



## Taxonomic Revision on Genus *Brassica* L. (Cruciferae A. Juss.) in Egypt

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### ABSTRACT

This study includes taxonomic revision, documentation, description and distribution of 8 *Brassica* species in Egypt; *Brassica cretica* Lam., *Brassica juncea* (L.) Czern., *Brassica napus* L., *Brassica nigra* (L.) K. Koch., *Brassica oleracea* L., *Brassica rapa* L., *Brassica tournefortii* Gouan. and *Brassica deserti* Danin & Hedge. Fresh specimens were collected from El- Qaluobea and El-Fayoum governorates, Egypt. Herbarium specimens were examined, photographed and kept in Flora and Phytotaxonomy Research Department to be available for the taxonomic researchers for further study. The results of this study showed the importance of morphological traits for taxonomic evaluation among the studied taxa of genus *Brassica* in Egypt. Moreover, a constructed key to *Brassica* taxa was designed.

**Keywords:** Cruciferae, *Brassica*, taxonomic revision.

### 1. Introduction

Cruciferae is a monophyletic group, which includes about 3709 species and 338 genera (Al-Shehbaz *et al.*, 2006). It is one of the most important plant families; it includes vegetables, ornamental and crop species (Kasem *et al.*, 2011). All taxa of this family are Mediterranean, Irano-Turanian and Saharo-Sindian zones except Antarctica region (Hedge, 1976 and Lysak and Koch, 2011). *Brassica* is one of the most agriculturally important genera of the family, it includes about 80 accepted species worldwide, with high morphological diversity and wide-ranging utility (Song *et al.*, 1988 and The Plant List, 2013).

*Brassica* L. is represented in Sinai by three species which *B. deserti* is endemic to Sinai (El-Hadidi 1989). *Brassica deserti* Danin Hedge in Notes Roy. Bot. Gard. Edinburgh 32 (2): 259 (1973). Weed: Di [Endemic] (El-Hadidi and Fayed 1995). In Egypt, Cruciferae is one of the four largest families, represented by about 103 species and 53 genera. Genus *Brassica* represented in Egypt by five wild species, namely: *B. rapa* L., *B. tournefortii* Goauan, *B. deserti* Danin Hedge, *B. nigra* (L.) Koch and *B. juncea* (L.) Czernj. & Coss. (Boulos 1999).

Taxonomic structure of the whole family is characterized by a large number of monotypic and small genera, mostly with clearly defined taxonomic limits. Due to its great economic importance, crops of *Brassica* received the attention of taxonomists from the earliest times (Warwick 2011). Cruciferae is treated by Post (1932) to include three groups (Siliquosae, Lomentaeae and Siliquulosae), each is composed of numbers of tribes. Schulz (1936) classified the family into 19 tribes and 29 sub-tribes, while Janchen (1942) recognized 13 tribes depending on the huge numbers of flowers and fruits features. Zohary (1966) divided the family into 6 tribes according to the fruit characters, but Davis (1975) divided the family into 6 groups and 10 tribes. Judd *et al.*, (1999) considered the family Brassicaceae a large family comprising Capparaceae, Cleomaceae and the traditional Brassicaceae and put it under the order Brassicales.

*Brassica* is a genus of about 37 species of flowering plants in family Brassicaceae (AL-Shehbaz *et al.*, 2007), many of which are important agricultural crops (Ambarak 2005). Brassicas are native to

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Europe and temperate Asia and are especially common in the Mediterranean region; some are considered invasive species in areas outside their native range (Heywood 1993). Economically, the family has important members of species; i.e. broccoli, brown mustard, brussels sprouts, cabbage, cauliflower, kale, kohlrabi, rape, rutabaga and turnip (Navarro and El. Qualidi 2002). *Brassica* taxa are herbs with a variety of growth habits. The plants generally have lobed or entire leaves, arranged alternately, and are often waxy and bluish green in color. Many species are biennials. The four-petaled flowers are usually borne in clusters and bear dry fruits known as siliques or silicles, depending on their length (Heywood 1993).

In Flora of Egypt, Täckholm (1974) mentioned the presence of *B. nigra* in three varieties namely; var. *bracteolata* (Fisch. & Mey.) Spach ex Cross, var. *torulosa* (Pers.) Alef. and var. *turgida* (Pers.) Alef. Later, all these infra-specific taxa were grouped as synonyms for *B. nigra* species by Bolous (1999 and 2009). Worldwide, the “Plant list” and the “IUCN Red List” (Korpelainen *et al.*, 2011) also grouped all the infra-specific taxa as synonyms to the species. Amer *et al.*, (2019) confirming the presence of two distinctive varieties var. *nigra* and var. *bracteolata* for *B. nigra* species.

Morphological characters were the most important source of information in plant taxonomy. A majority of taxonomic groups recognized today are defined by cardinal characters mainly from the floral morphological characters. Musil (1948), Vaughan (1956), Berggren (1960), Vaughan and Whitehouse (1971), and Corner (1976) successfully used variation in seed coat to identify and classify taxa belonging to tribe Brassiceae. Moreover, Murely (1951) and Berggren (1962) studied the external morphology and anatomy of seed testa of *Brassica*. Based on the beak of fruit characters, Appel (1999) studied the systematic of tribe Brassiceae. Koul *et al.*, (2000) studied the seed surfaces of 44 species belong to 11 genera of sub tribes Brassicinae, Raphaninae and Moricandiinae using scanning electron microscope (SEM). Tantawy *et al.*, (2004) studied the morphological characters of seeds for 34 taxa of Brassicaceae belong to 22 genera and 30 species.

The aim of this study was to carry out documentation and taxonomic revision of genus *Brassica* L. in Egypt as well as to construct a more recent identification key for the studied species.

## 2. Material and Methods

### Taxon sampling and identification

Several field trips were carried out, through April 2020 and March 2021, to collect the available studied *Brassica* species from different localities in Egypt (Table I). The study of 7 species representing genus *Brassica* included the morphological aspects, global distribution and herbarium specimens examined. Confirmed the taxonomic identification using the following references; Täckholm (1974); Boulos (2000 & 2009) and updated by Angiosperm Phylogeny Group III (2009); Chase and Reveal (2009) and Haston *et al.*, (2009).

### Morphological data

Morphological data were recorded on the fresh plant samples and the deposited sheets at the herbarium of Flora and Phytotaxonomy Research Department, Horticultural Research Institute, Agricultural Research Center (CAIM). The studied taxa were identified by the comparison with specimens kept in the CAIM herbarium. In addition to the keys of Hutchinson and Dalziel (1954), Täckholm (1974), and Boulos (2000), total of 30 morphological characters were recorded (Table 2), and the herbarium specimens were examined and photographed then prepared and kept in this herbarium.

### Statistical analysis

Statistical analysis of the different morphological characters was based on hierarchical cluster analysis. The retrieved output was used to construct specific morphological relationships among the studied *Brassica* species. Characters and character states were coded as multistate characters. The interval numbers of 30 morphological characters were used for the studied species (Table 2). The data treated as a Pearson correlation in a data matrix to measure degree of similarity value using SPSS version 22 (SPSS, 2013). The output was plotted in the form of UPGMA (Unweighted pair group method with arithmetic mean) dendrogram (Figure 1). The dendrogram was based on average linkage cluster analysis (between groups) and the rescaled distance cluster combined (Sneath and Sokal 1973).

**Table 1:** Scientific names, habit, sites and date of collection of the studied species.

Scientific names	Habit	Sites and Date of collection
<i>Brassica cretica</i> Lam.	Cultivated	El-Fayoum, April 2020
<i>Brassica juncea</i> (L.) Czern.	Wild	El- Qaluobea, March 2021
<i>Brassica napus</i> L.	Cultivated	El- Qaluobea, March 2021
<i>Brassica nigra</i> (L.) K. Koch.	Wild	El-Fayoum, April 2020
<i>Brassica oleracea</i> L.	Cultivated	El-Fayoum, April 2020
<i>Brassica rapa</i> L.	Wild	El-Fayoum, April 2020
<i>Brassica tournefortii</i> Gouan.	Wild	El- Qaluobea, March 2021
<i>Brassica deserti</i> Danin & Hedge	Wild	Not available

### 3. Results and discussion

*Brassica* L., Sp. Pl.: 666 (1753).

Annuals, biennials or rarely perennials; glabrous, glabrescent or pubescent. Stems erect, unbranched or branched distally. Leaves basal and cauline; petiolate or sessile; basal, rosulate or not, petiolate, blade margins entire, dentate, or lyrate-pinnatifid; cauline petiolate or sessile, blade base sometimes auriculate or amplexicaul, margins entire, dentate, lobed, or sinuate-serrate. Racemes (corymbose), considerably elongated in fruit. Fruit pedicels erect, spreading, ascending or divaricately-ascending, often slender. Flowers: sepals usually erect or ascending, rarely spreading, oblong, lateral pair usually saccate basally; petals yellow to orange-yellow (rarely white), obovate, ovate, elliptic, or oblanceolate, claw often differentiated from blade, (sometimes attenuate basally, apex rounded or emarginate); stamens tetradynamous; filaments slender; anthers oblong or ovate, (apex obtuse); nectar glands confluent or not, median glands present. Fruits siliques, dehiscent, sessile or stipitate, segments 2, linear, torulose or smooth, terete, 4-angled, or latiseptate; (terminal segment seedless or 1-3-seeded, usually filiform or conic, rarely cylindrical); valves each prominently 1-veined, glabrous; replum rounded; septum complete; ovules 10-50 per ovary; stigma entire or 2-lobed. Seeds uniseriate, plump, not winged, globose; seed coat reticulate or reticulate-alveolate.

#### Key to the studied *Brassica* species

A- Perennials; petals 15-18 mm long; terminal segments of fruits 3-4 x11 mm.

..... *Brassica oleracea*

AA- Annuals or biennials; petals 6-16 mm long; terminal segments of fruits 5-8 x 22 mm.

B- Flowers usually not overtopping buds, rarely at same level when open; petals

pale yellow, 10-16 mm long; terminal segments of fruits 5-9 x16 mm

long ..... *Brassica napus*

BB- Flowers overtopping buds; petals deep yellow, 11- 13 mm long; terminal segments of fruits 8-22 mm long ..... *Brassica rapa*

C- Fruits and pedicels erect; fruits not torulose; fruit pedicel 2-3 x 5-6 mm..... *Brassica nigra*

CC- Fruits and pedicels spreading to ascending; fruits often torulose; fruit pedicel 6-8 x 20 mm.

D- Basal leaves persistent, blades with 4-10 lobes each side, surfaces hairy; petals 4-7 × 1.5-2.5 mm.

- E- Siliqua 2- 5 cm long, nerved; beak 3- 5 mm  
..... *Brassica deserti*
- EE- Siliqua 4- 7 cm long, not nerved; beak 10- 20 mm  
.....*Brassica  
tournefortii*
- DD- Basal leaves deciduous, blades with 1- 4 lobes each side,  
surfaces glabrous; petals 9-13 × 3-7 mm.
- F- Fruits sessile, 0.3-0.4 × 3-5 cm, terminal segment  
4-5 x10-15 mm.....*Brassica juncea*
- FF- Fruits sub-sessile, (gynophore 1-1.5 mm long), 2-3 × 20-25 mm, terminal  
segment 3-4 mm long..... *Brassica cretica*

### Morphological aspects

1- *Brassica cretica* Lam., Encycl. 1: 747 (1785).

**Common name:** Broccoli and Cauliflower

#### Synonyms

*Brassica botrytis* (L.) Mill.; *Brassica cretica* subsp. *cretica*; *Brassica cretica* subsp. *nivea* (Boiss. & Spruner.) M.A.Gust. & Snogerup.; *Brassica cretica* var. *nivea* (Boiss. & Spruner.) O.E.Schulz.; *Brassica nivea* Boiss. & Spruner.; *Brassica oleracea* subsp. *botrytis* (L.) Metzg.; *Brassica oleracea* var. *botrytis* L.; *Brassica oleracea* var. *cretica* (Lam.) Coss., *Brassica oleracea* var. *italica* Plenck.

### Morphological description

Biennial, 1.5-2 m tall, glabrous, glaucous. Stem base elongated, not fleshy, cylindrical. Basal and lower cauline leaves green, few to several, widely spaced, not grouped into a head. Axillary leafy buds not forming heads. Basal and lowermost cauline leaves long petiolate, sometimes strongly overlapping and forming a head; leaf blade lanceolate in outline, up to 4 × 15 cm, margin dentate or pinnatifid with a large terminal lobe and smaller 10-13, oblong or ovate lateral lobes on each side of midvein. Upper cauline leaves sessile, ovate, or oblong, up to 10 × 4 cm, base cuneate, margin entire, or rarely dentate. Inflorescence white or green, compact, often globose, with fleshy peduncle, rachis, pedicels, and flowers. Flowers yellow. Fruits sub-sessile. Terminal segment conical, 3-4 x10 mm, seeds 1 or 2; style obsolete. Seeds dark brown or blackish, globose, 1.5-2.5 mm in diam., minutely reticulate.

### Global distribution

Native to Albania, East Aegean Is., Greece, Kristi, Lebanon-Syria, Palestine and Turkey. Introduced into Bangladesh, East Himalaya and Vietnam.

### Herbarium specimens examined

Toukh, 2/3/1913, Bolland 1352 (CAIM); Orman, 9/4/1926, Drar 568 (CAIM); El-Qoba, 21/4/1929, Shabetai 1561 (CAIM); Giza, 24/1/1927, Simpson 2112.

2- *Brassica juncea* (L.) Czern. Consp. Pl. Charc. 8 (1859).

**Common name:** Indian mustard.

#### Synonyms:

*Sinapis juncea* L.

### Morphological description

Annual herbs, 100-180 cm tall, pubescent or rarely glabrous, with fleshy taproots. Stems erect, branched above. Basal and lowermost cauline leaves long petiolate; petiole 5-8 cm; leaf blade ovate or oblong in outline, lyrate-pinnatifid or pinnatisect; terminal lobe ovate; lateral lobes 1-3 on each side of midvein, much smaller than terminal lobe, crisped, incised. Upper cauline leaves petiolate, oblanceolate, 3-5 × 7-10 cm, base cuneate, margin entire. Fruiting pedicels straight, divaricate, 0.5-0.8 x 1.5-2 cm. Sepals oblong, 4- 6× 1-1.7 mm, spreading. Petals yellow, 6.5-8 x 11-13 mm, ovate or

obovate, apex rounded or emarginate; claw 3-6 mm. Filaments 4-7 mm; anthers oblong, 1.5-2 mm. Fruit linear, 30-50 × 3-5 mm, terete or slightly 4-angled, sessile, divaricate or ascending; segment 2-4.5 cm long, 15-20 seeds per locule; valves with a prominent midvein, slightly torulose; terminal segment conical, 4-5 × 10-15 mm, seedless; style often obsolete. Seeds dark to light brown or grey, globose, 1-1.7 mm in diameter minutely reticulate.

#### Global distribution

Its original distribution lies between Eastern Europe and China. It has been cultivated for centuries in many parts of Eurasia. These days, the species is mainly grown in Bangladesh, Central Africa, China, India, Japan, Nepal and Pakistan, as well as southern Russia north of the Caspian Sea.

#### Herbarium specimens examined

Nile Delta, 19/1/1928, 5918 (CAIM). Dakhla Oasis, 15/3/1928, Drar 547 (CAIM).

3- *Brassica napus* L., Sp. Pl. 2: 666. (1753)

**Common name:** rapeseed oil and Canola oil

#### Synonyms

*Brassica napobrassica* (L.) Miller; *Brassica napus* var. *oleifera* de Candolle; *Brassica oleracea* L. var. *napobrassica* L.

#### Morphological description

Biennials, glabrous, Stem branched. Basal leaves winged petiolate, up to 15 cm long; blade lyrate, pinnately lobed, 3-4 × 15-20 cm, lobes 4-6 each side, (smaller than terminal), surfaces glaucous or glabrous. Cauline leaves (middle and distal) sessile; blade base auriculate or amplexicaul, (margins entire). Racemes not paniculately branched, (buds overtopping or equal to open flowers). Fruiting pedicels spreading to ascending (slender), 1-3 cm. Flowers: sepals (5-)6-10 × 1.5-2.5 mm; petals golden or creamy to pale yellow, broadly obovate, 10-16 × 6-9 mm, claw 5-9 mm, apex rounded; filaments 7-10 mm; anthers 1.5-2.5 mm. Fruits spreading to ascending, smooth, terete, 5-10 cm × 0.3-0.5 cm; valvular segment with 20-30 seeds per locule, terminal segment usually seedless, rarely 1 or 2-seeded (attenuate-conic, thin), 9-16 mm. Seeds dark brown to black, 2-3 mm diam.; seed coat finely reticulate.

#### Global distribution

Native in Europe. It is widely cultivated and has been introduced to other parts of the world.

#### Herbarium specimens examined

Near the Barrage Delta, 15/2/1924, Simpson, 2432 (CAIM); Geziret El-Dahab, 16/3/1928, Simpson, 2441 (CAIM); Dakhla Oasis, 16/1/1929, Shabetai, 501 (CAIM); Giza, 9/12/1929, Shabetai, 2099 (CAIM); Munifiyah, 8/2/1932, Shabetai, 3702 (CAIM); Dakhla Oasis, 4/3/1934, Shabetai, 4600 (CAIM).

4- *Brassica nigra* (L.) K.Koch., *Deutschl. Fl.* ed. 3, 4: 713 (1833).

**Common name:** Black mustard

#### Synonyms

*Brassica brachycarpa* P.Candargy; *Brassica bracteolata* Fisch. & C.A.Mey.; *Brassica elongata* var. *longipedicellata* Halácsy ex Formánek; *Brassica nigra* var. *abyssinica* Alexander Br.; *Brassica nigra* f. *breviflora* Zapal.; *Brassica nigra* var. *carneodentata* Kuntze.; *Brassica persoonii* Rouy. & Foucaud.; *Brassica sinapioides* Roth. ex Mert. & W.D.J.Koch.; *Brassica sinapis* Noulet.; *Sinapis erysimoides* Roxb.; *Sinapis persoonii* (Rouy. & Foucaud.) A.Chev.

#### Morphological description

A much branched annual herb 1-1.5 m tall, with a firm taproot. Stem erect, terete, up to 1.5 cm in diameter, glabrous, green or slightly glaucous. Leaves rather variable, petiolate, in a rosette and large in young plants, alternating and becoming gradually smaller further up the stem; lower leaves large, up to 16 × 5 cm, pinnatilobed, usually with 2 lower lobes and a much larger terminal lobe, central leaves moderately lobed; lower and central leaves irregularly dentate and often partly bristly hairy; uppermost leaves narrow-lanceolate, small, entire, glabrous. Inflorescences axillary or terminal, bractless racemes,

all together arranged paniculately; flowers bisexual, up to 8 mm long, 4-merous, bright yellow, on short pedicel; sepals 4, narrowly elliptical, 3-4 mm x 1.5 mm, spreading horizontally; petals 4, obovate, 6-8 x 2-2.5 mm; stamens 6, outer whorl of 2 shorter, inner whorl of 4 longer ones; pistil slightly shorter than longest stamens, with sessile, superior, elongated ovary and a style ending in a semi-globose stigma. Fruit a silique, 4-sided, up to 2.5 cm long, with a short beak at apex, erect and closely appressed to the inflorescence axis, containing 4-10 seeds, dehiscent when ripe. Seed globose, about 1 mm in diameter, black to red-brown, minutely pitted. Seedling with epigeal germination.

### Global distribution

This taxon was originated in the Asia, Minor-Iran area, but at present it occurs wild in the Mediterranean region, throughout central Europe, in the Middle East and in the Ethiopian highlands. It is widely cultivated and has been introduced to other parts of its native continents as well as Australasia and the Americas.

### Herbarium specimens examined

El-Qalag, 23/3/1923, Simpson, 2102 (CAIM); Embaba, 8/1/1927, Simpson, 4333 (CAIM); Kom Ombo, 12/2/1927, Simpson, 4430 (CAIM); Cairo, 1/3/1927, Simpson, 4489 (CAIM); Giza, 20/7/1928, Shabetai, 4431 (CAIM); Aswan, 6/4/1931, Shabetai, 1626 (CAIM); Ashmum, 28/2/1942, Khattab, 4512 (CAIM); Geziret el-Dahab, 16/2/1945, Shabetai, 4588 (CAIM); Talbiya, 16/12/1947, Khattab, 4591 (CAIM); Dokki, 7/1/1948, Khattab, 4598 (CAIM); Bulaa El-Dakrur, 3/3/1951, Shabetai, (CAIM); Giza, 10/1/1955, Khattab (CAIM).

**5- *Brassica oleracea* L., Sp. Pl. 2: 667. (1753).**

**Common name:** Brussels Sprouts, Kohlrabi and Cabbage

### Synonyms

*Brassica alboglabra* L.H. Bailey; *Brassica arborea* Steud.; *Brassica bullata* Pasq.; *Brassica campestris* subsp. *sylvestris* (L.) Janch.; *Brassica capitata* DC. ex H.Lév.; *Brassica caulorapa* (DC.) Pasq.; *Brassica cephalata* DC. ex H.Lév.; *Brassica fimbriata* Steud.; *Brassica gemmifera* H.Lév.; *Brassica laciniata* Steud.; *Brassica maritima* Tardent.; *Brassica millecapitata* H.Lév.; *Brassica oleracea* var. *capitata* L.; *Brassica oleracea* var. *caulorapa* DC.

### Morphological description

Biennial or perennial, 2-3 m tall, glabrous, glaucous. Stems erect, branched at or above middle, sometimes fleshy at base. Basal and lowermost cauline leaves long petiolate, sometimes strongly overlapping and forming a head; petiole up to 15 cm; leaf blade oblong, or lanceolate in outline, up to 10 × 25 cm, margin entire, repand, or dentate, sometimes pinnatifid or pinnatisect and with a large terminal lobe and smaller, oblong or ovate lateral lobes on each side of midvein. Upper cauline leaves sessile or subsessile in some cultivated forms, ovate or oblong, to 10 × 4 cm, base amplexicaul or auriculate, margin entire, repand, or rarely dentate. Racemes sometimes fleshy and condensed into a head. Fruiting pedicels usually straight, ascending or divaricate, 0.8-1.4 x 2.5-4 cm. Sepals oblong, 10-15 × 2-3 mm, erect. Petals creamy yellow or rarely white, 2-2.5 × 1-1.2 cm, ovate or elliptic, apex rounded; claw 0.7-1.5 cm. Filaments 0.8-1.2 cm; anthers oblong, 2.5-4 mm. Fruit linear, (2.5-)4-8(-10) cm × (2.5-)3-4(-5) mm, terete, sessile or on a gynophore to 3 mm, divaricate or ascending; valvular segment 2-3-7.5-9 cm, 10-20-seeded per locule, valves with a prominent midvein; terminal segment conical, (3-)4-10 mm, seedless or 1(or 2)-seeded; style obsolete. Seeds dark brown or blackish, globose, 1.5-2.5 mm in diam., minutely reticulate.

### Global distribution

*Brassica oleracea* is widely cultivated worldwide as a vegetable crop, and its various forms are generally recognized as varieties instead of subspecies; these include var. *acephala* de Candolle (kale and collards), var. *botrytis* L. (cauliflower), var. *capitata* L. (cabbage), var. *gemmifera* Zenk. (Brussels sprouts), var. *gongylodes* L. (kohlrabi), and var. *italica* Plenck (broccoli). It also occurs sporadically as a weedy escape from cultivation and seems unlikely to persist for long periods of time. It is reported to be naturalized on coastal cliffs (maritime slopes) in the northern Central Coastal Region and the central and southern North Coastal Region in California.

### Herbarium specimens examined

Naubaria, 3/5/1969, F. Saad, 5332 (CAIM).

6- *Brassica rapa* L., Sp. Pl. 666 (1753).

**Common name:** turnip, napa cabbage, bomdong, bok choy, and rapin.

### Synonyms

*Brassica campestris* L.; *Brassica amplexicaulis* Hochst. ex A.Rich.; *Brassica arvensis* Hablitz.; *Brassica asperifolia* Lam.; *Brassica brassicata* A.Chev.; *Brassica briggsii* Varenne.; *Brassica chinensis* L.; *Brassica celerifolia* (Tsen. & S.H.Lee) Y.Z.Lan. & T.Y.Cheo.; *Brassica cibaria* Dierb.; *Brassica colza* H.Lév.; *Brassica cyrenaica* Spreng.; *Brassica dubiosa* L.H.Bailey.

### Morphological description

Erect, annual herb up to 1.5 m tall, with stout taproot, sometimes partly swollen (turnip); stem branched. Leaves arranged spirally but in a basal rosette during the vegetative stage; stipules absent; lower leaves more or less petiolate, pinnately parted with 1-5 pairs of small lateral lobes and large terminal lobe up to 7 × 15 cm, crenate, toothed, sinuate or entire, usually hairy; stem leaves pinnately parted to simple, clasping at base, glabrous, glaucous. Inflorescence a terminal umbel-like raceme up to 60 cm long, with open flowers overtopping the buds, elongating in fruit. Flowers bisexual, regular, 4-merous; pedicel up to 3 cm long, ascending; sepals 5-8 mm long, spreading, yellow-green; petals obovate, 0.5-1 cm long, clawed, bright yellow; stamens 6; ovary superior, cylindrical, 2-celled, stigma globose. Fruit a linear silique 0.2-0.4 × 7-10 cm, with a tapering beak 0.5-3 cm long, dehiscent, up to 30-seeded. Seeds globose, 1-1.5 mm in diameter, finely reticulate, dark brown.

### Global distribution

The native range is difficult to ascertain due to its widespread cultivation and naturalization since ancient times. The species is present on all continents, being most common in temperate areas and at higher elevations in subtropical areas.

### Herbarium specimens examined

Abo Kebir, 4/2/1913, Bolland 612 (CAIM); Domutta, 16/3/1922, Simpson, 563 (CAIM); Talbia, 3/2/1926, Simpson, 688 (CAIM); Giza, 26/2/1927, Simpson, 711 (CAIM); Dokki, 1/3/1927, Drar, 5411 (CAIM).

7- *Brassica tournefortii* Gouan, Ill. Observ. Bot. 44 (1773).

**Common name:** Asian mustard, pale cabbage, African mustard, and Sahara mustard

### Synonyms

*Brassica amblyorhyncha* Coustur. & Gand.; *Brassica barrelieri* subsp. *tournefortii* (Gouan.) Malag.; *Brassica mesopotamica* (Spreng.) Bernh.; *Brassica sisymbrioides* (Fisch. ex DC.) Grossh.; *Brassica stocksii* Hook.f. & Thomson; *Brassica tournefortii* var. *dasycarpa* O.E.Schulz; *Brassica tournefortii* f. *dentata* O.E.Schulz.; *Brassica tournefortii* var. *leiocarpa* Maire. & Weiller.; *Brassica tournefortii* var. *recurvata* Bornm.; *Brassica tournefortii* var. *sisymbrioides* Fisch. ex DC.

### Morphological description

Erect annual herb, up to 100 cm tall, and a well-developed taproot system. It has a good number of primary stems and a large number of secondary. The size of the herb can vary considerably depending on soil moisture. The lower stems are densely covered with stiff bristles. The leaves are green and usually moderately well-developed basal rosette. The lower leaves are large and reduce in size upwards along the stem. During inflorescence only minute bracts are present at the top of the herbs stem. The leaves vary from 7-30 cm in length and are pinnately lobed, 8-14 lobes per leaf, toothed margins. During inflorescence a typical stem will consist of racemes of 6 to 20 flowers. The racemes become greatly elongated when in fruit. The flowers are a dull yellow in color and are inconspicuous. Individual flowers are approximately 1.5 cm in width with the petals measuring between 5-7 mm in length. The sepals measure 3 mm in length. The pedicels, when the herb is in flower measure between 4-10 mm, when in fruit the pedicel are elongated to between 10-20 mm in length. The pedicels diverge from the stem at about a 45 degree angle Fruit dehiscent silique, about 3.5-6.5 cm long with a diameter of 2-3 mm. The fruit consists of 2 locules. Each locule contains a single row of 7-15 seeds. The fruit ends with an

obvious terete beak capsule, 1-2 cm long. The seeds are red and have a globose form with a diameter of 1mm.

#### **Global distribution**

It is native to Africa, Asia and Europe. The species has become widely spread and naturalized in North America, Australia and New Zealand

#### **Herbarium specimens examined**

El-Qalag, 3/1/1922, Simpson, 335 (CAIM); Beni Sewif, 2/2/1928, Shabetai, 455 (CAIM); Giza, 24/2/1930, Shabetai, 479 (CAIM); Kharga Oasis, 15/3/1934, Shabetai, (CAIM); Burg El-Arab, 2/3/1940, 722 (CAIM); Burg El-Arab, 11/2/1969, Abbas, (CAIM); Alexandria, 20/1/1976, Abdel Fattah, (CAIM); Marsa Matruh, 5/3/1977, El-Khanagry and Mokhtar, 3551 (CAIM); Sohag, 2/3/1993, A. El-Mogali, (CAIM); El-Qantara Sharq, 18/3/2012, A. El-Mogali and A. Mostafa, (CAIM).

**8- *Brassica deserti*** Danin & Hedge. , Notes Roy. Bot. Gard. Edinburgh 32(2): 259 (1973).

**Common name:** Not available

#### **Synonym**

*Erucastrum deserti* (Danin & Hedge) V.I.Dorof., Bot. Zhurn. (Moscow & Leningrad) 85(7): 184 (2000).

#### **Morphological description**

Perennial herb, up to 15- 60 cm tall, with a well-developed number of primary and secondary stems. The lower stems are villous. The leaves are green and villous moderately well-developed basal rosette. The lower leaves are large and reduce in size upwards along the stem. During inflorescence only minute bracts are present at the top of the herbs stem. The leaves vary from 10-25 cm in length and are pinnately lobed, 8-14 lobes per leaf, toothed margins. During inflorescence a typical stem will consist of racemes of 6 to 20 flowers. The racemes become greatly elongated when in fruit. The flowers are a lemon-yellow in color and are inconspicuous. Individual flowers are approximately 1.5 cm in width with the petals measuring between 5-7 mm in length. Sepals 3 mm long. Pedicels 4-10 mm long and when in fruit the pedicel are 10-20 mm in length. Fruit dehiscent silique, about 2-5 cm long. The fruit consists of 2 locules. Each locule contains a single row of 7-15 seeds. The fruit ends with an obvious terete beak capsule 3-5 mm long. The seeds are red and have a globose form with a diameter of 1mm.

#### **Global distribution**

Endemic to Sinai, Egypt.

#### **Herbarium specimens examined**

No herbarium specimens are available. The species was mentioned as endemic species in Annotated list of the Flora of Sinai by El-Hadidi 1989. Also in materials for excursion Flora of Egypt by El-Hadidi and Fayed 1995. As well as World Checklist of Seed Plants (Govaerts1996), Flora of Egypt (Boulos 1999), Ziffer-Berger *et al.*, 2019 and Ukrainian Biodiversity Information Network.



*Brassica cretica*

*Brassica juncea*



*Brassica napus*

*Brassica nigra*

**Plate 1:** Habit of the fresh and Herbarium specimens of the studied *Brassica* species.



**Plate 2:** Habit of the fresh and Herbarium specimens of the studied *Brassica* species.

### Numerical taxonomy

Numerical taxonomic studies are significant for documenting and discovering new morphological characters and character states, and many studies have been made in this regard for understanding taxonomic relationships in different groups of plants (Soladoye *et al.*, 2010 and Rahman and Rahman, 2012). Genus *Brassica* L. was subjected to several studies, but the taxonomic delimitation of the genus is still not satisfactorily resolved and there is still disagreement among taxonomists. In addition to, most of these morphological features are modifiable and overlap considerably (Metcalf and Chalk 1979). In the present study, 8 species were evaluated on the basis of data matrix generated from 29 characters by using numerical analysis. The complete data matrix for studied taxa including the characters and character states as well as its value for each taxa are listed in (Table 2). The Proximity matrix shows the similarity values among the studied *Brassica* species showed in (Table 3). Numerical taxonomy of the studied taxa was determined according to the phenogram resulting from the UPGMA clustering (Fig. 1).

**Table 2:** Data matrix of the macro- morphological characters and character states of the studied *Brassica* species in Egypt.

Characters	Species							
	<i>Brassica deserti</i> (SP1)	<i>Brassica cretica</i> (SP2)	<i>Brassica juncea</i> (SP3)	<i>Brassica napus</i> (SP4)	<i>Brassica nigra</i> (SP5)	<i>Brassica oleracea</i> (SP6)	<i>Brassica rapa</i> (SP7)	<i>Brassica tournefortii</i> (SP8)
1- Habit: annual [1], perennial [2].	2	2	1	2	1	2	1	1
2- Height: short (< 2 m) [1]/ long (up to 2 m) [2].	1	2	1	1	1	2	1	1
3- Color: glucose [1]/ green [2].	1	1	2	2	1	1	1	2
4- Stem: simple [1]/ branched [2].	2	1	1	2	1	2	2	2
5- Stem texture: glabrous [1]/ hairy [2].	2	1	2	2	1	1	1	2
6- Stem base: elongated [1]/ fleshy [2].	2	1	2	1	2	1	1	2
7- Stem base: cylindrical [1]/ not so [2].	2	1	2	2	2	2	2	2
8- Lower leaf: widely spaced [1]/ rosette [2].	2	1	1	2	1	2	1	2
9- Lower leaf: petiolate [1]/ sessile [2].	2	1	1	1	1	1	1	2
10- Lower leaf: obovate-oblong [1]/ lanceolate [2].	2	2	1	1	2	2	1	1
11- Lower leaf: pinnatisect [1]/ pinnatifid [2].	1	2	1	1	2	2	1	2
12- Terminal lobe: ovate [1]/ oblong [2].	2	2	1	1	2	1	2	2
13- Lower leaf (terminal lobe): ovate [1]/ lanceolate [2].	2	1	1	1	2	2	2	2
14- Lower leaf (lateral lobes): 1-3 [1]/ 10- 13[2].	2	2	1	2	1	1	2	2
15- Lower leaf (lateral lobes): crisped [1]/ not so [2].	2	1	2	2	1	2	2	2
16- Upper leaf: petiolate [1]/ sessile [2].	2	1	1	1	1	2	1	2
17- Upper leaf: oblanceolate [1]/ ovate [2].	2	1	1	1	1	2	2	2
18- Upper leaf (margin): entire [1]/ toothed [2].	2	1	1	1	1	2	1	2
19- Inflorescence: compact [1]/ umbel-like [2].	1	1	1	1	2	1	2	1
20- Inflorescence: fleshy [1]/ not so [2].	2	2	2	1	2	2	1	2
21- Inflorescence: paniculated [1]/ not paniculated [2].	2	1	1	1	2	1	2	2
22- Sepal: narrowly elliptic [1]/ obovate [2].	1	1	1	1	1	2	2	1
23- Petal: obovate [1]/ oblanceolate [2].	2	2	1	1	1	2	2	2
24- Fruit: terete [1]/ 4-sided [2].	1	1	1	1	2	2	1	1
25- Seed: 20-30/locule [1]/ < 20/locule [2].	2	1	1	1	1	1	2	2
26- Terminal segment: seedless [1]/ 1-2 seeded [2].	1	2	1	1	1	1	2	2
27- Terminal segment: attenuate [1]/ not so [2].	1	1	1	1	1	2	2	1
28- Terminal segment: conical thin [1]/ terete [2].	1	1	1	1	2	1	1	2
29- Seed color: dark brown [1]/ red [2].	2	1	1	1	1	2	1	2

**Table 3:** Proximity matrix shows the similarity values among the studied *Brassica* species in Egypt.

Case	Matrix File Input							
	SP1	SP2	SP3	SP4	SP5	SP6	SP7	SP8
SP1	1.000	.033	.159	.247	.090	.090	.051	.493
SP2	.033	1.000	.159	.081	.090	.064	.051	.144
SP3	.159	.159	1.000	.447	.127	.127	.153	.288
SP4	.247	.081	.447	1.000	.323	.005	.021	.168
SP5	.090	.090	.127	.323	1.000	.121	.044	.057
SP6	.090	.064	.127	.005	.121	1.000	.098	.275
SP7	.051	.051	.153	.021	.044	.098	1.000	.061
SP8	.493	.144	.288	.168	.057	.275	.061	1.000

**Key:** *Brassica deserti* (SP1), *Brassica cretica* (SP2), *Brassica juncea* (SP3), *Brassica napus* (SP4), *Brassica nigra* (SP5), *Brassica oleracea* (SP6), *Brassica rapa* (SP7) and *Brassica tournefortii* (SP8).

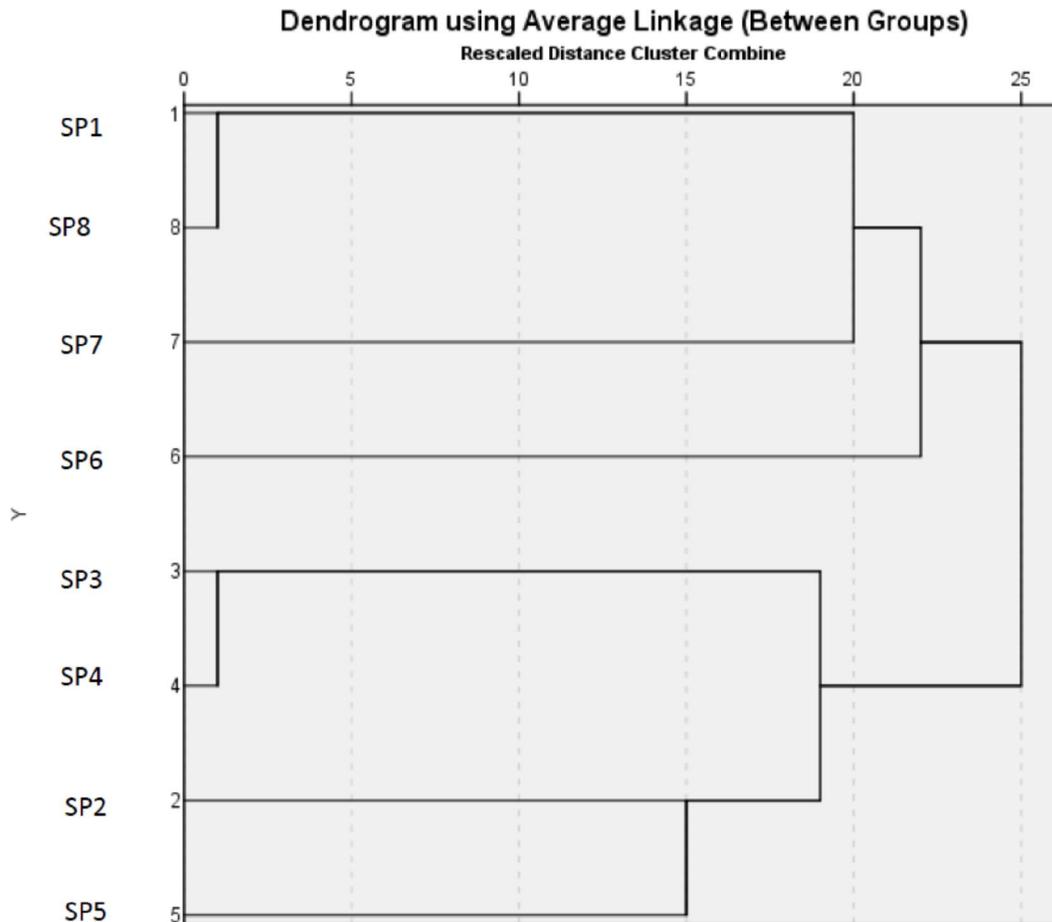


Fig. 1: Dendrogram shows the degree of similarity among the studied *Brassica* species in Egypt.

**Key :** *Brassica deserti* (SP1), *Brassica cretica* (SP2), *Brassica juncea* (SP3), *Brassica napus* (SP4), *Brassica nigra* (SP5), *Brassica oleracea* (SP6), *Brassica rapa* (SP7) and *Brassica tournefortii* (SP8)

#### Numerical analysis

The final dendrogram obtained from analysis the morphological characters of the studied *Brassica* species (Table 4 & Fig.1) showed that, the studied species split-into four groups (G1, G2, G3, G4). Group one was divided into two sub-groups. The first one included *Brassica deserti* and *Brassica tournefortii* while the second included only one species *Brassica rapa*. Second group contained *Brassica oleracea* only. Third group included *Brassica juncea* and *Brassica napus*. Forth group contained *Brassica cretica* and *Brassica nigra*. Moreover, *Brassica deserti* and *Brassica tournefortii* showed the highest degree of similarity value (0.493) followed by (0.447) between *Brassica juncea* and *Brassica napus*; while the lowest one (0.033) was noticed between *Brassica deserti* and *Brassica cretica*

#### 4. Conclusion

This study showed the importance of morphological traits for taxonomic evaluation among the studied *Brassica* species in Egypt. Qualitative and quantitative traits provide considerable information to distinguish among *Brassica* species,. The present study based on the morphological characters provided some degree of similarities among the studied species, and confirmed the position of species in each own group. A comprehensive and molecular further studies covering all *Brassica* species would be necessary.

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