



Around the World with Brassicas

Wisconsin Fast Plants, rapid-cycling brassicas, are part of a large family of plants called **crucifers** (Latin = Cruciferae). Crucifers are easily distinguished by the characteristic shape of their flowers—four petals in the shape of a cross or crucifix. A section, or genus, of the crucifer family is the genus ***Brassica***.

Brassicas have great economic and commercial value, and play a major role in feeding the world population. They range from nutritious vegetables, mustards and oil producing crops, to animal fodders and weeds.

Six of the most important *Brassica* species are closely interrelated. The relationship between these species can be represented as a triangle with the three diploid species forming the points of the triangle, and the amphidiploid species (crosses between the first three) on the sides (Figure 1).

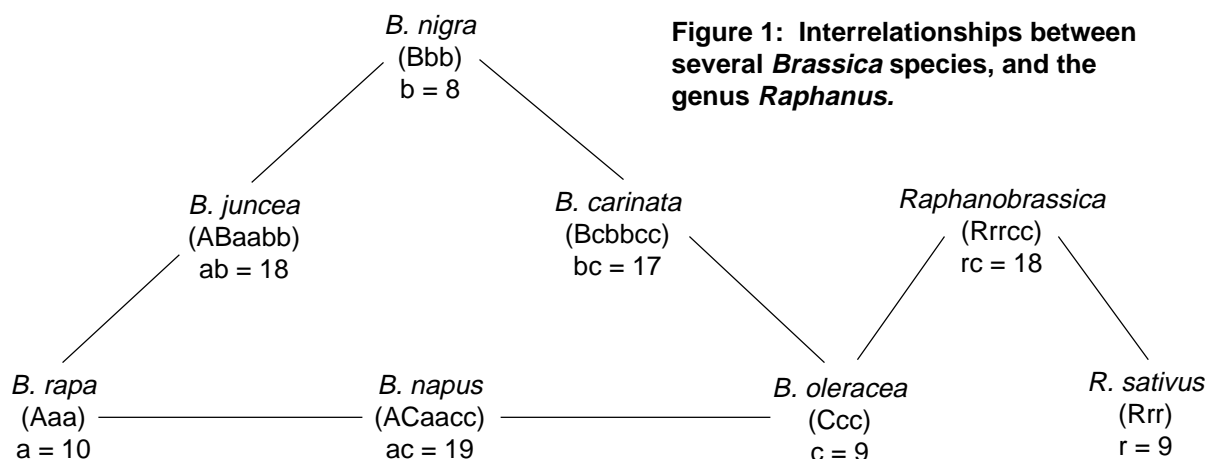
Brassica nigra ($2n = 16$), popularly known as black mustard, is a common weed. It looks very much like the Wisconsin Fast Plants. Seeds of *B. nigra* will stay dormant in the soil for years. Once the ground is disturbed — for instance, by a tractor or bulldozer — black mustard is one of the first plants to appear.

Brassica carinata results from a cross between *B. nigra* and *B. oleracea*. It is a tall, leafy plant found almost exclusively in Ethiopia. The leaves are stripped off and eaten and the seed is pressed as a source of edible oil.

Reviewing *Brassica oleracea* is a bit like taking a trip through the produce section of your supermarket. Collards, cauliflower, broccoli, Brussels sprouts, kohlrabi and cabbage all belong in the species *Brassica oleracea*. Members of *B. oleracea* are used extensively in Northern Europe and Central Asia and are an important vegetable in many countries.

Cauliflower is the main vegetable in India. One reason is that it can be stored without refrigeration. The outer leaves of the cauliflower wilt and form a protective layer around the head. In other parts of the world where refrigeration is still unavailable or considered a luxury, people also rely on other brassicas that store well (such as heading cabbage or kohlrabi) or those that continue to grow through a mild winter (collard, Brussels sprouts).

The forms of *B. oleracea*, known as kale, are used for a wide variety of purposes, including human food and animal fodder. Kale is used extensively in New Zealand and Scotland for feeding sheep. A particularly tall variety of kale, known as tree kale or Jersey kale, is grown in Portugal as a food crop and dates back to Roman times. On the Isle of Jersey, the tree kale is grown as fodder for the Jersey cattle. Jersey kale is also a source of a cottage industry for island inhabitants who make walking sticks from the eight-foot kale stems. These walking sticks are very popular in British hospitals, because they are very strong and



lightweight. A different variety of kale, developed in Japan for ornamental purposes, can be seen as a bedding plant. This ornamental kale spreads its curly leaves at ground level, and looks like a big red, pink or white flower.

Brassica napus is a cross between *B. oleracea* and *B. rapa*. Rutabagas are a variety of *B. napus* as is oil seed rape. This crop is the third most important source of edible oil behind soybean and peanut oil. In the United States, cooking oils and margarines are produced mainly from corn or soybeans. In other parts of the world, the main source of edible oil is pressed from the seed of oil seed rape. Oil seed rape flourishes in Canada and Europe, where the climate is too cool to produce a corn crop. In the summer, the Canadian prairies are literally 'fields of sunshine,' due to the yellow flowers of oil seed rape, also known as canola.

The last of the diploid *Brassica* species is *Brassica rapa* ($2n = 20$). Both turnips and Chinese cabbage fit into this species. Chinese cabbage is consumed by millions of people all over the world. Over 200 different varieties of Chinese cabbage can be found in China. The per capita consumption of brassicas in China is 1/4 pound each day. Multiplied by China's population, this approximates 250 million pounds of brassicas eaten in China every day. In northern China, where winters are long and cold, heading forms of Chinese cabbage are harvested in the fall. Stored anywhere and everywhere there is room (including under the beds), Chinese cabbage provides a major source of vitamins through the winter. One can easily imagine that by spring, no one in China ever wants to see Chinese cabbage again!

In Korea, Chinese cabbage is again a mainstay in the diet, but is processed in a different way. As the Germans ferment cabbage to make sauerkraut, the Koreans ferment cabbage to make kimchee, the national dish. Kimchee is made in large earthenware jars by layering Chinese cabbage, radish, garlic, hot peppers and salt. Every family has its special recipe — some even add fish to the kimchee. Whatever the recipe, kimchee is eaten three times a day, for breakfast, lunch and supper.

The final of the six *Brassica* species is *Brassica juncea* ($2n = 36$), the cross between *B. rapa* and *B. nigra*. *Brassica juncea* includes the group known as mustard. In the southern United States, the foliage of *B. juncea* is often eaten as mustard greens. The distinctive flavor of mustard, present to some extent in all the brassicas, is strongest in the various types of *B. juncea*. Most people use mustard as a condiment or spice. Mustard contains oils called glucosinolates, which are

activated by saliva and release the strong 'mustard' flavor. These glucosinolates are a help to both plants and humans. Certain pests are repelled and others attracted by glucosinolates. The strong flavor also helps to discourage deer and rabbits from eating brassica crops. In mammals, certain glucosinolates have been found to help detoxify cancer-causing nitrosamine chemicals in the liver.

Other intergeneric crosses are possible between various brassicas and other crucifers. An example is *Raphanobrassica*, the cross between *B. oleracea* and *Raphanus sativus* ($2n = 18$), the common radish. *Raphanobrassica* was first produced in the 1920's by a Russian plant breeder named Karpechenko. He had hoped to breed a 'supervegetable' with both the large head of a cabbage and the large root of a radish. The cross resulted in a big, leafy plant. Disappointed, he didn't pursue the plant cross any further. Recently, *Raphanobrassica* has been revived by the Scottish Plant Breeding Station in Dundee, Scotland. Its high dry matter content makes it an excellent fodder for sheep and cattle.

Selective breeding has produced Wisconsin Fast Plants from this tremendous resource of brassicas collected from all over the world (both wild and domesticated forms). Bred for their small size and rapid life cycle (35 days, seed-to-seed), Wisconsin Fast Plants are being used for research and classroom teaching.

Preview color slides of the Brassicas on the Fast Plants World Wide Web site, at the URL <http://fastplants.cals.wisc.edu>.

Individual slides or complete sets are available from the Fast Plants office, at \$2.00 per slide.

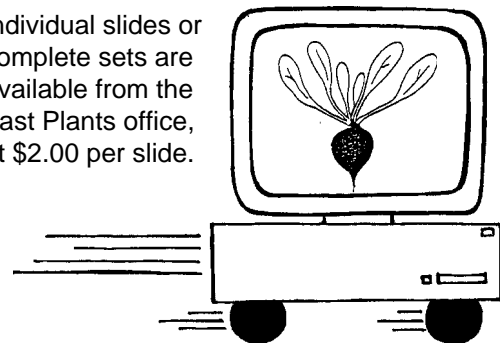


Table 1: Names of the subspecies of agriculturally important brassicas and radish

Species (genome)	Subspecies or variety	Cultivar group or common name
<i>Brassica nigra</i> (bb = 16)	---	Black mustard
<i>Brassica oleracea</i> (cc = 18)	<i>acephala</i> <i>alboglabra</i> <i>botrytis</i> <i>capitata</i> <i>costata</i> <i>gemmifera</i> <i>gongylodes</i> <i>italica</i> <i>medullosa</i> <i>palmifolia</i> <i>ramosa</i> <i>sabauda</i> <i>sabellica</i> <i>selensia</i>	Kales Chinese kale, Kailan Cauliflower, heading broccoli Cabbage Portuguese cabbage, Tronchuda Brussels sprouts Kohlrabi Broccoli, Calabrese Marrow stem kale Tree cabbage, Jersey kale Thousand-head kale Savoy cabbage Collards Borecole
<i>Brassica rapa</i> (aa = 20)	<i>chinensis</i> <i>narinosa</i> <i>nipposinica</i> <i>oleifera</i> <i>parachinensis</i> <i>pekinensis</i> <i>perviridis</i> <i>rapifera</i> <i>trilocularis</i> <i>utilis</i>	Pak choi Tsatsai Mizuna, Mibuna Turnip rape, Toria Saichin, Choy sum Chinese cabbage Tendergreen, Komatsuna Turnip Yellow sarson Broccoletto, Broccoli raab
<i>Brassica carinata</i> (bbcc = 34)	---	Ethiopian mustard
<i>Brassica juncea</i> (aabb = 36)	<i>capitata</i> <i>crispifolia</i> <i>faciliflora</i> <i>lapitata</i> <i>multiceps</i> <i>oleifera</i> <i>rapifera</i> <i>rugosa</i> <i>spicea</i> <i>tsa-tsai</i>	Head mustard Cut leaf mustard Broccoli mustard Large petiole mustard Multishoot mustard Indian mustard, Raya Root mustard Leaf mustard Mustard Big stem mustard
<i>Brassica napus</i> (aacc = 38)	--- <i>oleifera</i> <i>rapifera</i>	Fodder rape Oil rape Swede, Rutabaga
<i>Raphanus sativus</i> (rr = 18)	<i>radicola</i> <i>oleifera</i> <i>caudatus</i>	Radish, dikon Oil radish Rat tail radish

The haploid complement of chromosomes is a = 10, b = 8 and c and r = 9.

Morphotypes of the subspecies of *Brassica rapa*



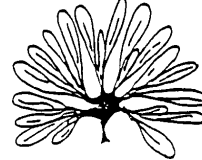
choy sum
Brassica rapa parachinensis



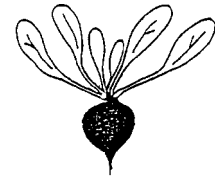
Chinese cabbage
Brassica rapa pekinensis



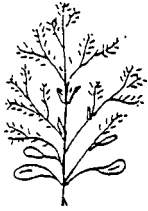
broccoli raab
Brassica rapa utilis



mibuna
Brassica rapa nipposinica



turnip
Brassica rapa rapifera



turnip rape or sarson
Brassica rapa oleifera or
B. r. trilocularis



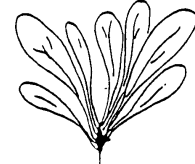
pak choi
Brassica rapa chinensis



Wisconsin Fast Plants
Rapid-cycling *Brassica rapa*



tsa-tsai
Brassica rapa narinosa



tendergreen
Brassica rapa perviridis

The Phylogeny of Fast Plants

Kingdom: **Planta**

- plants have cell walls and chlorophyll
- other kingdoms are: Monera (bacteria), Protista (protozoans), Fungi and Animalia

Division: **Tracheophyta**

- vascular plants

Subdivision: **Spermatophyta**

- seed plants

Class: **Angiospermae**

- flowering plants

Subclass: **Dicotyledonae (dicots)**

- two cotyledons, branching veins in leaves

Order: **Papaverales**

- special anatomy of fruit and embryo
- contains several families

Family: **Cruciferae or Brassicaceae**

- (e.g., mustards and cabbages)
- 4 petals, 4 sepals, 6 stamens, ovary consists of two fused carpels
- contains 375 genera

Genus: ***Brassica***

- pod a silique, embryos conduplicate
- contains over 3200 species

Species: ***rapa***

- chromosome number $2n = 20$
- contains 11 subspecies

Subspecies: **e.g.:**

chinensis (pak choi), *pekinensis* (Chinese cabbage), *rapifera* (turnip)

Cultivar: **cultivated variety name**

- domesticated through selection and breeding

