Indian J. Pl. Genet. Resources 13(3): 207-218, 2000

RAPESEED - MUSTARD GENETIC RESOURCES : STATUS AND PRIORITIES

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Rapeseed and mustard comprise a group of 8 cultivated cruciferous oilseed species of tribe Brassiceae. They are the main source of edible oil in Indian diet after groundnut. They play an important role in Indian economy contributing 27 and 25.3 per cent to the total oilseed production and hectarage respectively. *Brassica juncea* is the predominant species and accounts for nearly 80 per cent of the hectarage. Oilseed *Brassica* species represent a rich genetic diversity and are grown in eight agro-ecological zones of the country. However, much of the diversity is concentrated in the Indo-gangatic plains and sub-mountane Himalayas. Since the genetic resources play an important role in breeding programme, their conservation and systematic evaluation merit foremost priority. This paper highlights an state-of-the-art in the rapeseed mustard genetic resource activities in the country. Systematic, planned and coordinated efforts of NBPGR, AICRP-RM (presently NRCRM) and other research institutes have resulted into the acquisition/collection/assemblage of 17,439 accessions of cultivated, wild and allied species of these crops. However, these also include duplicate or even quadruplicate samples. Working collections are being maintained and evaluated for major economic attributes and stresses at the various research stations. Collections made have provided a broad germplasm base the breeding programme. Among the *B. juncea* crop, RC 781 (multiple diseases AB+WR+DM tolerant), YRT 3 (white rust tolerant), T 6342 (aphid tolerant), RW 175 (frost tolerant) and RS 781 (drought and frost tolerant) genes were identified. Among the exotic collections, Midas, Westar and Tower of *B. napus*; Candle, Span and Torch varieties of *B. rapa* have been found promising and used in the breeding programme. A list of useful accessions with desirable agro-morphological and quality traits and tolerance to biotic and abiotic stresses has also been presented for future utilisation. The paper also discusses the future thrust areas for augmenting the ongoing efforts and making the programme more effective.

Key words : Rapeseed - mustard, genetic resources, *Brassica*

Rapeseed-mustard comprises a group of seven cultivated cruciferous oilseed species of *Brassica* (tribe Brassiceae) and its related genus *Eruca*. Rapeseed in the Indian context consists of gobhi sarson (*Brassica napus* L.), the three ecotypes of *B. rapa* L. (syn. *B. campestris* L.) viz., toria, brown sarson (*lotni* and *tora* types) and yellow sarson and taramira (*Eruca sativa* Mill.), while the mustard group includes Indian mustard (*B. juncea* [L.] Czern. & Coss.), black mustard (*B. nigra* Koch), wild mustard (*B. tournefortii*), Ethiopian mustard or karan rai (*B. carinata* Braun.) and white mustard (*B. alba* Rab. [syn. *Sinapis alba*]). These are rabi crops accounting for 27 per cent of the total oilseed production from an hectarage of 25.3 per cent. They are the chief source of edible oil and foreign exchange earners. India's share in the world oil meal export stands at 32.7 per cent during 1995-96 (Mehta, 1998). India earned a sizeable amount of foreign exchange equivalent to Rs. 456 crore from April 1997 to February, 1998 by exporting 1.14 million tonnes of oil meal. (Anonymous, 1998).

Brassica is considered to be of Old World origin. India presents rich diversity of oilseed Brassicas. *Brassica rapa* vars. toria and brown sarson, *B. juncea* and *Eruca vesicaria*, considered to be of Indian gene centre (Arora, 1988), are distributed in eight agro-ecological zones of the country (Table 1). Much of the diversity is concentrated in the Indo-gangetic plains and sub-mountane Himalayas. The oilseed Brassicae are widely grown in the northern plains in the states of Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Gujarat, West Bengal, Assam, Bihar, Punjab, Himachal Pradesh and Jammu and Kashmir. Of these, Rajasthan, Uttar Pradesh, Haryana and Madhya Pradesh together account for 77 per cent of the total hectarage of rapeseed-mustard in India.

Table 1. Oilseed *Brassicas* in different agro-ecological regions of India

S.No.	Region	State
1.	Humid Eastern Himalayan Region	Arunachal Pradesh,Manipur,Meghalaya,Mizoram,Nagaland,Sikkim,Tripura
2.	Humid Bengal - Assam Region	West Bengal,Assam
3.	Sub-humid to humid Eastern and South Eastern uplands	Orissa,Eastern Madhya Pradesh,Andhra Pradesh
4.	Humid to semi-arid Western Ghats and Plateau	Karnataka,Tamil Nadu
5.	Semi-arid Lava Plateau and central uplands	Maharashtra,rest of Madhya Pradesh
6.	Arid Western plains	Gujarat,Rajasthan,Haryana
7.	Sub-humid Sutlej Ganga alluvial plains	Bihar,Uttar Pradesh,Punjab
8.	Humid Western Himalayan Region	Part of Uttar Pradesh,Himachal Pradesh,Jammu and Kashmir

Brassica juncea, the dominant species grown, is followed by *B. rapa* var. *toria*, brown sarson, yellow sarson and *E. sativa*. Since the last three decades, *B. napus* and *B. carinata* are under cultivation with varying success in pockets particularly areas having longer winter spell.

I. EXPLORATION AND COLLECTION

Crop specific explorations organized by the National Bureau of Plant Genetic Resources (NBPGR), formerly Plant Introduction Division, Indian Agricultural Research Institute, New Delhi, since mid sixties collected rich genetic diversity in oilseed Brassicas. Sporadic efforts were also made during 1970s to collect the germplasm under multi-crop explorations. However, in 1980s, under joint programme of the NBPGR and the All-India Coordinated Research Project on Oilseeds (AICRPO), several *Brassica* explorations were undertaken in drier parts of Rajasthan, Gujarat, Haryana, Bundelkhand region of Uttar Pradesh, parts of Bihar plateau, West Bengal, Orissa, hilly areas of Jammu, Kashmir valley, Himachal Pradesh, Uttar Pradesh and the north-eastern Himalayas. The plant exploration undertaken from 1966 to 1986 resulted in collection of 1,903 accessions of different species, types and races of Brassicae (Kumar, 1987). The intensification of efforts during 1986-1996 resulted in acquisition and collection of 3,658 accessions of exotic, cultivated, wild and allied species of Brassica (NBPGR, 1995, 1996, 1997; Singh, 1997). The popular types of mustard collected included 'jatai rai', 'desi rai' and 'maghi rai' from boardering areas of Bangladesh. Dwarf and early types of yellow sarson with pendulous pods were also collected from the same area. Whereas, tall, robust, multilocular types were collected from eastern Uttar Pradesh. The important species of oilseed Brassicae collected included *B. juncea*, *B. rapa* vars. toria, brown sarson and yellow sarson, *E. sativa, E. vesicaria* and *B. nigra*. Besides, a number of semi-wild and wild species such as *B. tournefortii, Sisymybrium officinale, Erysimum hieracifolium* and *Nasturtium montanum* were also collected (Kumar, 1987). Diversity of *B. toumefortii* (locally known as 'todia' or 'dholi sarson') and *B. nigra* was collected from drier parts of Haryana and Rajasthan (NBPGR, 1995, 1996, 1997; Singh 1997).

Indeed, *Brassica* species are among the most polymorphic of the crop species surveyed. Even within species there is tremendous variation in form. In general, two distinct morphological types of *B. juncea* were observed during collection, the oleiferous types were prevalent in the sub-continent and the leafy types were observed in hills of North-eastern-states and other hilly regions of the country. Considerable intra-varietal diversity in mustard was observed. Two morphologically distinct types of *B. rapa* L. var. brown sarson, namely *lotni* and *tora* types were also collected. The lotni is spreading type with profuse branching and has high degree of self-incompatibility, while the tora type is mostly compact, shorter in height with self-compatible mating system. The tora brown sarson has evolved from the lotni types, primarily because of the preference of the farmers for bold-seeded, uniformly maturing and tall growing plants in the mixed cropping systems. In the long process of human selection, the self-incompatibility mechanism has been lost. *B. rapa* L. var. yellow sarson was prevalent in eastern Uttar Pradesh, Bihar and West Bengal region. Probably evolved from tora brown sarson as a consequence of macro-mutation for the seed colour, the yellow sarson was morphologically more closer to tora type in its early vegetative phase with deep green divided leaves and slightly indented margins; the plants become more waxy at flowering and maturity, and the siliquae were trilocular (sometimes bivalved). *B. rapa* L. var. *toria* was found prevalent in plains of Assam, Garo hills of Meghalaya, Tripura, penninsular tract of Orissa, tarai region of Uttar Pradesh, along the foot hills of Himalayas. In northern and central region of the country, it is widely cultivated as a catch crop. The only visible difference between lotni brown sarson and toria is the days taken to crop maturity, toria usually matures in 90-110 days, while lotni brown sarson types mature in 125-145 days. *B. nigra* was found in limited scale in areas extending from north to south of the country. Morphologically, two distinct types, differing mostly in plant height and maturity were observed during collection - the northern types were quite tall while the southern types were dwarf. Eruca sativa, a related species of *Brassica*, believed to be a native of southern Europe and North Africa, is grown in the drier parts of north west India comprising the states of Punjab, Haryana, Uttar Pradesh and Rajasthan. It is highly cross-pollinated because of the presence of the homomorphic sporophytic self-incompatibility mechanism. The leaves are broad, juicy and divided-flowers are light yellow and slightly broader than cultivated brassicas and siliquae are club-shaped and closely appressed to fruiting branches (Kumar, 1988).

With the establishment of Germplasm Management (GM Unit) Research Centre in the ICAR-Project Coordinating Unit (Rapeseed Mustard) of the CCS-HAU (formerly HAU), Hisar in 1981, the genetic resource activities of oilseed Brassicae got impetus. The Germplasm Management (Rapeseed-Mustard) Unit had the crop specific objectives of assembly, collection, conservation, characterization, evaluation, cataloguing, documentation and distribution of germplasm for utilization of rapeseed-mustard crops. The National Research Centre on Rapeseed- Mustard established in 1993, is the national repository and takes care of the responsibilities of former Germplasm Management Unit, Hisar. At present, it has a collection of

4548 accessions (Table 2). Further, 6710 accessions of oilseeds Brassicas are available at cooperating centres of AICRP on Rapeseed - Mustard and other research institutes (Table 3).

Table 2. Current status of germplasm at National Research Centre on Rapeseed - Mustard, Bharatpur

Species	Accessions
B. juncea	3381
B. rapa var. *toria*	396
B. rapa var. *brown sarson*	225
B. rapa var. *yellow sarson*	164
Eruca sativa	271
Exotic lines	111
Total	4548

Table 3. Status of working germplasm collections at various centres in India

Centre	Available germplasm resoures							Total
	Mustard	Toria	Yellow sarson	Brown sarson	Gobhi sarson	Taramira	Karan rai	
Kangra	-	222	-	-	-	-	-	222
Ludhiana	392	-	16	29	126	-	-	563
Hisar	950	-	-	-	-			950
Bawal	-	-	103	62	16	-		327
Navgaon	667	-	-	-	-	-	-	667
Kanpur	1465	238	158	59	-	-	-	1920
Pantnagar	300	150	80	-	32	-	100	662
Faizabad	395	45	38	3	9	32	5	498
Gwalior	100	-	-	-	-			100
Morena	-	250	-	-	-	-	-	250
Jobner	-	-	-	-	-	350		350
Bhubaneswar	149	5	22	17	25	-	-	213
Total	4418	930	417	170	329	353	105	6710

II. INTRODUCTION FROM EXOTIC SOURCES

Broad-based plant germplasm resources are imperative for sound and successful crop improvement programmes. During the period 1981-87, the GM Unit (Rapeseed-Mustard) acquired 269 accessions of *B. juncea, B. rapa, B. napus, B. carinata, B. nigra, Sinapis alba* and *E. sativa* and *Crambe* species from 16 countries (Kumar, 1988). A total of 59 exotic accessions of oilseed *Brassica* species namely, *B. juncea, B. rapa, B. napus*, were obtained from Sweden, U.K. Canada, USA and China (Anonymous, 1993). Apart from these, wild types belonging to sub-tribe Brassicinae were also introduced. Three hundred sixty three accessions of exotic and wild relatives of *Brassica* were subsequently acquired by the NBPGR from 1995 to 1997 (NBPGR, 1995, 1996, 1997). At present the NBPGR has an impressive collection of 2,063 accessions of rapeseed-mustard from over 23 countries (Singh, 1997). The wild or weedy species are good sources for resistance to diseases and pests as well as tolerance to harsh environments (Harlan, 1984). At the National Research Centre on Plant Biotechnology (NRCPB), IARI Campus, New Delhi, efforts are underway to utilize these wild genetic resources to develop cytoplasmic male sterile lines and to improve the level of disease resistance (Singh, 1997).

MAINTENANCE OF GERMPLASM

Maintenance of genetic stock is an important activity. Rejuvenation and multiplication of the seeds depend upon the mode of pollination. Oilseed Brassicas have a wide range of mating systems ranging from total cross-pollination due to genetic self-incompatibility to predominant self-pollination. Consequently, the techniques employed for the maintenance of genotypes having these two different mating systems are different. *Brassica juncea*, *B. napus* and *B. carinata* have high self-pollination (85-95%) because of self-compatibility, low sucrose content in their nectaries (5-12%) and introse anther arrangement (Rai, 1996). In self-pollinated Brassicas, maintenance is easy and good selfed seeds can be obtained by enclosing inflorescences in bags. For maintaining the germplasm of self-pollinating species, genotypes are grown in augmented design in paired rows of 4.5 to 5 metre row length with 45cm row to row spacing and 90cm pair to pair distance. In order to maintain in pure form, individual accessions are bagged prior to initiation of flowering (Kumar, 1988).

Toria, *lotni* brown sarson and taramira are highly cross-pollinated because of the presence of sporophytic self-incompatibility mechanism, entomophily, very high sucrose content (40-61%) in their nectaries to attract honeybees, and the extrose anther arrangement (Rai, 1996). These crops require special attention for maintenance. Individual genotypes are grown in the field in a similar fashion as indicated for the self-pollinating Brassicas. They are maintained by sibmating. Pollen from representative plants of the same accession is used for pollinating at least 10 plants and female parents bagged prior to flowering. For maintaining genotypes of an individual plant of an outcrossed self-incompatible types, bud-pollination is the best way, through bud-pollination, young buds can be fertilized by compatible as well as by incompatible pollinations. At population level, insect proof cages can effectively be utilized for the maintenance. Pollination is achieved by keeping honeybee colonies (Kumar, 1988). It is better to harvest only central-rows for seed purposes. Another method for maintenance of *Brassica* germplasm is by growing it at an appropriate isolation distance, which varies for different species. An isolation distance of 400 metre has been found to give an adequate isolation in the cross-pollinated B.rapa var. brown sarson for the maintenance of breeder's seeds (Kumar and Singh, 1978). Currently, a total of 16,777 accessions available are being maintained at the NBPGR, NRCRM, NRCPB and various AICRP-RM cooperating centres. These collections are, however, duplicates or even quadruplicates.

IV. CONSERVATION OF GERMPLASM

The NBPGR, New Delhi has been assigned the mandate for long term conservation of germplasm (base collections) and also of coordinating conservation activities at the national level. The facilities for *ex situ* seed storage for both long term and medium term exist. All the accessions are first subjected to test for germination and moisture content. The samples are dried to 6-8 per cent moisture content and sealed hermetically in laminated aluminium foil packets, to store in the separate modules at –20°C for long term and at 4°C for medium term (active collections), respectively (Singh, 1997). The IBPGR (1981) has recommended that sample size for long term storage should have a minimum of 12,000 seeds per accession, which correspond to 50 g seeds of *Brassica* species. Gomez Campo (1972) has described a procedure for medium term storage (active collections) whereby small seed samples are stored in an individual glass vial with blue silica gel inside and stored under low temperature (–50°C). Presently, over 4,580 accessions of oilseed Brassicae have been conserved in the National Gene Bank (Singh, 1997). The periodic regeneration of the seed accessions is necessary to maintain optimal seed viability over the long term as well as replenish the seed stock.

V. EVALUATION, CHARACTERIZATION AND CATALOGUING

The precise evaluation of genetic resources and dissemination of findings is imperative for their utilization in the crop breeding programme. If evaluated systematically, the genetic resources of a crop plays a pivotal role in breeding programme by continuously providing new genes to evolve better varieties with high level of tolerance to major biotic and abiotic stresses, high crop yield and quality.

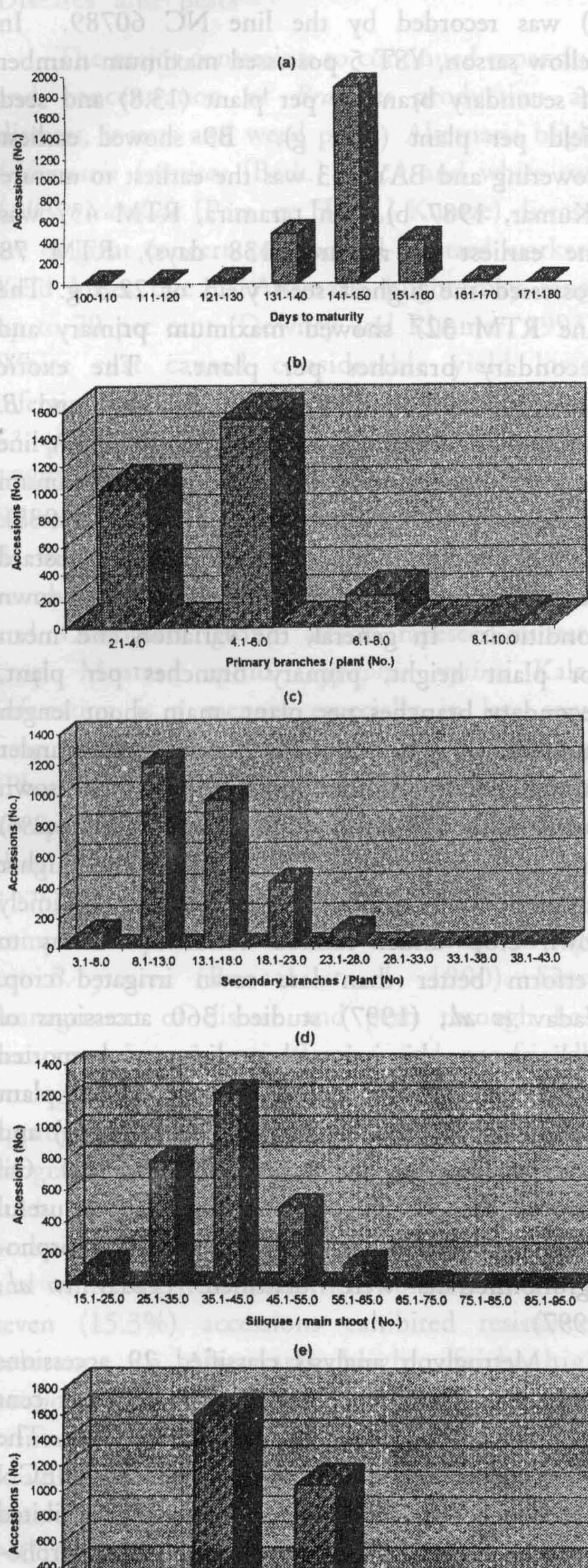
Agro-morphological characters

The best evaluation is one that relates the traits measured to plant breeder's need. The NBPGR has prepared a descriptor for characterising and evaluating Indian mustard germplasm on the basis of 49 traits that include agro morphology, seed oil and seed meal quality and reaction to diseases and insect pests (Mahajan *et al.*, 2000). Presently, a total of over 16,777 accessions of Brassica germplasm are being maintained, evaluated for different agromorphological characters and are used at various centres, under different agro climatic conditions in the country. At the Hisar and NRCRM, Bharatpur; Navgaon and Pantnagar cooperating centres of AICRP-RM, a total number of 15,799 accessions of rapeseed mustard were characterized from 1982 to 1996 (Anonymous, 1993; AICRP-RM 1994, 1995, 1996).

Analysis of grouping pattern of about 2,800 accessions of mustard evaluated at GM Unit, Hisar for agro-morphological characters and oil content (Anonymous, 1993) revealed that majority of the accessions (67.03%) matured between 140-150 days-only 2 accessions took less than 110 days to mature. The days to maturity (Fig. la) varied from 131 to 140 days for about 477 accessions. The primary branches ranged from 2.1 to 10.0 but 2,567 accessions (91%) had only 6.0 primary branches per plant (Fig. 1b). The secondary branches per plant ranged from 3.1 to 42.0.Two thousand one hundred and seventy two accessions (76.94%) exhibited variation from 8.1-18.0 (Fig. lc) and 550 accessions had more than 18 secondary branches per plant. The number of siliquae on main shoot is an important yield contributing character and also had high heritabilty. Thus variation in the character is of paramount significance. It varied widely but nearly 72 per cent accessions had only 45 siliquae on main shoot. Only 16 accessions had more than 65 siliquae on main shoot (Fig. 1d). The siliquae length did not show much variation-2,712 accessions had siliqua length 4.5 cm, (Fig. le). Majority of the accessions (95.2%) had 15 seeds per siliqua; only 2 accessions showed very high number of seeds per siliqua (Fig. 1f). The distribution of accessions for seed yield was fairly uniform (Fig. lg). Three hundred twenty three accessions had more than 14.5 g of seed yield per plant (Fig. 1g). The 1000-seed weight ranged from 2.1 to 4 g in 76.5% of the accessions, however, 24 accessions (0.9%) also showed high seed weight (6.0 g) (Fig. 1h).

Oil content in mustard accessions ranged from 30.6 to 44.6 per cent. But 92 per cent of these accessions had 40.5 per cent oil-only 198 had more than 40.5 per cent oil content. (Fig. 1i). Of the 144 accessions of *Brassica* : *B. carinata* (12), *B. napus* (10), *B. rapa* var. *toria* (4), *yellow sarson* (53), *brown sarson* (65), the majority were having excellent oil content (43%). Yellow sarson accessions exhibited as high as 34 seeds per siliqua. In general wide variation was observed in the pattern of inflorescence, siliquae arrangement, siliqua length and root system in the rapeseed mustard germplasm (Fig. 2a,b,c,d).

At NBPGR, over 2,940 accessions of different oilseed Brassicas have been evaluated for 15 morpho-agronomic descriptors *B. juncea* (1,550),



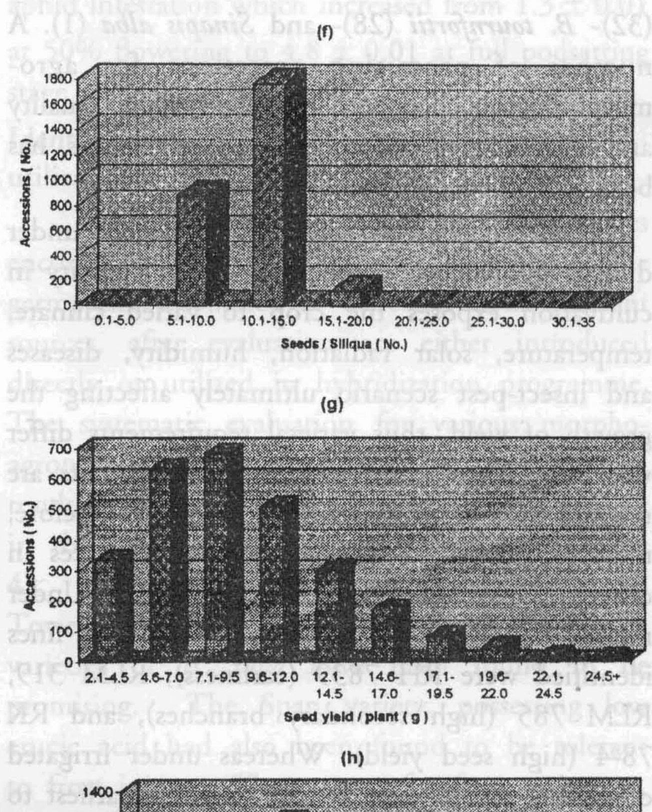


Fig. 1. Distribution of mustard accessions based on (a) days to maturity; (b) primary branches/plant; (c) secondary breanches/plant; (d) siliquae on main shoot; (e) siliqua length; (f) seeds/siliqua; (g) seed yield/plant; (h) seed weight and (i) oil content

B. rapa (*toria* 690; *yellow sarson* 255- *brown sarson* 192)- *B. napus* (157), *B. carinata* (41); *B. nigra*

(32)- *B. tournfortii* (28)- and *Sinapis alba* (1). A number of promising accessions for agro-morphological characters, oil quantity and quality and tolerance to abiotic and biotic stresses has been identified (Singh, 1997).

Oilseed Brassicas are being cultivated under diverse agroclimatic conditions. This diversity in cultivation exposes the crop to varied climate, temperature, solar radiation, humidity, diseases and insect-pest scenario ultimately affecting the growth of yield, thus varietal requirements differ widely. Hence the donors for various traits are relevant only in a specific agro-climate. Therefore, there is a need to evaluate genetic resources in different agro-climatic/specific conditions. Under rainfed conditions, a number of promising lines identified were RH 7839 (earliness), RLM 319, RLM 785 (high secondary branches), and RK 78-4 (high seed yield). Whereas under irrigated condition, B 137 and B 169 were the earliest to mature (121 days); CSR 164 recorded maximum primary branches (20.5)- CSR 498 showed the highest number of secondary branches (46). Lines B 199, B 380, RC 1277 gave the highest seed yield (Kumar, 1988).

Mustard accessions showed lyrately-lobed leaves; the majority had hairs on the leaves. Two lines showed purple splash on leaves. The colour of the leaves in general was dark green with purple splash on the internode and siliqua. Except of one line which had green yellow corolla, all lines had yellow corolla and 53 lines possessed appresed siliquae (Kumar, 1988).

Kumar *et al.*, (1987a) evaluated 1,035 Indian mustard accessions under irrigated and 134 accessions under limited moisture conditions and identified several useful donors. In another study, Kumar *et al.*, (1987b), reported variation in morpho-agronomic characters of 565 accessions comprising brown sarson (99), yellow sarson (50) and taramira (416). In brown sarson, NC 63636 was the earliest to flower (35 days) and mature (122 days). The highest seed yield per plant (26.1 g) was recorded by the line NC 60789. In yellow sarson, YST 5 possessed maximum number of secondary branches per plant (13.8) and seed yield per plant (20.1 g). B9 showed earliest flowering and BAYS 53 was the earliest to mature (Kumar, 1987 b). In taramira, RTM 437 was the earliest to mature (138 days), RTM 78 possessed the highest seed yield of 22.3 g. The line RTM 327 showed maximum primary and secondary branches per plant. The exotic germpiasm lines of *B. juncea*, *B. napus* and *B. carinata* were very tall and late maturing. A line Lini (*B. napus*) with long pods and maximum seeds per pod was also identified (Kumar, 1988). Kumar *et al.*, (1997) evaluated 75 mustard accesions under rainfed and irrigated late sown conditions. In general, the variation and mean for plant height, primary branches per plant, secondary branches per plant, main shoot length and siliquae per main shoot was greater under rainfed conditions than that of under late sown conditions. However, siliqua length (CV 16.2%) and seeds per siliqua (CV 19.2%) had higher variation under late sown irrigated crop. Timely sown crop under rainfed conditions seems to perform better than late sown irrigated crop. Yadav *et al.*, (1997) studied 360 accessions of Indian mustard in irrigated conditions and reported high variability for secondary branches per plant (CV 32.3%), 1000-seed weight (CV 24.5%) and primary branches per plant (CV 20.8 %). Oil content showed the least variation. Several useful donorsforhighoilcontent (41%) andothermorpho-agronomictraits were identified. (Yadav *et al.*, 1997).

Metroglyph analysis classified 29 accessions of gobhi sarson in 4 clusters with 34.5 per cent (10) of the accessions grouped in cluster 1. The cummulative index score ranged from 10 (NECN 15) to 19 (NECN 8). The accessions exhibited substantial variability for different agromorphological traits except days to maturity and oil content (Yadav *et al.*, 1998).

Diseases and pests

The major constraints to continued expansion and concentration of *Brassicas* production are diseases, insects and weed pests. Alternaria blight (*Alternaria brassicae* [Berk.] Sacc.) and white rust (*Albugo candida* [Pers. ex Hook.] Kuntze) diseases are of great concern to rapeseed-mustard workers. Yield losses due to Altemaria blight may range up to 70 per cent (Downey and Rimmer, 1993). White rust caused considerable yield losses infecting leaf and staghead upto 27 per cent and 63 per cent, respectively (Saharan and Lakra, 1988); Downy mildew (*Peronospora parasitica*) and Sclerotinia stem rot (*Sclerotinia scierotiorum* [Lib.] de Bary) are assuming serious proportion. A number of insects belonging to the Lepidoptera and Coleoptera group attack rapeseed-mustard crop. Mustard aphid (*Lypaphis erysimi* Kalt.) infestation is a menace especially in late sown crop causing a heavy toll upto 76 per cent (Phadke, 1980). Varieties of *B. juncea* possess comparativly better tolerance to mustard aphid than the varieties of *B. rapa* (Rai and Sehgal, 1975). However, *B. carinata* selections have shown comparatively better tolerance than either *B. rapa* or *B. juncea* (Bansal *et al.*, 1990). Since management of disease and pests through host resistance is an cost effective and eco-friendly strategy, therefore, there is a need to search for appropriate donors for utilization in the breeding programme to develop resistant varieties. In a study at NRCRM (Kumar *et al*:, 1997), 242 accessions were screened for Alternaria blight (leaf and white rust (leaf under field conditions. Thirty seven (15.3%) accessions exhibited resistance/ tolerance to Alternaria blight, fairly high proportion (71%) of the accessions showed resistance/ tolerance to white rust. The promising strains showing resistance/tolerance to both diseases were IB 1571, IB 1639, NC 60448, NC 60456, NC 60467, CSR 741 and CSR 820. None of the 242 accessions evaluated for aphid infestation tolerance, showed any tolerance or resistance to aphid infestation which increased from 1.3 ± 0.01 at 50% flowering to 4.8 ± 0.01 at full podsetting stage (Kumar *et al.*, 1997).

Identification of resource genes and their utilization

The utilization aspect of genetic resources encompasses the whole of plant breeding. The germplasm assembled or collected from different sources, after evaluation are either introduced directly or utilized in hybridization programme. The systematic evaluation for various morpho-agronomic, quality traits, biotic and abiotic stresess, resulted in the identification of donors for use in the varietal improvement programme (Table 4). Amongst the exotic collections, Midas and Tower of *B. napus*, Candle, Span and Torch varieties of *B. rapa* have been found to be promising. The Span variety, possessing low erucic acid had also been found to be tolerant to frost injury. The sources for frost resistance, namely, RW 175 and DBS 1 identified in *B. juncea* and *B. rapa*, respectively, from the available germplasm are being used in hybridization programme. Likewise, the sources for resistance/ tolerance to Altemaria blight and white rust diseases, RC 781 and YRT 3 and aphid resistance, T 6342 and Cream white flower glossy stem identified from the genetic stock of *B. juncea* and being extensively used in hybridization programme and several varieties/strains were developed (Table 5). *B. carinata* by and large has been found to be free from white rust and downy mildew infection.

VI. FUTURE THRUST AREAS

The need for intensifying the research on genetic resources of oilseed Brassicae in India in the context of the changing global scenario of plant genetic resources, such as Intellectual Property Right (IPR), Trade Related Intellectual Property Rights (TRIPS) and Convention on Biodiversity (CBD) has been realized. A threat of genetic erosion is necessiated due to large scale

Table 4. Promising donors identified for different agro-morphological and quality traits

Stress/Condition	Germplasm lines/Genotypes/Varieties
Biotic Stress	
White Rust	*B. juncea* : RC 781, PYSR 8,PYSR 13, PR 10 *B. rapa* var. yellow sarson - PYS 16 *B. rapa* var. toria : PT 77, Bhabhari
Alternaria blight	RC 781, KRV-tall, SR 142-2, PHR 1, Jatai sarson
White rust	Downy mildew and Alternaria blight
Orobanche	*B. juncea*: Durgamani
Mustard aphid	*B. rapa* - IB 787, Chamba 1, 2 *B. juncea*: T6342, B 85 (Glossary), PR 52 B. 85 (white flower) *B. napus* : GSL 1, Karab,Gulivar, Pi 171538 *B. hirta* : Pi 751516
Abiotic Stress	
Drought	RH 781, RH 785, RH 819, RH 7361, RH 7513, Vardan, Durgamani, Pusa Barani, *B. toumefortii*
Frost	*B. rapa* : Bele, Candle, Span, FR 80 *B. juncea* : RH 781, RW 32-2, PR 52, PR 2030, RH 781, RH 851, DIRA 343,NDR 8604,CS 52
Quality traits	
High oil	*B. juncea*: PR 36, EC126743-1, EC126743, Donskaja *B. rapa* : KT101, TK 8503, PT5, PT25, PT 48
Low erucic acid	*B. juncea* : Zem 1, Zem 2, EC 287711 *B. rapa* : Tobin, Candle
Low glucosinolate	*B. juncea* : RC 247, RC 270, RS 79, RS 81, EC 287711 *B. rapa* : Tobin, Bele, Torch
Yellow seed coat	TM 2, TM4, TM 27, TM 21, YRT 1, RIK 1-1, Domo, UU 22
Other desirable agronomic attributes	
Earliness	IB 1755, IB 1886, Seeta, BR 40, BR 46
Non shattering	RH 30, RIK 8, P 26-31, PR 10, Pusa Bold, Rajat
Bold seeds	RH 30, Pusa Bold, R 74-3, Pusa 1001, NDR 8501
Intercropping	PR 43, RH 30, RH 781, RH785, Laha 101, Vardan, Sanjucta Asech

cultivation of improved varieties replacing the traditional land races, weedy and wild races of the crop. For instance, in India *B. toumefortii,*

Table 5. Improved germplasm of rapeseed-mustard tolerant/resistant to biotic and abiotic stresses and other situations

Stress/Condition	Varieties/Strains developed
Biotic stress	
Aphid tolerant	*B. juncea* : RH 7846, RH 7847, RH 9006, RH 9020, RWAR 842, CSR 1017B. rapa : Chamba 1, Chamba 2
Alternaria blight tolerant (moderate)	Saurabh (RH 8113), RH 8814
Abiotic stress	
Salt tolerant	Narendra Rai (NDR 8501), CS 52, CSR 50
Frost tolerant	*B. juncea* : RH 781, RH 7361, RW 351, RC 199, *B. rapa* var. brown sarson -. Candle, Bele, Span, KBS 1
Drought tolerant	RH 781, RH 785, RH 7361, RH 7513, CSR 212, CSR 814, CSR 975
Herbicide (Atrazine) resistant (For chemical weed control)	GSL 2
Other conditions	
Late sown condition	RH 7859 (North-West Zone), Pusa Bold (Central Zone), RLM 619 (Eastern Zone)
Non- traditional areas	Rajat, Pusa Jaikisan (Maharashtra), Seeta (TN and AP)
Shattering resistant	*B. juncea* : RH 30, Rajat (PCR 7), RLC 1021, Pusa Bold, Rohini
Yellow seed coat	YRT 4, TM 9, TM 11, DIRA 313, RH 8689
Long siliqua	RH 7859, RH 7860, RH 8816A, RH 8816

a close relative of *B. rapa* and very common in northern India is getting extinct (Singh, 1997). Taking all the aspects in totality, the following priority areas of research are identified.

- A time bound programme of plant exploration and germplasm collection should be chalked out laying emphasison borderareas of Bihar - West Bengal facing Nepal and Bihar - West Bengal Assam facing Bangladesh, Jammu - Kashmir and Uttar Pradesh hills, Karnataka - Andhra Pradesh, Orissa and North eastern states.

- Characterization, evaluation and documentation especially for biotic and abiotic stresses and oil and seed meal quality should be taken up. For efficient and speedy evaluation and characterization of genetic resources, a network should be created. For effective screening for biotic and abiotic stresses, appropriate 'hot-spots' should be identified rather than carrying out evaluation and running a risk of escape and/or sub-optimal environment.
- Utilization of modern analytical techniques and bio-technological tools to eliminate duplicates and triplicates.
- Synthesis of germplasm complexes in allogamous species.
- Development of low cost system for maintenance of allogamous species.
- Determination of optimum seed sample in case of auto-and allogamous oilseed Brassicae for medium and long term storage conditions.
- Diversity analysis utilizing conventional and modern techniques.
- A national register assigning a common accession number to all the available genetic resources of rapeseed-mustard should be prepared.

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