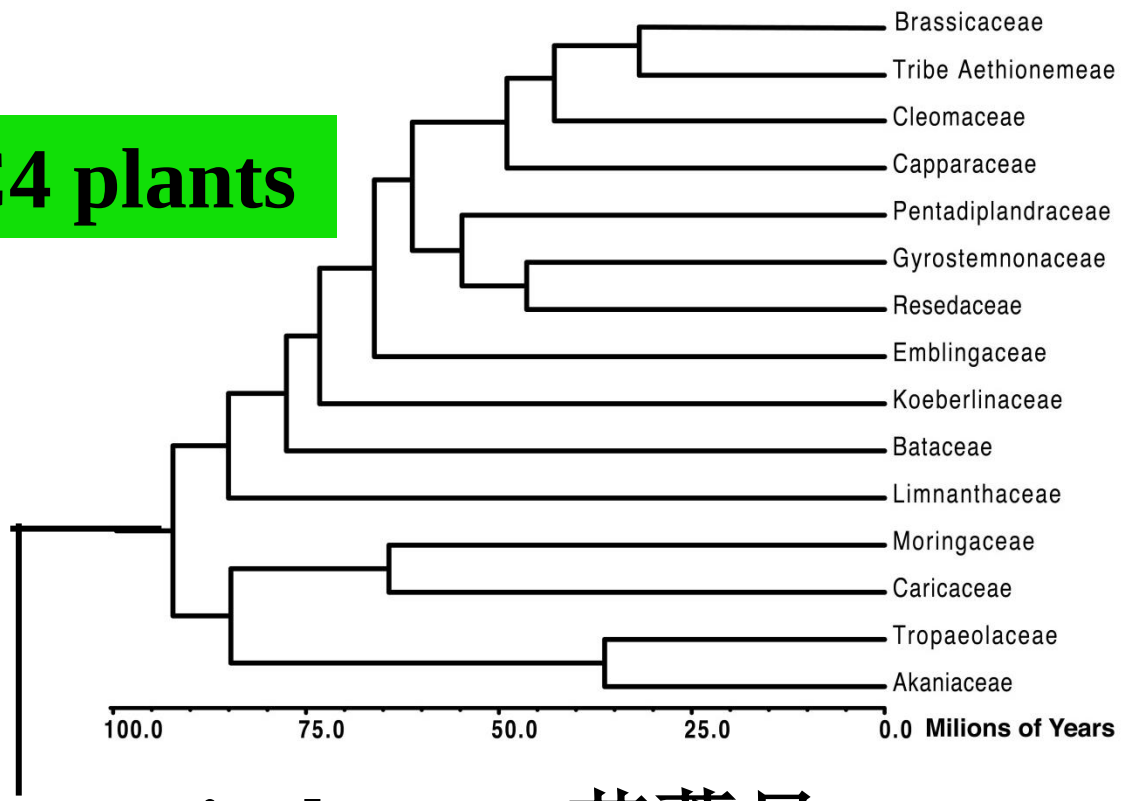
Brassicales: 18 families (4765 species)



nes
markers

Pat Edger et al. (Pires lab) unpublished data

C4 plants



Brassicales 芸薹目

Brassicaceae 芸薹科

Brassiceae 芸薹族

Brassica 芸苔属

Brassica Paradise

Acknowledgement:

Students and colleagues worked and working in my lab

Colleagues in rapeseed research team leading by Dr. Y Zhou & Prof. T Fu

Members of BGSP

National & International funding agencies

Internal & International companies

Friends

Thanks !