

TARAMIRA (*ERUCA SATIVA*) AND ITS IMPROVEMENT - A REVIEW

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ABSTRACT

Taramira is an important oilseed crop of drier regions of north-western India. The oil is not directly eaten, although it is mixed with mustard oil to increase the pungency of the later. It originated in Mediterranean region. It has $2n=22$ chromosomes which are very small. Genetic improvement is limited in this crop, although some varieties are available. Very recently a variety RTM-314 has been released for the general cultivation. Taramira has good traits particularly conferring disease resistance which can be transferred to *Brassica campestris* and *B. juncea* both are important crops. Some efforts are underway in this regard with limited success.

Taramira (*Eruca sativa* Mill) is a low growing, annual oilseed crop with dull green, deeply cut, compound leaves. The leaves are characterized by a distinctive spicy, pungent flavour resembling horseradish. The plant was considered by early writers as a good salad herb, but not to be eaten alone. Ancient Egyptians and Romans both have considered the leaves in salad to be an aphrodisiac. Taramira also known as rocket in European countries is a member of the family brassicaceae. Plaxton's botanical dictionary (Hereman, 1868) lists it under *Eruca tournefort* and writes that the name should have originated from the word 'uro' meaning to burn, because the seeds have a burning taste and when applied to the skin causes blisters. Taramira is generally grown on marginal lands of north and north west India and is generally known by different names. Singh (1958) states that this is known as tara, tera, schwan, seoha, duan turra, tirwa, merha, merkai, chara and ushan in Uttar Pradesh; as sondha in Gwalior (Madhya Pradesh) and as tara or simply as taramira in Punjab. In Europe it is known as rocket salad, rocket, roquette or arrugula, where this is generally grown for young leaves which are eaten as green salad. In trade terms taramira is generally put under mustard group. The name "rocket" derives from the French roquette, a diminutive form of the Latin eruca, the Italian rucetta, and

medieval French Provençal roqueto (From the website of University of Florida). Although taramira oil is not edible because of its chemical composition, it is generally mixed with mustard oil to give more pungency to the later a trait preferred in mustard oil (Table 1). Chief uses of taramira are limited to its use as massage oil, or in industries for the production of lubricants and blown oil (Singh, 1958). The oil cake is used as a feed for cattle. Cattle fed on taramira cake are reported to be free from ticks (Singh, 1958). Administration of taramira oil has reduced the effects of diabetes mellitus in rats (El Missiry and El Gindy, 2000). Unani system of medicine has preparations made from taramira (Ghauri and Afridi, 1997).

Rocket is widely cultivated in Europe and its cultivation has reached to Americas through migration (Pignone, 1997). Mohamedien (1995) reports that particular ecotypes of rocket are used as salad in Egypt. In Europe the name rocket is applied to a number of species belonging to genus *Eruca* and *Diplotaxis* (Dias, 1997 and Pignone 1997) of which the commonly grown *Eruca* species is *Eruca sativa* Mill. while the commonly grown *Diplotaxis* species are *D. tenuifolia* (L.) DC and *D. muralis* (L.) DC (Pignone, 1997). *Diplotaxis* species are commonly known as wild rocket (Bianco and Boari, 1997). In Europe the use of rocket as food has been in vogue since time

Table 1. Composition of taramira oil in comparison to mustard (Sharma *et al.*, 1991)

Component	Sarson (%)	Rai (%)	Taramira (%)
Erucic acid	57.2	41.5	46.3
Oleic acid	20.2	32.3	28.7
Linoleic acid	14.5	18.1	12.4
Saturated fatty acids	6.0	5.4	10.5

immemorial, its use is gaining importance even more in recent times (Bianco, 1995). As such its cultivation as a vegetable is still limited and the market demand is often met by harvesting the plants from the wild rather than by cultivating it, particularly in Italy (Bianco and Boari, 1997). In Asia, particularly in India reports on its use as salad are not known. In Asia major growing area is in India followed by a limited area in Pakistan. In India a major portion of area is in the state of Rajasthan with limited areas in Gujarat and Haryana. In Rajasthan it is cultivated over an area of 26746 ha with an annual production of 10033 tonnes (Anonymous, 2001-2). The area and production fluctuates widely (Fig. 1). It was cultivated on a record area of 281 thousand ha in the year 1987-88. There is an increasing tendency to grow mustard in the traditional taramira areas owing to development of irrigation facilities (Fig. 1). During normal rainfall mustard is preferred over taramira which contributes to the wide fluctuation in the area and production over years because of the planting which depends mainly on rains, where. Perusal of Fig. 2 amply supports the stated fact. Looking into its ability to tolerate drought and aphid resistance, presently efforts are underway to transfer these traits into economically preferred *Brassicas* like *Brassica campestris* (Agnihotri *et al.*, 1990; Sikdar *et al.*, 1990). Even in UK some efforts are being done to develop transgenics of *Brassica* which have the flavour of *Eruca* in the leaves (Magrath and Mithen, 1997).

Origin and Taxonomy

Taramira is believed to be a native of Southern Europe and North Africa (Bailey,

1949; Prakash, 1980). Yarnell (1956) reports that taramira was abundant in the gardens of Europe in the 16th century, while there is no record about its introduction into Indian Sub-continent (Prakash, 1980). Introduction into United States took place before 1854 but could not become popular there (Sturtevant, 1915).

The taxonomic position of taramira in the earlier times was very confusing. It was first put in the genus *Brassica* and named *Brassica eruroides* (Roxburgh, 1832), while Hooker (1872) referred to it as *Brassica eruca*. Plaxton (Hereman, 1868) described it as *Eruca tournefort* and lists about 3 species namely *Eruca hispida*, *Eruca sativa*, and *Eruca vesicaria*. Seven subspecies namely *alba-glabra*, *alba-pilosa*, *eruroides*, *exotica*, *flava glabra*, *flava pilosa* and *turgida* were listed in *Eruca sativa*. Plaxton (Hereman, 1868) further stated that among these *Eruca hispida* originated in Naples, *Eruca vesicaria* from Spain, while all the subspecies of *Eruca sativa* originated from Southern Europe. Basically all these species are hardy annuals with white to yellow flowers. Miller has put in a separate genus *Eruca* (Tutin *et al.*, 1964). There is confusion with regard to different species of the genus *Eruca*. Gomez-Campo (1980) lists about four species in genus *Eruca* while Matsuzawa and Sarashima (1986) report presence of ten species under *Eruca*. Tsunoda *et al.* (1980) report the maintenance of three species namely *Eruca vesicaria* (L) Cav., from Zargoza, Spain; *Eruca pinnatifida* (Desf.) Pomel from Morocco and *Eruca sativa* (Miller) from Alexandria, Egypt at the Faculty of Agriculture, Tohoku University. Vesperinas (1995) has established through interspecific crosses the separate nature of *E. sativa* and *E.*

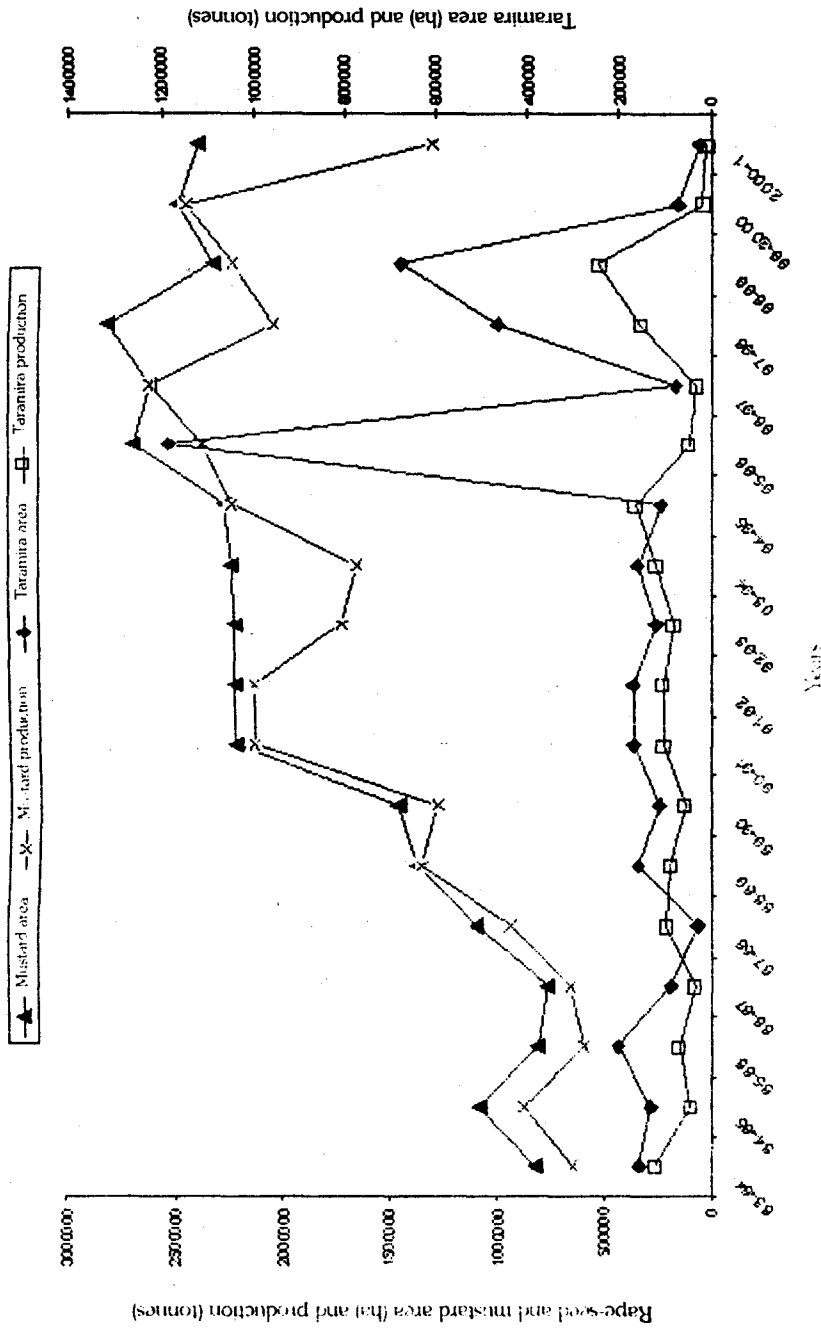


Fig. 1. Area and production of white and rapeseed mustard in the state of Rajasthan

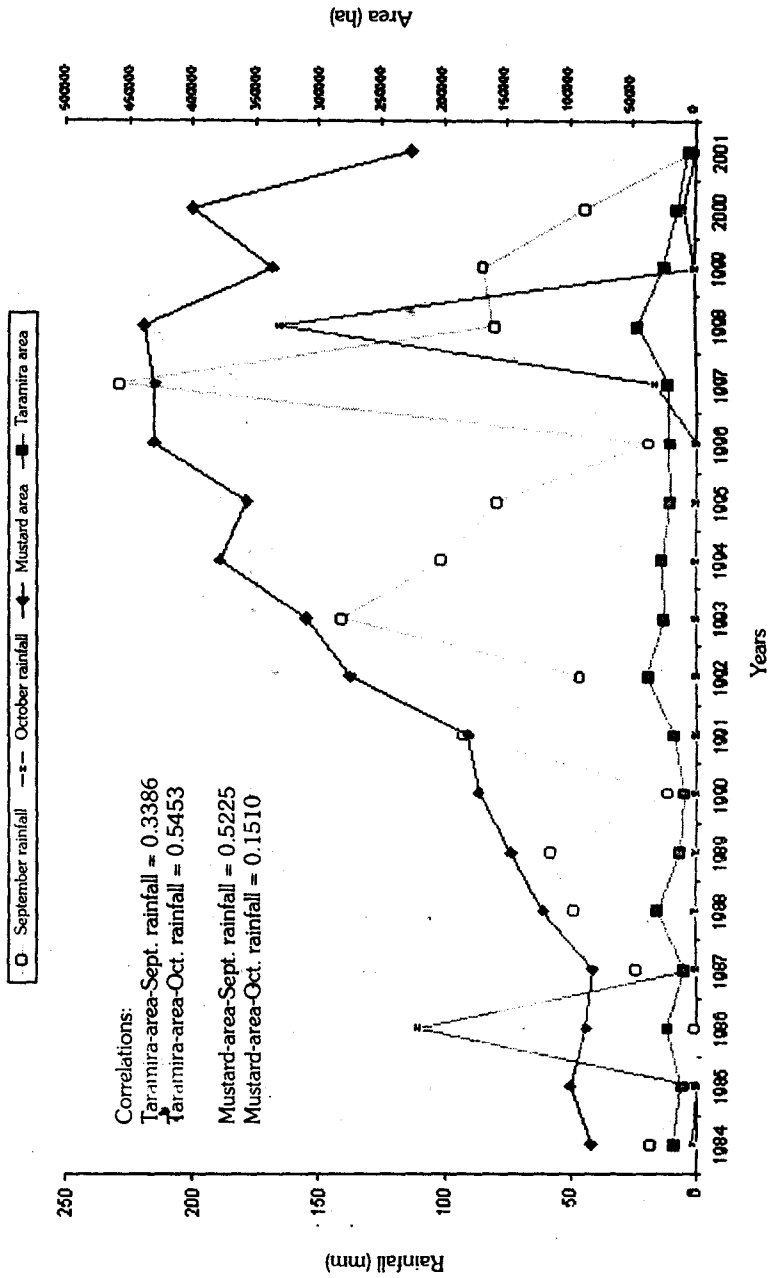
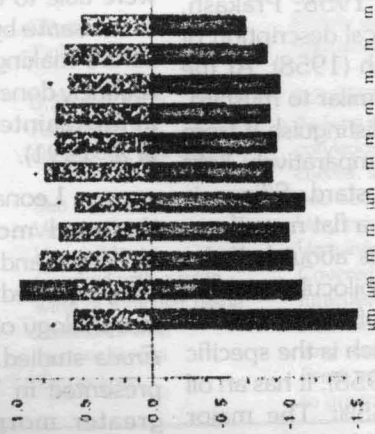


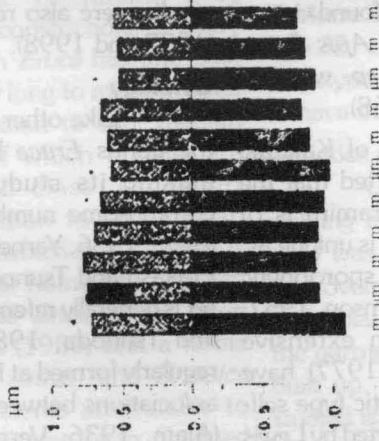
Fig. 2. Area of Rapeseed-mustard and taramira and rainfall of September and October months in Jaipur region of Rajasthan state

Eruca vesicaria ssp. *pinnatifida* (Deaf.) Emb. and Maize



Karyotypic formula = $sm^x + Bm + 2sm$ ($2n=22$)
 Haploid complement length 18.43 μm

Eruca vesicaria ssp. *sativa* (Mill.) Theb.



Karyotypic formula = $sm^x + Bm + 2sm$ ($2n=22$)
 Haploid complement length 16.73 μm

Fig. 3. Idiogrammatic representation of the haploid complement of *Eruca* species (Blangforti and Venora, 1997)

vesicaria. In India only *Eruca sativa* is grown. Information with regard to other species is not available.

Morphology

It is an annual, one metre tall plant and is an out breeder with sporophytic type of self-incompatibility (Singh, 1958; Prakash, 1980). Detailed morphological description of this crop was given by Singh (1958). At the first glance the plant looks similar to mustard, but the siliqua may help to distinguish it from mustard. The plants are comparatively light green in comparison to mustard. Siliqua is about 2.5 cm in length with a flat mensiform seedless beak whose width is about half the size of valves. The pods are bilocular and the seeds are in a double row of series in each compartment of the fruit which is the specific feature of this crop (Singh, 1958). It has an oil content ranging from 30-35%. The major component of oil is Erucic acid (about 46%).

Flowers open in the morning generally when it is warm i.e. around 9 AM. The opening may be delayed during cool periods, cloudy or rainy days. Cross pollination is by insects and about 100 species of insects were found visiting the flowers in Punjab, of which *Apis florea*, *Andrena ilderda* and *Halictus sp.* were of foremost importance (Singh, 1958).

Based upon the system of Kakizaki (1930), Narsingdas (1958) reported that the self incompatibility found in taramira is of gametophytic system. This report is unique as, in general, the crucifers exhibit sporophytic system of self-incompatibility (Thomson, 1957; Haruta, 1962). Later, through extensive experimentation, Verma *et al.* (1977) have shown the existence of sporophytic type self-incompatibility which is also supported by Lewis (1977). While Lewis (1977) and Verma *et al.* (1977) have shown the self-incompatibility to be controlled by 2 to 3 genes, Verma and Lewis (1977) have shown the self-incompatibility to be invoked by four genes. The system of

incompatibility is complex (Lewis, 1979; Wallace, 1979) and is because of the interaction between the specific 'S' alleles (Shivanna, 1985). Verma *et al.* (1985) have also shown the existence of partial self-incompatibility along with self-incompatibility. Sharma *et al.* (1985) were able to overcome self-incompatibility in *Eruca sativa* by treating the stigma with lectins before making pollination. Bud pollination is routinely done to overcome self incompatibility in the maintenance of germplasm (Sharma *et al.* 1991).

Leonardis *et al.* (1997) have studied the seed morphology using specialized technique and scanning electron microscopy. They reported clear cut differences in the seed morphology of different species of the genus *Eruca* studied. The morphological data are presented in Table 2. The seeds exhibited greater morpho-biometric interspecific homogeneity and clearly distinguishes the *Eruca* species from *Diplotaxis*. The most important discriminative character between these two genera is represented by seed length, which varies from 1.30 to 1.55 mm in *Eruca*. Similar results were also reported by Xiu Zhen *et al.* (1977 and 1998).

Cytology

Like other members of Brassicaceae, the genus *Eruca* have small chromosomes making its study difficult. The diploid chromosome number of *Eruca sativa* is 22 (Alam, 1936, Yarnell, 1956; Mukherjee, 1973; Prakash and Tsunoda, 1983) and the haploid set is generally referred to "E" genome (Prakash and Tsunoda, 1983). Eleven bivalents are regularly formed at Metaphase I and secondary associations between bivalents are also found (Alam, 1936; Verma and Chauhan, 1985). Based upon these secondary associations, Alam (1936) concluded that the basic number in this species may be six. This inter-bivalent association, according to Verma and Chauhan (1985), reflects cryptic structural alterations/

Table 2. The average dimensions of seed and seed morphology (Leonardis *et al.* 1997)

Parameter	<i>Eruca pinnatifida</i> var <i>aura</i>	<i>Eruca vesicaria</i>	<i>Eruca sativa</i>
Seed length (mm)	1.47	1.35	1.44
Seed width (mm)	0.99	0.83	1.04
Seed thickness (mm)	0.55	0.77	0.80
Shape	Ovate	From widely elliptical to widely ovate	From ovate to widely elliptical
Side outline	Elliptical	Widely elliptical	Widely elliptical
Transverse outline	Tightly elliptical	Subcircular	From subcircular to subrhombic
Radicular shape	0.25 mm wide	0.3 mm wide	0.3 mm wide
Radicular extremity	As long as the cotyledons, sub obtuse	As long as the cotyledonous, curved, subacute	As long as the cotyledonous, curved, subacute
Cotyledonous extremity	Sub obtuse	Sub obtuse	-
Basal cut	Very evident	Very evident	Very evident
Radicular and cotyledonous furrow	Very evident	Very evident	Very evident
Hilum and micropyle	Covered with a wide wing of funicular tissue	Covered with funicular tissue	Covered with funicular tissue
Tegument	Reticulum with narrow lamina	Reticulum with very narrow lamina	Reticulum with very narrow lamina
Colour	Egg yellow	From yellow brown to green olive	From yellow brown to green olive

rearrangements in the genomic organization.

Comparing the ideotypes, Mukherjee (1973) showed *Eruca* to be related to *Brassica*. Mukherjee (1973) classified the chromosomes into 4 classes- class 'A' having long chromosomes with two constrictions (primary and secondary) of which *Eruca* has one pair. Class 'B' - comparatively long to medium sized chromosomes with median to sub- median primary constriction of which 8 pairs are present in *Eruca* and class 'C' -short chromosome with median to sub median primary constriction for which only one pair is present in *Eruca*. Partial homology between genomes of *Eruca* and *Brassica* has been reported by Mizushima (1950) and a fertile hybrid between *Eruca sativa* and *Brassica campestris* with 5 bivalents attributable to allosynthetic pairing has also been obtained indicating a distant evolutionary relationship between *Eruca* and *Brassica*. Inter generic hybrids of *Eruca sativa* with various *Brassica* species were obtained by Matsuzawa and Sarashima (1986).

Blangiforti and Venora (1997) have studied the karyotype using specialized image analysis system and dedicated soft ware 'Karyo 95'. The results obtained are presented in Fig 3. While the three species studied by these workers had same chromosome number, $2n=22$, the speculation of the degree of karyotype evolution indicated that *Eruca* species to have evolved more than *Diplotaxis*.

Genetics and Crop Improvement

Concerted efforts for improving the yielding ability of taramira are limited as the crop was always given less importance. The improvement work before 1979 was sporadic and isolated (Prakash, 1980). As is expected, the germplasm collections have also not been built up. Thus, the material used in several studied is generally local.

Establishment of an ad-hoc scheme at S.K.N.College of Agriculture, Jobner under a sanction from Indian Council of Agricultural Research in 1979 was the beginning of systematic effort to improve the yielding ability

of this crop (Anonymous, 1986). The major objectives of the project was to make extensive collections of germplasm and its evaluation. As a result, extensive collections (516) were made from various parts of the country. The same project was later on converted into All India Coordinated Research Project on Oilseeds Project (Taramira Unit) in the year 1987 at the S.K.N.College of Agriculture, Jobner.

Germplasm holdings and evaluation:

International Plant Genetic Resources Institute (IPGRI), Rome established Rocket

Genetic Resources Network in 1994. Summarizing the holdings of Rocket Germplasm world over Pignone (1997) writes that the gene banks of Gatersleben (Institut für Pflanzengentik und kulturflanzenforschung), Germany, Horticultural Research Institute at Wellesbourne, UK and Ames, Iowa (USA) have good collections of *Eruca*. The composition of *Eruca* germplasm in the genebank located at Braunschweig, Germany is summarized in Fig. 4.

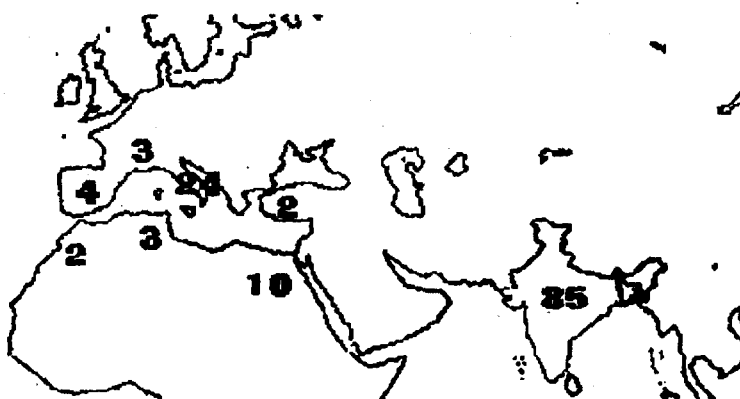


Fig. 4. Holdings of *Eruca* listed in the rocket network database

The details of Indian collections of *Eruca* germplasm are summarized in Table 3. These germplasm collections are maintained both at S K N College of Agriculture, Jobner and at National Research Centre on Rape Seed and Mustard, Sewar (Bharatpur), Rajasthan. Duhoon and Koppar (1998) have indicated Mewar region of Rajasthan and Chambal region spanning over Rajasthan and Madhya Pradesh states of India as the hot spots of variability for *E. sativa*. Exploration should therefore be conducted in these regions to collect the natural variability.

Variability

A wide range of variability is available

for various characters of taramira (Table 4). Although considerable variability is available for siliqua per plant, branches per plant, plant height and yield, the variation for days to flowering and maturity and oil content is, however, very much limited (Table 4). Genetic advance for secondary branches per plant, pods per plant and seed yield per plant is high. The realized gains however have not been very promising as these do not follow the expectations (Table 4). This is because of high effect of environment and the interaction between genotype x environment. Low genetic advance has been reported for oil content (Sharma *et al.*, 1991). Similar results have also

Table 3. Collection of taramira germplasm in India (Bhandari and Chandel, 1997)

Organization	Year of collection	Areas explored	No. of samples gathered
S K N College of Agriculture, Jobner	1980	Parts of Rajasthan	516
NBPGR, New Delhi	1982	North-western and central India	64
	1983	Jammu region, MP, Kachch region in Gujarat and Pune	10
	1984	Semi arid regions of Haryana	26
	1986	Northeastern Rajasthan	16
	1987	Southern Rajasthan	1
	1988	Southeast Rajasthan	1
	1989-90	Southeast and Western Rajasthan	16

Table 4. Range, coefficient of variation, heritability and genetic advance in taramira (Sharma *et al.*, 1992)

Character	Range	C.V.	Hetiability (h ²)	Genetic advance
Days to 50% flowering	50.00-55.67	3.40	22.89	1.61
Days to maturity	118.61-124.33	1.56	12.89	0.41
Plant height (cm)	49.37-84.07	16.59	9.73	3.39
Primary branches per plant	3.70-6.63	19.23	9.60	3.74
Secondary branches per plant	3.37-16.20	33.01	50.36	34.22
Pods per plant	59.17-181.83	22.78	70.04	32.86
Pod length (cm)	1.60-2.27	9.27	41.11	7.98
Seeds per pod	13.07-26.87	23.66	8.94	4.98
Test weight (cm)	2.02-3.90	14.45	60.69	17.94
Seed yield per plant (g)	2.57-9.25	33.65	49.48	34.25
Seed yield per plot (g)	144.4-401.1	24.23	60.54	31.47
Oil content (%)	32.23-36.43	3.22	41.68	2.78

been reported from an extensive evaluation done at Hisar (Anonymous, 1991). Yadav *et al.* (1998) reported that secondary branches/plant had the highest coefficient of variation, followed by 1000-seed weight and primary branches/plant. Heritability was high for 1000-seed weight, siliqua length, seeds/siliqua and seed yield/plant.

Divergence analysis in taramira by Sodani *et al.* (1990) showed that grouping of lines in different clusters was not related to their geographic origin. Siliquae/plant, seed yield/plant and plot, and test weight contributed maximum towards total divergence. In another study of genetic divergence based on metroglyph analysis by Meena (1996) indicated

that all the genotypes could be grouped into three distinct groups- (i) group I- high yielders, (ii) group II- consisted of moderate yielders and (iii) group-III consisted of low yielders. The low yielders basically had lower values for siliqua length and number of seeds per siliqua. The high yielders on the other hand had above average biological yield.

In a similar study Rathore (1996) reported that the two groups, high yielders and low yielders, differed in number of primary branches per plant, besides secondary branches per plant.

Evaluation of oil content and fatty acid composition of 100 genotypes of *E. sativa* by Yadav *et al.* (1998) showed the oil content to

Table 5. Correlations of seed yield with various morphological traits

Character	Source		
	Sastry <i>et al.</i> (1991)	Meena (1996)	Rathore (1996)
Days to 50% flowering	-0.067	0.056	0.011
Days to maturity	0.196*	0.058	-0.002
Plant height	0.346**	0.031	-0.059
Primary branches/plant	0.255**	0.212	0.274*
Secondary branches/plant	0.249**	0.216	0.337*
Silique/plant	0.861**	0.261*	0.282*
Siliqua length	0.101	0.135	0.067
Seeds per siliqua	-0.004	0.196	-0.020
Test weight	-0.169	0.105	0.119
Oil content	-0.134	0.020	-

* Significant at P=0.05 and ** Significant at P=0.01.

range from 31.86 – 41.31%. They (Yadav *et al.*, 1998) reported large variation in erucic acid (26.7 – 52.4%), oleic acid (14.1 – 23.4%), linoleic acid (6.9 – 15.7%), linolenic acid (8.3 – 15.3%) and eicosenoic acid (9.3 – 18.3%). Yaniv *et al.* (1998) on the other hand reported the contents of erucic acid and eicosenoic acid contents to vary from 33 to 45% and 7.3% to 9.8%, respectively, in collection of *E. sativa* from Israel.

Character associations

The seed yield per plant and per plot were significantly and positively correlated with days to maturity, plant height, primary branches per plant, secondary branches per plant and silique per plant (Table 5). These characters have also shown significant positive association among themselves (Sodani *et al.*, 1990 and Yadav *et al.*, 1998).

In this crop, pods per plant has highest positive and direct effect on seed yield followed by secondary branches, pod length and plant height while oil content had highest negative direct effect on seed yield. hence, more weightage should be given to pods per plant while making selection to breed high yielding varieties in taramira. Secondary branches per plant, plant height and pod length are the other characters which should be considered in a selection program for seed yield as these have

positive direct effect on seed yield per plant. The above characters also had a wide range of variability, which offers wide scope for improvement of taramira by indirectly selecting for these characters (Meena, 1996 and Rathore, 1996). Among the fatty acids, erucic acid was negatively correlated with oleic acid ($r=0.7096$), linoleic acid ($r=0.5102$), linolenic acid ($r=0.6010$) while oleic acid was positively associated with linoleic acid ($r=0.2397$) as per the report of Yadav *et al.* (1998).

Maintenance of germplasm

The main constraints in *Eruca* germplasm maintenance are- low seed germination, oily seeds, capsules opening at maturity, possibility of contamination with local pollen and possibility of increasing self-incompatibility (Pignone, 1997). Germination has not been a problem at S K N College of Agriculture, Jobner in the maintenance of germplasm. Cryopreservation did not affect germination in *Eruca* spp. (Martinez-Laborde *et al.*, 1998).

Taramira being cross pollinated crop with self-incompatibility, maintenance of germplasm is a problem. Bud pollination may be used to overcome self-incompatibility, this method however, is not desirable as it leads to genetic erosion. Use of muslin cloth bags covering 10 plants helps in lessening genetic

erosion. This method is being used routinely at S K N College of Agriculture, Jobner.

Seeds of taramira can be stored at room temperature for two seasons and this will to some extent, help maintain the population structure by lessening generation interval.

Genetics of yield and yield related traits

Information on the genetics of yield and its related traits in taramira are scanty. In a ten parent diallel, Kumar and Yadav (1986 a and b) have shown that dominance was found to be significant for yield and its component traits excepting for siliqua length for which additive components were important. Kumar *et al.* (1988) have reported preponderance of non-additive gene effects for primary branches/plant under normal and saline environments, although both additive as well as non-additive gene effects were involved in the inheritance of the above as well as other yield traits, however, the inheritance pattern was influenced by the environment as observed by the changes in the direction and magnitude of the gene effects depending on the soil conditions. The main shoot length and seed yield/plant were influenced by additive genes on normal soil, whereas by non additive genes on the alkali soil (Kumar *et al.*, 1988).

Nehra and Sastry (1995) have reported complex inheritance for seed yield and its component traits. Trend between *per se* performance and the varietal Heterotic effects were negatively correlated.

Varietal development:

As has been pointed out earlier, only limited work has been done for the genetic improvement of taramira. Prakash (1980) points that in the earlier stages, varietal improvement has been through mass selection, but later, development of poly crosses, synthetics and composites were attempted. As a result, two varieties namely, ITSA (maturing in 169 days) and T-27 (maturing in 150 days)

were released for general cultivation. ITSA released in Punjab in the year 1961, for rainfed irrigated conditions on every type of soil, is a reselection from Lyallpur Local. T 27 first released in 1974 in Haryana state for light soils under rainfed conditions, is a direct selection from Gurgaon Local (Tunwar and Singh, 1985). Only these two varieties are available for commercial cultivation. Recently a variety RTM 314 has been developed by Dr. E.V.Divakara Sastry and his colleagues at S K N College of Agriculture, Jobner which has been released and notified by Central Varietal Release Committee, New Delhi, India. This is therefore the first to be released after a gap of almost 2½ decades.

Keeping in view the limitation imposed by the lack of variability in the germplasm collection, crop improvement programs needs to be designed in such a way that they can exploit the available variability in the germplasm most effectively manner. With this objective in focus, at S K N College of Agriculture, Jobner, both intra and inter population improvement programmes are in progress.

I. Population Improvement:

(a) Intra Population Improvement

1. Selection of individual-plants based on the performance of half-sib progeny in the promising population of the germplasm collection has been used as a method and RTM-1 and RTM-2 are the examples of success of this method. It is expected that these populations can be further improved through recurrent selection for earliness, oil content and seed yield.

In a study using 150 half-sib families generated from RTM-314, a variety of taramira, Sastry and Yadav (1999) have reported that the estimates of σ^2_A and σ^2_p for plant height, number of secondary branches, number of siliquae per plant and number of seeds per siliquae were very low. The estimates of heritability (narrow sense) were very high

for plant height, number of secondary branches, number of siliquae per plant and number of seeds per siliquae. The expected selection gain between families was lower in comparison to expected gain from within family selection.

2. Selection based on S_1 progenies can also be used as an effective method and can be initiated in some of the original or derived populations to achieve improvement in the desired characters.

3. Full sib selection program to develop superior progenies is another method which can be used.

Development of composites like JOB-TC-1 and JOB-TC-2 are the examples of inter population improvement (Table 6). In JOB-TC-2 greater emphasis was placed on earliness. Efforts in the population improvement programme need to be strengthened and selection criteria has to be improved.

Table 6. Performance of taramira composites at Jobner, Rajasthan
(Average over three years, Sharma *et al.*, 1991)

Component	Maturity (days)	Seed yield (kg ha)	Downey mildew incidence (%)
JOB-TC-I	146.0	822.96	45.44
JOB-TC-II	148.8	940.73	56.11
T-27 (check)	151.49	824.77	50.21

Mutation breeding and Polyploidy

Mutation breeding has not been attempted in this crop as yet, some reports on polyploidy are however, available but are more of academic interest. The induced tetraploids obtained using colchicine treatment were vigorous having bigger siliqua, seeds, stomata and pollen grains (Singh, 1958; Labana *et al.*, 1977). The tetraploid was found to be meiotically unstable, resulting in laggards and gametes with an unbalanced number of chromosomes (Labana *et al.*, 1977).

Evaluation for disease and pest resistance

Taramira is resistant to aphids and white rust and efforts to transfer these traits into other crucifers are frequently attempted. Evaluation of germplasm against *Fusarium* wilt and downy mildew has indicated that none of the lines are immune for both the diseases (Sharma *et al.*, 1991). Classification of lines according to their resistance are presented in Table 7. All the accessions of *E. sativa* were found to be resistant to white rust by Bansal *et al.* (1997) and presence of resistance in some accessions of *Eruca* against *Leptosphaeria*

maculans (Tewari *et al.*, 1995), mustard aphid (Vekaria and Patel, 2000; Chander and Bakheta, 1998; Agrawal *et al.*, 1996).

Intergenic and interspecific hybridization

Crosses of *Eruca sativa* with other species of the family Brassicaceae have been attempted since long with varying results. The objectives of the hybridization also varied; however, of late it is mainly to transfer useful agronomic characters of *Eruca* to other species.

Few F_1 plants were obtained when intergeneric crosses between *Eruca sativa* and *Brassica campestris* using *B. campestris* as mother parent (Mohammad *et al.*, 1931). Roberts *et al.* (1999), on the other hand found that the hybrids to be morphologically intermediate to the parents and were sterile. PMC analysis indicated highly unstable chromosome pairing and segregation patterns and the occurrence of bridges and fragments. Matsuzawa and Sarashima (1986) and Agnihotri *et al.* (1990) also attempted similar crosses and using embryo rescue obtained viable hybrid plants. Agnihotri *et al.* (1990) confirmed the hybridity of these

Table 7. Disease resistance in taramira (Sharma *et al.*, 1991)

Reaction	Lines showing reaction for	
	Downey mildew	Fusarium wilt
Immune	Nil	Nil
Tolerant	RTM-2-I, RTM-127, 166, 316, 355, 238, 397, 110, 360	RTM-465, T-27, RTM-466, Job-TC-1, RTM-397, 112, 461, 360, 126, 101, Job-TC-2, RTM-521, 522
Moderately tolerant	Job-TC-2, RTM-521, 522, 523, TMH-48	TMH-24, 25, 46, 48, RTM-33, 501, 316, 357, 288, 314, 110, 141, 1
Moderately susceptible	ITSA, RTM-33, 21, 314, 115, 141, TMH-24, 25, 52, T-27	RTM-127, 2-I, 398, 515, 306, 355, 115, 2, Job-TC-2
Susceptible	TMH-48, ITSA, Job-TC-2, RTM-1	RTM-462
Highly susceptible	Nil	Nil

morphologically, cytologically and by DNA analyses. Sikdar *et al.* (1990) obtained hybrid plants from *Eruca sativa* and *Brassica juncea* through protoplast fusion. In a similar study, Bijral and Sharma (1999) found the hybrids with *B. juncea* to be self fertile and produced sufficient quantity of seed when backcrossed to both parental species. Hybrids were also obtained with *B. oleracea* (Nagaharu *et al.* 1937; Matsuzawa and Sarashima, 1986) and *B. chinensis* (Mizushima, 1950). Unfortunately the hybrids obtained from most of these crosses were not stable and no useful plants could be obtained from the above crosses. Matsuzawa *et al.* (1999) attempted interspecific hybridization of *E. sativa* with *B. campestris* to develop a new cytoplasmically male sterility (CMS) system in *B. campestris*. Male sterile

alloplasmic plants were selected and maintained upto F₆ generation. In F₇ and F₈ generations these male sterile plants were bred to *B. campestris*. The southern blot analysis showed the male sterile plants to contain cytoplasm of *E. sativa*. This study provides a novel way to produce CMS plants in *B. campestris*. Intergeneric crosses of *Eruca sativa* with several *Brassica* spp was also attempted by Prasad *et al.* (1997) and Bang *et al.* (1997) with almost similar conclusions as reported above.

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