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## Biodiversity in arid fruit crops: A review

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### ABSTRACT

Hot arid regions are confronted with climatic adversities besides lack of sufficient irrigation water availability. However, there are numerous fruit species which have inbuilt mechanism to sustain under inhospitable edaphoclimatic condition with available rainfall. The fruits like ber, *deshi bordi*, *jhar ber*, *khejri*, *ker*, *pilu*, etc. have been grown successfully under natural condition without irrigation. In some pockets (10-12%), where irrigation water is available either by canal system or underground tubewell, cash crops like date palm, pomegranate, fig, aonla, citrus fruits, etc. are some of the successful ventures by the farmers. The available natural biodiversity present in these fruit crops have been successfully employed to develop high yielding improved varieties mostly by selection from seedling population. The development of clonal propagation techniques enabled perpetuation of developed varieties without the loss of original quality. The strengthening of R&D in ICAR institutes and SAUs further helped in the development of location specific agro-techniques, which led to yield enhancement and post-harvest value addition in typical arid fruit crops. This review article highlights the availability of biodiversity and varietal development in arid fruit crops.

### Introduction

The hot arid regions of India are suitable for growing many fruit species despite climatic constraints and limited irrigation facilities. These include ber (*Ziziphus mauritiana* L.), *bordi* (*Ziziphus rotundifolia*), *Jhar ber* (*Ziziphus nummularia*), *khejri* (*Prosopis cineraria*), *pilu* (*Salvadora oleoides*), pomegranate (*Punica granatum* L.), aonla (*Emblica officinalis*), date palm (*Phoenix dactylifera*), bael (*Aegle marmelos*), *lasora* (*Cordia myxa*), *karonda* (*Carissa carandas*), *ker* (*Capparis decidua*), etc. These fruit crops are very rich from nutraceuticals

and can provide income security besides contributing to environmental amelioration and ecosystem services. Great deal of variability exists in these fruit crops at both genotypic and phenotypic level as they have been primarily propagated by seeds.

The role of germplasm in the improvement of arid fruit crops has been well recognised. Most of the present-day commercial cultivars are selections from the variability generated by the germplasm collected/introduced in the past. A large number of collections are maintained and evaluated for utilisation at different research stations (Table 1).

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**Table 1.** Germplasm and their conservation status and major diversity states of different arid fruit crops

Crop	Conservation centres	Number of accessions	Conservation status	Major states of diversity
<i>Aegle marmelos</i> (Bael)	ICAR-NBPGR, New Delhi	427	Cryo-bank (265) and field gene bank (162)	Jharkhand, U.P., Orissa, West Bengal, Rajasthan, Gujarat, Bihar, Chhattisgarh, H.P., A.P., M.P., Maharashtra, Kerala
	ANDUA&T, Ayodhya	12	Field gene bank	
	ICAR-CISH, Lucknow	36	Field gene bank	
	ICAR-CIAH, Bikaner	21	Field gene bank	
	ICAR-CAZRI, Jodhpur	08	Field gene bank	
<i>Capparis decidua</i> (Ker)	ICAR-NBPGR, New Delhi	35	Cryobank (265)	Rajasthan, Gujarat
	ICAR-CIAH, Bikaner	09	Field gene bank	
<i>Cordia myxa</i> (Lasora)	ICAR-NBPGR, New Delhi	231	Cryobank (12) & field gene bank	Rajasthan, Haryana, H.P., Gujarat, Maharashtra, U.P., M.P., Jharkhand, Chhattisgarh
	ICAR-CIAH, Bikaner	67	Field gene bank	
	ICAR-CAZRI, Jodhpur	17	Field gene bank	
<i>Emblica officinalis</i> (Aonla)	ICAR-NBPGR, New Delhi	51	Field gene bank	U.P., Gujarat, Rajasthan, M.P., Bihar, Tamil Nadu, Jharkhand
	ANDUA&T, Ayodhya	22	Field gene bank	Chhattisgarh
	ICAR-CAZRI, Jodhpur	08	Field gene bank	
<i>Phoenix dactylifera</i> (Date palm)	ICAR-CIAH, Bikaner	64	Field gene bank	Gujarat, Rajasthan, Punjab
	SKRAU, Bikaner	35	Field gene bank	
	PAU Research Station, Abohar	31	Field gene bank	
	GAU Research Station, Mundra	24	Field gene bank	
	ICAR-CAZRI, Jodhpur	23	Field gene bank	
<i>Carissa carandas</i> (Karonda)	ICAR-NBPGR, New Delhi	29	Field gene bank	Bihar, West Bengal, Chhattisgarh, Orissa, U.P., M.P., Jharkhand, Rajasthan, Gujarat, Maharashtra, Kerala, Karnataka, Haryana
	ICAR-CIAH, Bikaner	05	Field gene bank	
	ICAR-CAZRI, Jodhpur	05	Field gene bank	
<i>Punica granatum</i> (Pomegranate)	ICAR-NBPGR, New Delhi	360	Field gene bank	Maharashtra, Gujarat, Karnataka, Rajasthan, Tamil Nadu, H.P., U.P., J&K
	ICAR-NRCP, Sholapur	375	Field gene bank	
	ICAR-IIHR, Bengaluru	203	Field gene bank	
	ICAR-CIAH, Bikaner	144	Field gene bank	
	ICAR-CAZRI, Jodhpur	28	Field gene bank	
<i>Ziziphus mauritiana</i> (Indian jujube, ber)	ICAR-NBPGR, New Delhi	285	Field gene bank	Rajasthan, U.P., Haryana, Gujarat, M.P., A.P., Karnataka, Tamil Nadu, Maharashtra
	ICAR-CIAH, Bikaner	372	Field gene bank	
	ICAR-CAZRI, Jodhpur	40	Field gene bank	

Several promising varieties of different arid fruits have been developed by utilizing the existing germplasm. The important varieties developed through selection from diverse germplasm are given below.

**Table 2.** Germplasm utilized for selection of promising varieties

Crops	Varieties
Ber	Gola, CAZRI Gola, Seb, Mundia, Umran, Kaithali, Banarasi Kadaka, Illaichi, Chhuhara, Thar Bhubraj, Thar Sevi-ka, Goma Keerti, etc.
Pomegranate	Ganesh, Bassein Seedless, Jalor Seedless, Muskat, Jodhpuri Red, G-137, Alandi, Dholka, Kandhari, Bhagwa, Super Bhagwa, CAZRI Vishal, CAZRI Shresth, P23, P26, Jyoti etc.

Aonla	NA 7, NA-6, NA-10, Kanchan, Krishna, Balwant, Laxmi-52
Date palm	Medjool, Khadrawy, Halawi, ADP-1, Shamran, Zahidi and Khunaizi, etc.
Karonda	Pant Suvarna, Pant Manohar, Pant Sudarshan, Maru Gaurav, CAZRI Sadabahar
Lasora	Maru Samridhi, Karan Lasoda, Thar Bold, CZCM-2011, CZCM-2012, CZCM-2062, CZCM-2021
Bael	NB-5, NB 9, Pant Aparna, Pant Sujata, Pant Shivani, CISH Bael-1, CISH Bael-2, Goma Yashi
Fig	Poona Fig, Dianna, Dinkar, Black Ischia

Biodiversity in some selected fruits plants of hot arid region is described below:

### Aonla (*Emblica officinalis*, Gaertn.)

Aonla or Indian goose berry is ancient fruit of Indian origin. Its fruit is valued in indigenous Ayurvedic medicine for curative properties. The genetic variability is widespread particularly in Uttar Pradesh (Pratap Garh), Gujarat, Rajasthan and Maharashtra. Banarasi, Francis, Banshi Red, Chakaiya, and Deshi are well known old cultivars. NA6, NA7, NA10, Krishna, Kanchan, Anand-2, etc. are the recent cultivars. Evaluation of aonla cultivars in arid areas of Rajasthan revealed variation in growth attributes and physico-chemical parameters of fruits in different varieties (Meghwal and Azam, 2004).

### Ber (*Ziziphus* spp.)

The ber or Indian jujube is the most important arid fruit belonging to family Rhamnaceae with more than 600 species world wide of which 18-20 are native to India (Watt, 1883). Singh and Arora (1978) listed eight species having edible fruits found in different parts of India. The *Ziziphus mauritiana* is commercially important which has more than 300 varieties. The *jhar ber* (*Z. nummularia*) is endemic to arid region and grows naturally in crop field under rain fed condition. The third species, *Z. rotundifolia* also bears edible fruits but of smaller size which is used as rootstock for *Z. mauritiana*. Huge variability available in *Z. rotundifolia* may be exploited for selection of elite types having desirable fruit characteristics and further maintained by vegetative propagation techniques which is already well standardized. The presence of enormous diversity may be attributed to sexual propagation, heterozygosity, cross pollination and natural polyploidy. The most of so-called improved varieties have been evolved as a result of natural and man-made selection. Khoshoo and Singh (1963) reported that segmental allopolyploidy also plays an important role in creation of variability.

### Pomegranate (*Punica granatum* L.)

Pomegranate belongs to family Punicaceae and is one of the favourite table fruits in tropical and subtropical

regions. Pomegranate has very narrow genetic variability. The genus *Punica* consists of two species i.e. *granatum* and *protopunica*, with two sub species (*chlorocarpa* and *prophyrocarpa*) in *granatum*. The major variability is found in Maharashtra, Karnataka, Tamil Nadu, Gujarat and Rajasthan. The germplasm collection at various research centers in India includes several cultivars, including exotic introductions from the temperate zone. The germplasm is being maintained at Rahuri, Abohar Bengaluru, Ayodhya, Hisar, Jodhpur, Bikaner, Junagarh, Ludhiana, Solan, and Udaipur.

At ICAR-CIAH, Bikaner, about 106 germplasm of pomegranate have been collected and maintained in field gene bank (Anonymous, 2023). Muskat, Bassein Seedless, Dholka, Jalore Seedless and Jodhpuri Red are the traditional cultivars. Selections P-23 and P-26 from Muskat, Ganesh from Alandi, G-137 from Ganesh, and IIHR selection from Basein Seedless, and Yercaud-1 (Sayed *et al.*, 1985) have been made. A new cultivar Mridula has been developed at Rahuri, from the open pollinated progeny raised from the  $F_1$  population, derived from Ganesh x Gul-E-Shahi Red (Anonymous, 1994). It has red arils with very soft seeds.

At Hisar, Shirin Anar and Russian seedlings were found resistant to bacterial leaf (Singh and Rana, 1993). Evaluation of nine pomegranate cultivars under arid conditions of Jodhpur showed significant variation in plant growth, fruit yield and physico chemical properties of fruits (Prasad and Banker, 2000). The pomegranate orchard in Jalore and Jodhpur district in western Rajasthan have spread through seed propagation with lot of variability (Vashistha *et al.*, 2003).

At ICAR-CAZRI, Jodhpur, a new variety CAZRI Vishal has been developed recently (Singh and Meghwal, 2020). This is a selection from  $F_1$  population of a cross between Ganesh x Khog. The seeds are soft with pink arils. Its fruits mature early (120-130 days after anthesis). The TSS is 17.5-18.6 % with low acidic juice (0.48-0.52%) along with high recovery of arils (60%) and juice (>40%). Maru Shresth (CAZRI/JSM-17) is another variety released from CAZRI (Anonymous, 2023). It is medium maturing (140-150 days after anthesis) variety. Fruits are medium in size (270-300 g) with attractive bright red colour rind. The seeds are soft with dark red and bold arils. The average TSS is 17.8°B with high juice content (43.1%). The fruit yield is about 20-25 kg/ plant after five years of planting following ideal management practices. The developed variety Maru Shresth may offer alternative to predominant variety i.e. Bhagwa for sustainable cultivation of pomegranate in India.

## Jamun (*Syzygium cumini*)

*Syzygium cumini* (Linn.) Skeels syn. *Eugenia jambolana* Linn. has long been in cultivation in Malayan Archipelago and India and said to be originated in India, Burma and Ceylon. The genus *Syzygium* has many species yielding edible fruits and some of these are of ornamental value. *Syzygium jambos* (rose apple or gulab jamun) found in India is a popular fruit. Its fruits are yellow and the tree is ornamental. *S. zeylanica* a small tree with edible fruits is found in the Western Ghats. *S. malaccensis* (Malay rose apple) and *S. uniflora* (Surinam cherry or Pitanga cherry) are also found in south India. *S. javanica* (water apple) is distributed over south India and Bengal. A wild species, *S. fruticosum*, with small edible, dark purple fruit is grown as wind break and *S. densiflora* used as rootstock is found to be resistant to termites.

A number of seedling strains with variation in fruit shape, size, pulp colour and content, TSS, acidity and earliness are found particularly in U.P., Gujarat and Maharashtra, providing good scope for selection of better types. However, no standard variety exists, but the common type grown in north India is purple red jamun having bigger size, oblong fruits which ripen in June-July. Another type is late ripening (August) and bears round blackish, small fruit. Singh *et al.* (1999) evaluated eight genotypes under Ayodhya conditions and reported that oblong types had more weight and relatively small seeded.

## Date palm (*Phoenix dactylifera* L.)

Date palm is considered to be the oldest cultivated fruit tree. It is believed to be originated from countries around Persian Gulf. There are three major species of date palm grown in India viz., *Phoenix dactylifera* L., *P. sylvestris* L. Roxb. and *P. canariensis* Chabaud. *Phoenix dactylifera* is very common and grown commercially because of its superior quality edible fruits. Several Phoenix species grow wild in different parts of the country. *P. sylvestris* grows naturally with small sized fruits with less pulp content. In India, date groves are found in coastal belts of Kachchh from Anjar to Mandvi and other regions of Gujarat.

At present, 35 date palm varieties are conserved at Date palm Research Station, Bikaner, 19 cultivars at ICAR-Central Arid Zone Research Institute, Jodhpur but only 5-6 varieties are recommended for commercial cultivation. The evaluation of 19 cultivars at ICAR-CAZRI, Jodhpur indicated variation in flowering time and fruit characteristics (Anonymous, 1994-95). The date of initiation of spathe emergence varied from 15 January (Medni) to 18 February (Nagar Hilali). The initiation of Doka stage was earliest in cv. Abdul Rehmana and Medni (June, 2) followed by Muscat-2 (June, 10) and last in cv. Sayer (June, 30). The peak daoka stage was also earliest

in Medni and Abdul Rehman and last in Barhee. The colour of berry at doka stage was yellow in all the cultivars except Khadrawy (yellowish green), Umshok (Red), and Muscat-2 (Reddish purple).

## Fig (*Ficus carica* Linn.)

The edible common fig is thought to be a native of southern parts of Arabian Peninsula, Italy, the Balkan Peninsula and the USSR. The genus *Ficus* has over 1000 species, and the species found wild in India are *F. semicordata* syn. *F. pumila* syn. *F. cordifolia* (pakar, gagjaira), *F. glomerata* (gular, domoor), *F. hispida* (kathumabar, konea-dunmbar), *F. auriculata* syn. *F. roxburghii*, *F. macrophylla* (timla, tirmal) pamtai forsk.

Singh (1969) suggested that since the fig varieties grown in India have faintly lobed leave, these are probably hybrids between the common fig and Indian wild species. The available fig varieties are; Poona fig, Dinkar, Daultabad, Excel, Conadria, Black Ischia and Dianna.

## Bael (*Eagle marmelos* Correa)

Bael is an indigenous fruit crop well known for its nutritional and therapeutic properties. It is in great demand for native system of medicine such as *ayurvedic*. The marmelosin content of fruit is known as the panacea of the stomach ailments. Plenty of seedling trees of bael are spread all over the country with great deal of variability. Wide ranging variation in physico-chemical characteristics of fruits were observed by Lal (2002) in a trial on seven strains of bael in Rajasthan.

## Gonda (*Cordia myxa* L.)

Gonda also known as lasoda or lehsua is a drought tolerant fruit crop, which is found growing as stray plantation in semi-arid and arid regions of Rajasthan, Haryana, Gujarat and Madhya Pradesh. This drupaceous fruit has mucilaginous pulp, which constitutes about 70 per cent of the fruit. An important member of family Boraginaceae and genus *Cordia* to which large number of species belongs of which *Cordia gharaf* is another popularly known species. The genus is distributed throughout the country especially in western region. A great variation exists in size of fruits and their pulp content. Accordingly, large fruited type in Gujarat is recognized as "Paras". At Bawal in Haryana, 27 germplasm of gonda have been collected.

An exploration survey of gonda germplasm in Haryana indicated range of diversity in morphological and qualitative characters of fruits (Kaushik and Dwivedi, 2004). At ICAR-CAZRI Jodhpur, nine gonda accessions collected from different parts of Rajasthan and adjoining areas were

evaluated for growth and fruiting behaviour and fruit characteristics (Anonymous, 2007). Long term evaluation of germplasm resulted in identification of five high yielding genotypes i.e. CZCM-2011, CZCM-2012, CZCM-2021, CZCM-2025 and CZCM-2062. The accession CZCM-2025 has been released as Maru Samridhi from CAZRI with fruit yield of more than 100 kg per plant.

The variety Karan Lasoda has been identified as improved selection from SKNAU, Jobner, while Thar Bold from CIAH Bikaner. The budded plants of these varieties are in great demand. The development of new varieties and standardization of agro-techniques have resulted in popularization of this species as commercial sole orchard rather than boundary plantation practiced earlier.

### **Karonda (*Carissa carandas* L.)**

Karonda is evergreen, densely branched, spiny shrub and an excellent for bio fencing species belonging to family Apocynaceae. There are about 20 species of which five are of Indian origin including *C. carandas*. At Rahuri in Maharashtra, some promising types No. 13, 16, 12 and 3 have been identified (Karale *et al.*, 1989). At ICAR-Central Arid Zone Research Institute, Jodhpur, 27 collections were made from karonda growing tracts in Rajasthan and Maharashtra. Phenotypic variability was observed in plant growth, fruit size, shape and colour of fruit, (Bankar and Prasad, 1992; Bankar *et al.*, 1992). Diversity in *Carissa* have also been observed in northwestern India, particularly in Mount Abu and Khandala in Maharashtra (Mehra and Arora, 1982). Six accessions and a variety (Pant Manohar) of karonda were evaluated at ICAR-CAZRI, Jodhpur (Anonymous, 2008). They could be grouped into two broad categories based on fruit colour. Good diversity in canopy volume, plant height, growth habit, precocity, morpho-physico-chemical characteristics of leaves, fruits and fruit yield were recorded (Meghwal *et al.*, 2012). Based on the performance of the germplasm over a period of eight years for fruit yield and other desirable attributes, the accession number CZCC-2011, CZCC-2022 and CZCC-2031 could be found suitable for hot arid zone on account of their higher yield and bold fruit size (Meghwal, 2018).

Subsequently one of the accessions (CZCC-2011) was released as Maru Gaurav an improved high yielding variety from ICAR-CAZRI, Jodhpur (Meghwal *et al.*, 2019). Another accession CZCC-2001 has been found to flower and fruit three times in a year. The first flowering occurs during March April with fruit maturity in June-July, while second flowering take place in the month of July-August with fruiting in October-November. The third flowering occur during late October to early November with fruit maturity during December-January. This genotype has recently been released from ICAR-CAZRI, Jodhpur as CAZRI Sadabahar

(Anonymous, 2020). Thar Kamal has been released recently from ICAR-CIAH, Bikaner (Singh *et al.*, 2015) while Pant Manohar, Pant Suverna and Pant Sudarshan were released earlier from GBPUA&T, Pantnagar

### **Ker (*Capparis decidua* Forsk. Edgew)**

*Ker* a much branched, straggling, glabrous small tree or shrubs belongs to family Capparidaceae. The species is valued for its fruits which are used as vegetables and made into pickle. Exploration survey of *Capparis decidua* undertaken in different parts of Rajasthan and Haryana indicated wide variability in morphological and fruit related traits (Singh *et al.*, 2007). Significant variations were recorded in traits like growth habit, presence of spines, plant spreads and compactness of canopy, time of flowering and fruiting, etc. The plant height ranged from 120 cm to 750 cm while plant spread from north to south direction varied from 90 cm to 660 cm. Marked variation in the size of spines was also observed with 60.6% plant having spines of 3-5 mm, 27.3% had small sized spines (<3 mm) while 3% plant had large spines (>5 mm), the remaining 9.1% plants were without spines. The fruit shape was globular with slight variation. Diversity with respect to plant types, canopy, flowering and fruiting were also observed during survey of natural population in Jaisalmer district of Rajasthan (Mahla and Singh, 2013).

### **Khejri (*Prosopis cineraria*)**

*Khejri* is lifeline of desert dwellers due to its multiple utility and its ability to tolerate odds of climatic conditions. Each part of *khejri* is useful in some or the other way (Saroj *et al.*, 2001). *Prosopis cineraria* (Linn) belongs to Leguminosae, sub-family Mimosoideae; is one of the 44 species of leguminous trees and shrubs in the genus *Prosopis*. Indian arid region is considered as home of *Prosopis cineraria* and even today, it is principal species in arid ecosystem. The natural propagation of *khejri* is by seeds; hence, variability in the natural population is evident.

Survey of *Prosopis cineraria* in western Rajasthan revealed wide phenotypic variation with respect to vegetative growth, yield and attributes of pods. In general, there are two distinct ecotypes, one having erect branching, narrow angle, and bigger leaf size, more thorn with more open canopy and another drooping branches, wide angle, smaller leaf size, less thorn with compact canopy. The colour of pod was found as an important indicator. Based on ripe pod colour, there are two types: one is green pod colour which is common and another pink pod colour which is rare (Saroj *et al.*, 2001).

The pods also vary in shape, size, seed content and taste. The variability in vegetative vigour of *khejri* trees has also been mentioned by Mann (1980), Muthana (1980) and Kaul *et al.* (1991). Recent survey of *khejri* germplasm for desirable pod

types for culinary purpose resulted in identification of two superior types of plants having longer pods and thorn less (Anonymous, 2008). Thar Shobha is selection from naturally occurring trees from Bikaner.

### Phalsa (*Grewia subinaequalis* D.C.)

Phalsa is one of the oldest known fruits, which finds mention in Vedic literature as having certain medicinal qualities. It is one of the most drought tolerant crops, suitable for cultivation in wasteland and salt affected soils, as it can be grown in saline soils up to 12 dSm<sup>-1</sup> and in sodic soils up to 40 ESP. Its small-scale cultivation is confined near big cities in the states of Haryana, Punjab, Gujarat, Rajasthan, U.P. and Maharashtra.

A member of family Tiliaceae having 18 genera and 40 species which are mostly distributed in tropical and subtropical region of the world (Gauri Shankar, 1985). The genus *Grewia* has 140 species, out of which 40 occur in India. However, *G. subinaequalis* D.C. is only of commercial importance. Thar Pragati is the first improved variety released from ICAR-CIAH Regional Station, Godhara (Singh *et al.*, 2018).

### Pilu (*Salvadora oleoides* Decne.)

Pilu is a very common tree found growing luxuriously in Thar desert especially in Rajasthan and Gujarat areas. The tree gives good fodder for camels during summer when other vegetations are scarce. Fruits are rich in non-edible oil (40-50%) which has many industrial uses. It is an excellent plant for shelterbelts and wind breaks. *Salvadora oleoides* grown naturally in arid areas showed great deal of variability in different growth and quality attributes (Jindal *et al.*, 2006).

### Khirni (*Manilkara hexandra*)

Khirni is found wild in the forests of South India, North-central India, parts of Gujarat and Rajasthan. ICAR-NBPGR, New Delhi collected 47 accessions and recorded wide variability in eight physico- chemical characteristics (Malik *et al.*, 2010). GK-1, GK-10 and Thar Rituraj are improved varieties (Singh *et al.*, 2018).

## Conclusion

The hot arid regions of India are reservoirs of agrobiodiversity despite adverse edapho-climatic conditions and limited rainfall. The crop improvement methods like selection and introduction have led to improvement in the fruit species suitable for arid regions. The development of clonal propagation techniques and availability of irrigation facilities

have further played key roles in the utilization of these fruit crops. The collection and conservation of fruit germplasm at different research institutes in field gene bank is necessary for future research requirement including the development of varieties resistant to biotic and abiotic stresses. Although, the efforts made so far has helped in commercialization of many arid fruit crops like ber, pomegranate, aonla, date palm, etc., however, lot more needs to be done to fully exploit some underutilized fruit species like *ker*, *pilu*, *jhar ber*, *lasora* and phalsa, etc. to their full potential.

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## Conflict of Interest

The authors have no conflict of interest.

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