

Brassica and allied species: Uses and significance

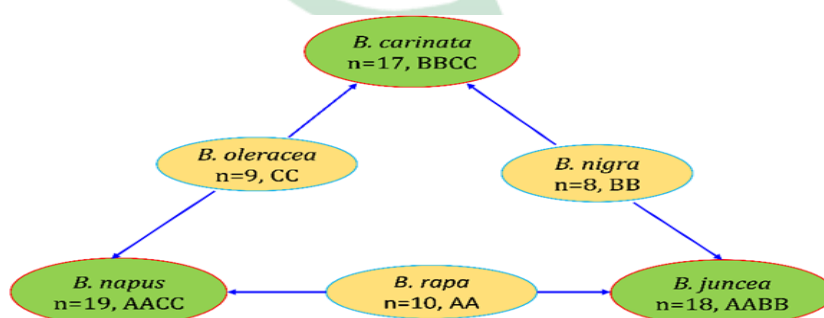
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Introduction

The Family Brassicaceae contains over 3,700 species in 338 genera, having significant genetic diversity. These species and genera are diverse in terms of morphology with variable uses. The genus Brassica is one of the ten core genera of the tribe Brassicineae, which includes *Coincya*, *Diplotaxis*, *Eruca*, *Erucastrum*, *Hirschfeldia*, *Raphanus*, *Sinapidendron*, *Sinapis*, and *Trachystoma*. The tribe Brassicinae contains about 235 species in 49 genera. The diploids species range in genomic numbers from $x=7$ or $x=12$. Brassica species were domesticated by humans long back over large geographical regions all across the globe, especially in Europe and Asia. In India, Brassicas are thought to be cultivated as early as 4000–1500 BC. Similarly, in China, these are being used since 1122 BC, and in Europe, they were cultivated for oil during the middle-ages. Pythagoras makes early mention of mustard in 530 BC as a remedy for scorpion bites by Greeks, Romans, and Chinese writings of 5000 to 200 BC. The oil was used earlier in Asia as a lamp oil later it was used as cooking oil. The Romans mixed must with crushed mustard seed to form a paste known as 'mustumardens'. The English name mustard is derived from the Latin word 'Mustum' or 'Must' which is the juice of grapes and 'ardens, meaning 'Hot' or "Burning". The word "Rapeseed" likely comes from "Rapa" the Latin word for turnip.



Significance of brassica and allied genera

The Brassica crops include oiliferous species viz., *Brassica napus* (rapeseed/swede), *B. Rapa* (turnip rape; syn. *B. campestris*), *B. carinata* (Abyssinian/Ethiopian mustard), and *B. juncea* (Indian mustard), vegetable species such as *B. oleracea* (e.g., broccoli, cabbage and cauliflower), *B. Rapa* (Chinese cabbage, pakchoi and turnip), and *B. juncea* (mustard, head mustard, broccoli mustard, and leaf mustard), edible root species including *Raphanus* spp., as well as condiment and herb species such as *B. nigra*, *B. Rapa* var. yellow sarson, *B. Rapa* var. brown sarson and *Sinapis* spp. U triangle of origin of crop Brassicas is presented in figure 1. The list of some of the Brassica and related species is presented in table 1. Apart from this Brassica species are also used for medicinal purposes, animal forage and fodder, green manure and soil conditioners, as well as industrial lubricants and biodiesel. Hence, Brassicaceae is considered within the 10 most economically important plant families due to its diversity of plant species and their usefulness to humankind. Brassica and allied species tolerant to biotic and abiotic stresses are presented in table 2.

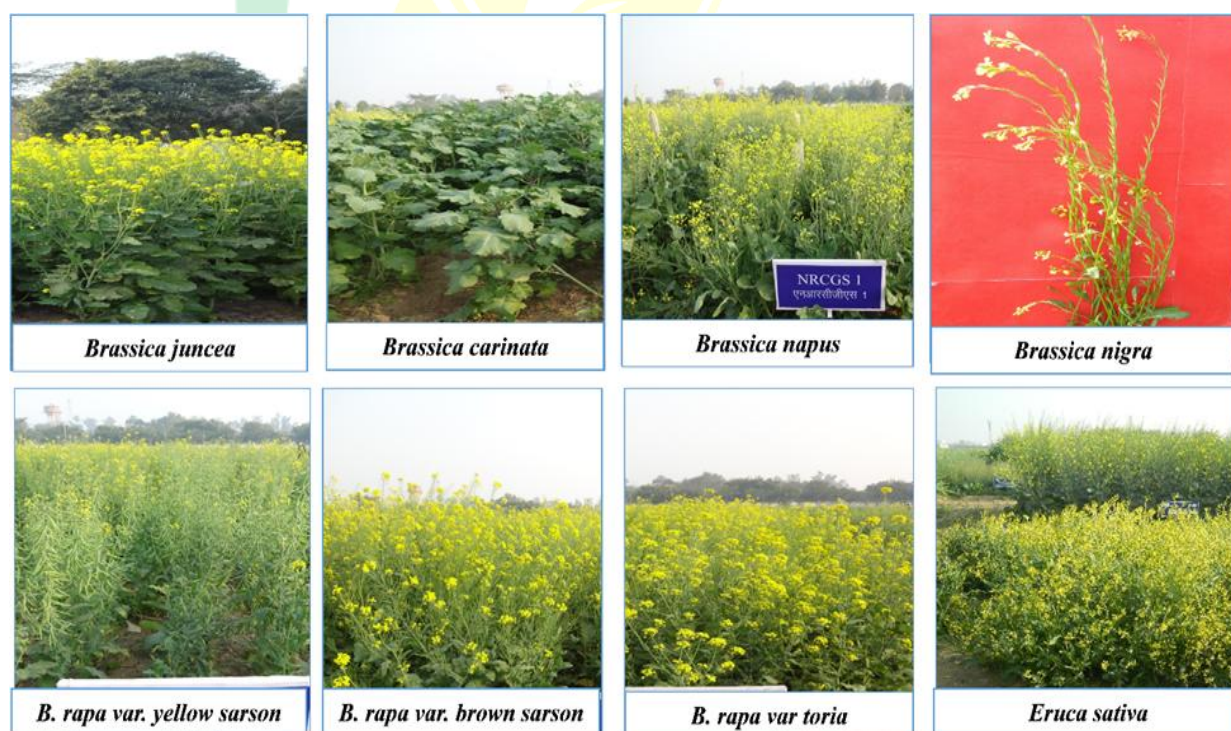


Fig.2: Cultivated oilseed Brassica species

Table 1: Some of the important Brassica and related genera

Scientific name	Common name	Chromosome no.	Genome size (Mb/1C)
<i>Arabidopsis thaliana</i>	Thale Cress, Mouse-ear Cress	2n=10	125
<i>Brassica juncea</i>	Indian mustard	2n=36 (AABB)	534
<i>B. napus</i>	Rapeseed, canola	2n = 38 (AACC)	566
<i>B. carinata</i>	Karan rai	2n = 34 (BBCC)	642
<i>B. nigra</i>	Black mustard	2n = 16 (BB)	632
<i>B. oleracea</i>	Cabbage	2n = 18 (CC)	696
<i>B. rapa</i>	Bird rape	2n = 20 (AA)	529
<i>B. tournefortii</i>	Asian mustard, African mustard, Sahara mustard	2n = 20 (TT)	791
<i>B. elongata</i>	Elongated mustard, long-stalked rape	2n = 22	-
<i>B. fruticulosa</i>	Mediterranean cabbage or twiggly turnip	2n = 16	-
<i>Camelina sativa</i>	Gold-of-pleasure, False flax	-	
<i>Capsella bursa - pastoris</i>	Shepherds purse	2n = 16, 32	203
<i>Crambe byssinica</i>	Abyssinian kale, Abyssinian cabbage	2n=90	-
<i>Diplotaxi serucoides</i>	White Wall Rocket	2n = 14	632
<i>D. muralis</i>	Sand-rocket	2n = 42	-
<i>D. tenuifolia</i>	Wall-rocket	2n = 22	-
<i>Erucavesicaria</i> sub sp. <i>sativa</i>	Garden rocket	2n = 22	560
<i>Erucastrum gallicum</i>	Dog mustard, Hairy rocket,	2n = 30	-
<i>Lepidium sativum</i>	Garden cress, mustard cresspoor	-	380

<i>Orychophragmus violaceus</i>	Chinese violet cress	2n = 24	-
<i>Raphanus raphanistrum</i>	Wild radish, Jointed charlock	2n = 18	-
<i>Raphanus sativus</i>	Radish	2n = 18	402
<i>Sinapis alba</i>	White mustard	2n=24 (SS)	553
<i>Sinapis arvensis</i>	Wild mustard	2n = 18	367
<i>Thlaspi arvense</i>	Field pennycress; Fanweed; French weed, Stinkweed	2n = 14	539

Table 2: Brassica and allied genera as a source for biotic and abiotic stress tolerance:

Trait	Species
Edaphic Adaptation	
Heavy metal (Ar, Cd, Ni, Pb, Se, Sr, Zn) tolerance and Hyper accumulation	<i>Lepidium sativum</i> , <i>Streptanthus</i> spp., <i>Thlaspi montanum</i> , <i>T. caerulescens</i>
Abiotic stress tolerance	
Salt tolerance	<i>Crambe maritime</i> , <i>Erucavesicaria</i> subsp. <i>sativa</i> , <i>Lesquerella fendleri</i> , <i>Lobularia maritime</i> , <i>Raphanus raphanistrum</i> ssp. <i>Maritimus</i> , <i>Thellungiella salsuginea</i> ,
Cold tolerance	<i>Barbarea vulgaris</i> , <i>Descurainia sophia</i> , <i>Thellungiella</i> ssp. <i>salsuginea</i> , <i>Thlaspi arvense</i>
Drought tolerance	<i>Brassica carinata</i> , <i>B. tournefortii</i> , <i>Carrichter aannua</i> , <i>Diplotaxisacris</i> , <i>D. harra</i> , <i>Enarthrocarpus strangulates</i> , <i>Erucave sicaria</i> , <i>Erucaria boveana</i> , subsp. <i>sativa</i> , <i>E. microcarpa</i> and <i>E. uncata</i> , <i>Lesquerella</i> spp., <i>Moricandiaspp.</i> , <i>Physorhynchus</i> spp., <i>Pseuderucaria clavata</i>
Disease Resistance	
White rust -Albugo candida	<i>Brassica carinata</i> , <i>B. rapa</i> , <i>B. juncea</i> , <i>B. nigra</i> , <i>B. maurorum</i> , <i>Erucavesicaria</i> sub sp. <i>sativa</i> , <i>Raphanus sativus</i>
Black leaf spot/ Alternaria	<i>Alliaria petiolata</i> , <i>Barbarea vulgaris</i> , <i>Brassica nigra</i> , <i>B.</i>

spp. – <i>Alternaria brassicae</i> , <i>A. brassicicola</i> , <i>A. raphani</i>	<i>elongate</i> , <i>B. fruticulosa</i> , <i>B. maurorum</i> , <i>Camelina sativa</i> , <i>Capsella bursa-pastoris</i> , <i>Diplotaxis catholica</i> , <i>D. erucoides</i> , <i>Erucave sicaria</i> sub sp. <i>sativa</i> , <i>Hemicrambe fruticulosa</i> , <i>Neslia paniculata</i> , <i>Raphanus sativus</i> , <i>Sinapis alba</i> , <i>S. avensis</i>
Downy mildew (<i>Peronospora parasitica</i>)	<i>Brassica oleracea</i> , <i>Erucave sicaria</i>
Clubroot (<i>Plasmodiophora brassicae</i>)	<i>Arabidopsis thaliana</i> , <i>Armoracia rusticana</i> , <i>Brassica rapa</i> , <i>Capsella bursa-pastoris</i> , <i>Raphanus spp.</i>
Sclerotinia stem rot (<i>Sclerotinia sclerotiorum</i>)	<i>Capsella bursa-pastoris</i> , <i>Erucave sicaria</i> sub sp. <i>sativa</i> , <i>Erucastrum gallicum</i>
<i>Verticillium dahliae</i>	<i>Armoracia rusticana</i>
<i>Verticillium longisporum</i>	<i>Brassica napus</i> , <i>B. oleracea</i> , <i>B. rapa</i>
Black rot (<i>Xanthomonas campestris</i>)	<i>Alliaria petiolata</i> , <i>Barbarea vulgaris</i> , <i>Brassica juncea</i> , <i>B. nigra</i> , <i>B. carinata</i> , <i>B. nigra</i> , <i>B. rapa</i> , <i>Erysimum hieraciifolium</i> , <i>Matthio laincana</i> ,
Insect resistance	
Flea beetles (<i>Phyllotreta cruciferae</i> and <i>P. striolata</i>)	<i>Arabidopsis thaliana</i> , <i>Brassica incana</i> , <i>B. juncea</i> , <i>B. villosa</i> , <i>Camelina sativa</i> , <i>Capsella bursa-pastoris</i> , <i>Crambe byssinica</i> , <i>C. hispanica</i> , <i>C. glabrata</i> , <i>Sinapis alba</i> , <i>Thlaspiarvense</i>
Diamond-back moth (<i>Plutella xylostella</i>)	<i>Barbarea vulgaris</i> , <i>Brassica juncea</i> , <i>B. oleracea</i> , <i>B. napus</i> , <i>Crambe byssinica</i> , <i>Raphanus raphanistrum</i>
Cabbage aphid (<i>Brevicoryne brassicae</i>)	<i>Brassica fruticulosa</i> , <i>B. spinescens</i> , <i>B. cretica</i> , <i>B. incana</i> , <i>B. macrocarpa</i> , <i>B. villosa</i> , <i>Erucave sicaria</i> sub sp. <i>sativa</i> , <i>Sinapis alba</i>
Mustard aphid (<i>Lipaphi serysimi</i>)	<i>Brassica carinata</i> , <i>B. nigra</i> , <i>B. juncea</i> , <i>Brassica spp.</i> , <i>Erucave sicaria</i> sub sp. <i>sativa</i>
Cabbage white fly (<i>Aleyrode sproletella</i>)	<i>Brassica cretica</i> , <i>B. fruticulosa</i> , <i>B. incana</i> , <i>B. insularis</i> , <i>B. spinosa</i> , <i>B. villosa</i>

Cabbage root fly or Cabbage maggot (<i>Delia radicum</i>)	<i>Brassica fruticulosa, B. incana, B. macrocarpa, B. spinescens, B. villosa, Camelina sativa, Sinapis alba</i>
Cabbage seedpod weevil (<i>Ceutorhynchus obstrictus</i>)	<i>B. juncea, B. nigra, B. tournefortii, Sinapis alba</i>
Mustard sawfly (<i>Athalia proxima</i>)	<i>Camelina sativa</i>
Nematode Resistance	
Beet cyst nematode (<i>Heterodera schachtii</i>)	<i>Raphanus sativus, Sinapis alba</i>
Root-knot nematode (<i>Meloidogyne</i> spp.)	<i>Eruca sativa, Raphanus sativus, Rapistrum rugosum, Sinapis alba</i>

A wild and weedy relative of Brassica naturally occurs in the Mediterranean region (mainly Morocco, Spain, and Algeria). These species have a wide distribution range from the Mediterranean to India. Harbard (1976) classified the germplasm of these wild relatives of Brassica and referred to them as Brassica coenospecies. The wild relatives in the family are of paramount significance as these are a reservoir of many potential genes of abiotic stresses like drought (*B. tournefortii*, *E. sativa*), cold (*Erucastrumabyssicum*) and biotic stresses including white rust (*Raphanus sativus*), alternaria blight (*Camellina sativa*, *Diplotaxi serocoids*, *S. alba*) aphid, powdery mildew, alternaria blight, nematode, male sterility (*Moricandia arvensis*), high photosynthetic rate (*Enarthro carpuslyratus*), pod shattering resistance (*Enarthrocarpus*, *B. tournefortii*). These coenospecies serve as a donor for introgression of desirable traits through conventional hybridization and/or advanced biotechnological approaches like protoplast fusion and genetic engineering which led to the development of some somatic hybrids and transgenic in Brassicaceae. The genus Brassica and allied genera have been extensively investigated by researchers worldwide as model plant species for scientific studies on cytogenetics, genomics, proteomics, bioinformatics, evolution and domestication, speciation, and molecular biology. *Arabidopsis thaliana* is one



of the most studied model plant species of the Brassica family. The development of high-density maps in Brassica species helped in tagging of genes for disease resistance, abiotic stress, fertility restoration, oil quality, and morphological traits. The successful CMS and restorer lines developed based on ogura and mori cytoplasm are being used in the development of commercial hybrids in rapeseed-mustard. However, the Development of modern high-yielding cultivars, monocultures, changing food habits, deforestation, natural vagaries like drought, floods, led to genetic erosion of most of the crops including oilseed Brassica. Therefore, proper collection, systematic characterization, documentation, and conservation of these species need to be done for their effective utilization in the crop improvement program.

References

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