

Oilseed *Brassica* Germplasm : Status, Utilization and Priorities

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Brassica is a genus of the Brassicaceae (Cruciferae), commonly known as the Cruciferae family. The family Brassicaceae, includes about 3,500 species and 350 genera, is one of the ten most economically important plant families (Warwick *et.al.*, 2000). *Brassica* contains about 100 species, including cabbage, cauliflower, broccoli, brussels sprouts, turnip, various mustards and weeds (Willis, 1973). *Brassica* crops are among the oldest cultivated plants known to humans with written records dating back to ca. 1500 BC (Prakash, 1980) and archaeological evidence of its importance dating back to 5000 BC (Yan 1990). The important members of this group are: *Brassica napus*, *B. rapa*, and *B. juncea* -sources of canola and industrial oil. Oilcake is used as an animal feed. Further, *Brassica* species have several medicinal uses. The utilization of oilseed Brassicas is steadily increasing. Rapeseed-mustard comprises a group of seven cultivated oilseed Brassicas of tribe Brassicaceae within the family Brassicaceae. They are the main source of edible oil in Indian diet after groundnut. The different species are, Indian mustard (*Brassica juncea* (L.) Czern. & Coss.), toria (*B. rapa* L. ssp. *toria*), yellow sarson (*B. rapa* L. ssp. *yellow sarson*), brown sarson (*B. rapa* L. ssp. *brown sarson*), gobhi sarson (*B. napus* L.), karan rai (*B. carinata* Braun.) and taramira (*Eruca sativa* Mill.). Oilseed Brassicas represent a rich diversity (Table 1), which are being cultivated in 23 states and union territories (Misra and Kumar, 2008). However, much of diversity is concentrated in the Indo-gangetic plains and sub-mountain Himalayas.

Table 1. Diversity in rapeseed-mustard and related species (after Kumar and Misra 2007)

Species	Genome	Chr. No (n)	Mating system
Mustard			
<i>Brassica juncea</i>	AB	18	Self compatible*
<i>Brassica carinata</i>	BC	17	Self compatible
<i>Brassica nigra</i>	B	08	Self incompatible
<i>Brassica tournefortii</i>	T	10	Self incompatible
<i>Sinapis alba</i>	S	12	Self incompatible
Rapeseed			
<i>Brassica rapa</i> (syn . <i>B. campestris</i>)			
ssp. <i>toria</i>	A	10	Self incompatible
ssp. <i>yellow sarson</i>	A	10	Self compatible
ssp. <i>brown sarson</i>	A	10	Self incompatible
<i>Brassica napus</i>	AC	19	Self compatible
<i>Eruca sativa</i>	E	11	Self incompatible
<i>Brassica oleracea</i> **	C	09	Self incompatible

*Out crossing 5-15per cent, ** =Vegetables

The Brassicaceae, is distinguished on the basis of the presence of conduplicate cotyledons (i.e. the cotyledons are longitudinally folded around the radical) and/ or two-segmented fruits (siliquae), which contain seeds in one or both segments, and only simple hairs, if present (Misra, 2008a). Three characteristics separate the mustard family from all other plant families:

- The stamens are tetradynamous, meaning there are four long stamens and two short stamens in each flower.
- The flowers have four petals that form a cross, hence the alternate family name *Cruciferae*.
- The pods have a thin translucent, frame-like inner membrane, the replum, that separates the two sides of the pod and to which the seeds are attached, called siliqua.

Importance of oilseed brassica

Brassicacae play an important role in the world agriculture as oilseeds, vegetables, forage and fodder, green manure and condiments. Indian mustard, is predominately play important role the oil seed economic A large proportion of mustard oil is used directly in cooking, the oil is also used in the manufacture of salad dressage and table oils, confectionery fats and shortenings which is two are used in making cakes, biscuits, pastries and many other products. It is also of great importance in the manufacture of margarine. The fatty acids and their derivatives are widely used for industrial purpose. Oils may not be used directly in the preparation of paints, linoleum or inks, due to its semi-drying nature. However, its derivatives and fatty acid can be used for this purpose. It is also used in production of rubber, tanning industries, as lubricants, and manufacture of soaps, detergents and bonding compounds. It seems likely that many new uses will be found for oil in future, such as medium for pesticide application, as herbicide additives and as fuel in the form of biodiesel. Oilseed cake or meal is a byproduct during the extraction of oil from the seeds. It is an important source of protein for animals and it's currently being considered as a potential supplementary source for human beings. The cake has 35 to 40percent crude protein depending upon the variety as well as condition of growing and processing. The amino acid content is comparable well with soybean meal, but it is richer in sulphur amino acids and poorer in lysine. The fiber content in meal is very higher, as compared to soybean meal, which lead to a lowering of the metabolically and digestible energy values and decrease in the bioavailability of minerals. The low glucosinolate meal is good food for young ruminants and lactating cows, piggery and poultry purposes (Kumar *et. al.*, 2004). The economically most important product is oil. The mustard oil contains substantial amount of unsaturated fatty acid and the low concentration (around 7 percent) of saturated fatty acid. In unsaturated fatty acid it contains oleic acid (8-40percent), lenolenic acid (5-10 percent), linoleic acid (10-29 percent), eicosinoic acid (5-12 percent) and erucic acid (40-55 percent). The *Brassica* seed meal (oil cake) contains: protein (36-38 percent), carbohydrate (14-16 percent), fiber (10-15 percent), moisture (6-8 percent), ash (4-6 percent), mineral (3-4 percent), vitamins (0.7-0.9 percent) glucosinolate (2-3 percent), phytic acid (3-6 percent), sinapine (1-1.5percent) and 1.6-3.1 percent of tannin (Agnihotri and Kumar 2004).

Area, production and yield of oilseed brassicas

Rapeseed- mustard crop is grown in subtropical and tropical countries and total production in world was 46.27 mt from 26.79 m ha with yield of 1730 kg/ha during 2006-07. The major rapeseed-mustard producing countries are China, India, Canada, Germany and France. In the world India ranked second and third for area and production, respectively. In India, rapeseed-mustard crops accounted for 29.1 percent of the total oilseeds production and 26.1 percent of the total oilseed area during 2005-06. Globally, India accounts for 26.5 percent and 16.6 percent of the total hectarage and production of rapeseed-mustard, respectively (Anonymous 2007). In India, oilseed crop and rapeseed-mustard group of species accounts for 14.1 and 3percent of the gross cropped area, respectively. Among the oilseed crops, rapeseed- mustard ranked second after groundnut in total oilseed production in India. Rapeseed-mustard is the major source of income for the marginal and

small farmers in rainfed areas. Because of its less water requirements (80-240 mm) and thus fits well in the rainfed cropping system. The average yield of these crops in India varies from 900-1200 kg/ha. This crop occupying about 6.18 m ha area and 7.36 mt production with 1190 kg/ha average yield during 2008- 09, of this around 35percent area is under rainfed. Among the cultivated oilseed *Brassica* over 75percent of area and production is of Indian mustard (Misra 2004a, Misra 2008a). It is predominantly cultivated in Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, Gujarat, Himachal Pradesh, Bihar, Assam, West Bengal, Orissa. Rajasthan ranked first in term of production with acreage and production around 40percent (Misra 2008a). In Rajasthan, Bharatpur region ranked first in of area for production followed by Alwar, Sawai Madhopur, Karoli, Sriganganagar, Jhunjhunu, Jaipur, Ajmer, Siker and Tonk.

***Brassica* germplasm**

Plant genetic resources or germplasm are the key point of any agriculture production system. Genetic resource provides basic raw materials to crop improvement programmes. The success as well as pace of varietal development programmes depends upon available genetic variability for utilization. Germplasm constitutes reservoir of genes for resistance to various biotic and abiotic stresses. The sum total of all allelic sources influencing a wide range of characters constitutes the plant genetic resources of a crop. In broader sense plant germplasm resources is the sum total of genes in a crop species. However, “Biodiversity International” (formerly known as IPGRI: International Plant Genetic Resource Institute, Rome) the genetic resource defined as genetic material of plants, animal and other organisms that is of value for present and future generations of people and genetic diversity defined as the genetic variation present in a population and species. Therefore, both germplasm and genetic diversity are essentially required for undertaking successful crop improvement programme.

For strengthening genetic resources management; evaluation, conservation and documentation of germplasm, exchange under appropriate quarantine measures and distribution of germplasm for utilization as well as medium and long term conservation of valuable germplasm in national gene bank (in India located at NBPGR, New Delhi) for posterity of mankind are essential activities. Characterization and evaluation are important activities under plant genetic resources programmes. Characterization is the basic morphological description of accessions while a preliminary evaluation work is carried out in the course of rejuvenation. Germplasm should preferably be evaluated for important morpho-agronomic traits under different agro-climatic conditions and the systematic evaluation for various morpho-agronomic, quality traits, biotic and abiotic stresses, resulted in the identification of donors for use in the varietal improvement programme (Misra, 2008b). Worldwide, there are more than 90,000 accessions of *Brassica* conserved in 140 germplasm banks.

According to Boukema and Hintum (1999) five countries share nearly 60 per cent of *Brassica* germplasm holdings. They are China (17 per cent) followed by India (15 per cent), UK (10 per cent), USA (9 per cent) and Germany (8 per cent). Presently more than 57,700 accessions of different oilseeds are available in the country. NBPGR maintains over 21,700 accessions of various oilseed crops at its headquarters and regional stations. Of these 9644 (till March 2009) belongs to rapeseed-mustard (Table 2). NBPGR has also instrumental for collecting 4095 indigenous rapeseed- mustard germplasm and introducing 3401 exotic accessions during 1986-2006 (Sharma and Singh, 2007). In our country we have over 14000 rapeseed – mustard germplasm accessions (Kumar and Misra, 2008).

Table 3. Status of germplasm at national genebank (till March 2009)

Type of germplasm	Total Acc.
Indigenous	9042
Exotic	246
Wild	65
Released/ farmers/ folk varieties	254
Genetic stocks	37
Total	9644

Table 3. Status of working germplasm collections in India (till July 2009)

Name of species	Total Acc.
Indian Mustard	9720
Brown Sarson	478
Yellow Sarson	1064
Toria	1918
Taramira	578
Gobhi Sarson	595
Karan Rai	243
Other	126
Total	14722

For effective utilization of oilseed Brassicas diversity concentrated efforts have been made. The systematic evaluation for various morpho-agronomic, quality traits, biotic and abiotic stresses, resulted in the identification of donors (Misra, 2008b) for use in the varietal improvement programme and subsequently resulted into release of 181 improved varieties and in addition to this 37 germplasm lines have been registered for utilization in crop improvement programmes till 2009. These include several varieties developed by utilizing direct selection of germplasm, hybridization with local germplasm and exotic germplasm (Misra and Kumar, 2008, Kumar *et.al.*, 2004). The improvement of quantity and quality of oils and oilseeds greatly depends on available genetic resources and their exploitation through conventional plant breeding methods and biotechnological techniques.

Germplasm collection and introduction

To collect indigenous variability of oilseed Brassicas, systematic efforts were made by erstwhile Plant Introduction Division of the Indian Agriculture Research Institute, New Delhi, under PL 480 scheme on "Collection, Evaluation and Maintenance of Brassica Germplasm" during 1960s and over 2000 accessions of rapeseed-mustard and allied genera were collected from north-eastern plains and hills, and north-western plains and central plateau. Sporadic efforts were made in 1970s to collect Brassica germplasm under multi-crop explorations. With the establishment of the Germplasm Management Unit in the Project Coordinating Unit (Rapeseed-Mustard) by the Indian Council of Agricultural Research at the CCS-Haryana Agricultural University, Hisar in 1981 and its subsequent shifting into the National Research Centre on Rapeseed-Mustard at Bharatpur (renamed as Directorate of Rapeseed- Mustard Research in 2009) in 1993, efforts were made to collect the

indigenous as well as to introduce exotic germplasm of Brassica and its wild allies (Kumar *et.al.*, 2004). At present over 14000 working collections are being maintained /used in the country. However, under joint programme of National Bureau of Plant Genetic Resources, New Delhi and All India Coordinated Research Project on Rapeseed- Mustard (AICRP-RM), several Brassica- specific explorations were undertaken in the drier parts of Gujarat, Rajasthan, Bundelkhand region of Uttar Pradesh, parts of Bihar, West Bengal, Orissa, hilly areas of Jammu and Kashmir, Himachal Pradesh and the north-eastern Himalayas. As a result of explorations, 3677 collections of different species of Brassica were made from different states during 1976-1999. Local landraces of *B. juncea* such as 'jatai rai', 'desi rai', and maghi rai' were collected from farmer's fields in the areas bordering Bangladesh. In yellow sarson, dwarf and early types with pendulous siliqua were collected from Indo-Bangladesh border whereas tall, robust, multi-locular types were mainly collected from eastern UP. Diversity of *B. tournefortii* and *B. nigra* was collected from drier parts of Haryana and Rajasthan. Explorations for wild crucifers in Pauri Garwal hills of Uttar Pradesh added 22 accessions of *Capsella*, *Crambe*, *Lepidium* and *Sisymbrium* spp. Several exploration trips were conducted by the Directorate of Rapeseed- Mustard Research, Bharatpur (Rajasthan) and so far, around 800 accessions were collected from different parts of country including Assam, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Meghalaya, Nagaland, Punjab, Rajasthan, Uttar Pradesh, Uttranchal and West Bengal. Some of the unique collections were made, which include yellow seeded toria, dwarf mustard, dwarf and early toria, white flowered yellow sarson etc.

During the last two decades, NBPGR has introduced over 3800 accessions of rapeseed-mustard from over 25 countries, under strict phyto sanitary conditions, with specific traits like high yield, high oil content, and resistance to biotic and abiotic stresses as well as desirable quality traits. Most of the *Brassica* germplasm lines introduced from Europe and Canada are of *B. napus*. These lines are very tall, late in maturity and poor yielding under Indian conditions. However some of the lines are having superior oil quality with low erucic acid and low glucosinolate, which have been introgressed into Indian cultivars. Some of the promising introductions of *Brassica* germplasm cultivars, their economic traits and source countries have been mentioned in Table 4.

Table 4. Promising *Brassica* germplasm introduced through NBPGR

Species	Traits	Cultivar/Accession	Source
<i>Brassica juncea</i>	Low erucic acid	Zem 1 (EC-223759)	Australia
		Zem 2 (EC 223760)	Australia
		EC-322090-093	China
		EC-367880-885	Canada
	Low glucosinolate	EC-346016	Canada
EC-287711		Sweden	
BJ-1058		Sweden	
High oil content	EC-264486	Canada	
	EC-303460-463	UK	
	Donskaja	Russia	
White rust resistant line	EC-264487	Canada	
Alternaria tolerant Drought tolerant	EC-206712	France	
	EC-333584-85	Sweden	

Table 4 Cont.

Species	Traits	Cultivar/Accession	Source
<i>B. rapa</i>	Low erucic acid	EC-226808	Canada
		EC-226808	Sweden
	Double zero lines	EC-302478 EC-242690-91	Sweden Sweden
	High oil content	EC-232318	Canada
<i>B. nupus</i>	Double zero lines	EC-271577-81	UK
		EC-200831-32	Canada
	Drought tolerant	EC-333586-587	Sweden
<i>B. carinata</i>	Improved cultivars	PGR-13221-222, EC-223405	Canada Pakistan

(Modified after Singh 1996)

Germplasm evaluation

Germplasm should preferably be evaluated for important morpho-agronomic traits under different agro-climatic conditions and evaluated for disease and pest reactions at the hot spots. Based on evaluation data crop catalogues are compiled for utilization of desirable genotypes by the crop breeders. A large number of rapeseed- mustard germplasm evaluated and characterized for various agro-morphological traits and biotic stresses (Misra *et.al.*, 2004, Misra and Kumar, 2009). Range values of various agro-morphological and quality traits in different *Brassica* spp have been given in table 5. It has been observed that variability was maximum for secondary branches per plant and least for oil and protein content. Information collected on germplasm of rapeseed-mustard in the country demonstrates the availability of valuable genetic reservoir, which could be exploited for improving the existing cultivars.

Table 5. Range of some of the important agro-morphological traits in top 3 oil seed Brassicas germplasm accessions

Characters	Crop		
	Indian mustard	Yellow sarson	Toria
Plant height (cm)	72.8-232.8	53.2-188.2	36.6-155.4
Main shoot length (cm)	23.8-112.4	24.7-89.6	16.6-75.
Siliquae on main shoot	12.0-82.2	10.0-78.6	13.6-77.8
Siliquae length (cm)	2.4-6.5	2.8-7.9	2.4-7.7
Seed per siliqua	6.1-23.8	8.6-44.6	8.1-24.4
1000-Seed weight (g)	1.1-8.2	1.4-6.9	1.0-4.8
Oil content (percent)	26.1-44.5	35.1-47.0	35.7 - 45.6
Harvest index (percent)	4.7-37.7	3.7-39.0	13.6 - 41.1

The sources for resistance to pests, diseases, salinity, frost and drought were identified and utilized in breeding programmes (Table 6). The systematic evaluation for various morpho-agronomic, quality traits, biotic and abiotic stresses, resulted in the identification of donors for use in the varietal improvement programme and subsequently resulted into release of over 180 improved varieties.

Table 6. Sources of various biotic / abiotic stresses and quality traits (after Misra 2004b)

Sources of tolerance to *Alternaria* blight

B. juncea : EC-129126, EC 399301, PAB 9511, PAB 9534, RC 781

B. carinata : PBC-9921 (Kiran), PC 5, Pusa Swarnim (IGC 01)

B. napus : GSL-1, HNS-3, PBN-2001, PBN-2002, PBN-9501, PBN 9502

Sources of location/ race-specific resistance to White rust

B. juncea : EC-399300, EC 399301, JMMWR- 941 - 1 – 2, PWR 2001, PWR 9541

B. carinata : JTC 1, Kiran(PBC-9921), PC 5, PC 5-17, Pusa Gaurav (DLSC 1), Pusa Swarnim (IGC 01)

B. napus: GSL-441, HNS-4, PBN-2001, PBN-2002

Sources of location/ race-specific resistance to downy mildew

B. juncea : BIOYSR

B. napus : PBN-2002

Genotypes having glucosinolate content less than 30 micro mole/g defatted meal

B. juncea : NUDH-YJ-1, NUDH-YJ-2

B. napus : HNS 99(0E)3, NUDB-09, NUDB-26-11

Genotypes having low erucic acid (single low)

B. juncea : LES - 17 -1, LES 21, LES 38, YSRL 9- 18 -23, TERI (OE) M 21

B. napus : NUDB-26-11, Phaguni [TERI (0E) R 03], Shyamali [TERI (0E) R 09], TERI Unnat

Genotypes having low erucic acid (< 2percent) and low glucosinolate i.e.Canola type(< 30 μ moles / g fat free meal)

B. juncea : Heera, NUDHYJ- 5, TERI GZ-05

B. napus : BCN 14, CAN 138, GSC 5(GSC3A), TERI (00) R 985, TERI(00) R 986, TERI(00) R 9903

Early duration(100- 110days)

B. juncea : JD 6, Kanti, NDRE 4, Sej 2

Salt tolerance (Ece up to 10 ds/m)

B. juncea : CS 52, CS 54(CS 614-4-1-4), RH 8814

Yellow seeded

B. juncea : Basanti, NDYR 8, NDYR 10, TM 4, YRN 6

Tetralocular

B. juncea : Geeta (RB 9901)

High oil content (\approx 45 percent)

B. juncea : NDYR 8, NDYR 10

Apetalous source

B. juncea : RC 199

The registration of germplasm and varieties was initiated by NBPGR/ ICAR in 1997 with a view to give due recognition to the plant breeders associated with development / identification of novel genotypes/ germplasm/ variety for utilization in crop improvement programmes. In this endeavor, 37 germplasm lines have been registered.

Germplasm utilization

For any crop improvement programme, a broad range of genetic resources is a must. In the past, a wide spectrum of genetic stocks of Brassicas has been assembled, which include land races as well as different varieties and related species from different countries. Based on preliminary evaluation and characterization data, promising donor genotypes have been identified. Under All India Coordinated Research Project on Rapeseed-Mustard and National Research Centre on Rapeseed-Mustard (ICAR), varietal development programme is in progress. A large number of promising varieties (Table 7) have been released for cultivation for different agro-climatic regions and some are in the pipeline for release in the coming future. Out of this 181, a total of 66 are direct selection from germplasm. In rapeseed-mustard, breeders have been working with limited germplasm. This has been one of the major bottlenecks in *Brassica* improvement. The sizeable collection of germplasm available in the country does not represent the entire variability available in the indigenous material.

Table 7. Released/ recommended varieties of rapeseed- mustard in India and selection from germplasm (till July 2009)

Crop	Number of varieties released	Selection from germplasm
Brown sarson	09	06
Gobhi sarson	12	01
Taramira	05	03
Toria	31	16
Yellow sarson	22	14
Black mustard	01	01
Karan rai	07	02
Indian mustard	94	23
Total	181	66

Status of documentation

Most of the germplasm already introduced and collected by the efforts of NBPGR as well as complemented by different AICRP (RM) centres, and have characterized and evaluated for important morpho-agronomic descriptors. The information of characterization and evaluation data have been published in annual reports, research papers as well documented in crop catalogue from time to time.

Future perspective

There is a need to intensify the research on genetic resources of oilseed brassicas in the country. The following priority areas of research have been identified:

- There is a need to broaden the genetic base; the regions of higher diversity should be explored. The exploration and collection from unexplored areas / hotspots are extensively needed.

- Exploration from the countries like Australia, Canada, China, Japan, Russia, Spain, Sweden; especially for quality, high heterosis (oil content, yield), biotic, abiotic stress and wild species.
- Introduction of germplasm of wild / weedy relatives as well as cultivated species of rapeseed-mustard from the centers / areas of rich generic diversity.
- Multi-location evaluation and characterization of germplasm, and subsequently their proper documentation is required to be strengthened.
- Molecular characterization of germplasm.
- Maintenance of gene pool for various traits such as quality, biotic and abiotic stresses.
- Participation of farmers during collection of germplasm and indigenous knowledge.
- Development of a core set of the germplasm for different traits for efficient handling and utilization of germplasm.

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