



Taxonomic Notes on an Endemic Variety of *Portulaca oleracea* [Portulacaceae] Found in India is suppose to Promote as Separate Species *Portulaca linearifolia*

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ABSTRACT: Santapau & Henery reported four species of *Portulaca* found in all over India namely *P. oleracea*, *P. pilosa*, *P. quadrifida* and *P. wightiana*, among these *P. oleracea* and *P. pilosa* further divided in variety and sub species or race by Sivarajan & Manilal and Geesink respectively. In the present investigation author has experienced that *P. oleracea* var. *linearifolia* proposed by Sivarajan & Manilal has adequate amount of different characters right now from habit, morphology, shape and size of leaf, shape of operculum and seed testa characteristics hence, assumed to promote the variety as a separate species under name *Portulaca linearifolia* (Sivarajan & Manilal) Dheeren Panwar com. nov., rather than the variety of type species.

KEY WORDS: India, Portulaca, Taxonomy

INTRODUCTION

The genus *Portulaca* was described by Linnaeus in species plantarum (1753) and originally 4 species were documented [1]. Successively the number of species increased as Poellnitz (1934) reported 104 species in his monograph [2]. Currently, according to the plants of the world online database, there are about 153 portulaca species accepted from all over the world [3]. In India, Santapau and Henery (1973) reported seven species of *Portulaca* [4]. Later on, these are reduced to at least four species namely *P. oleracea*, *P. pilosa*, *P. quadrifida* and *P. wightiana*. These four species were also reported in India by J.D. Hooker (1875), Bhandari (1990), and B.V. Shetty & V. Singh (1987) in “Flora of British India”, “Flora of Indian Desert” and “Flora of Rajasthan” respectively [5,6,7]. Later on, Sharma & Sanjappa (1993) reported two more species namely *Portulaca grandiflora* and *Portulaca tuberosa* along with four species as cited above by various authors [8]. Recently Jagdish dalavi (2018) and Sivaramakrishna P & Yugandhar P (2020) discover three new species of *Portulaca* from India namely *Portulaca badamica*, *Portulaca lakshminarasimhaniana*, and *Portulaca laljiae* respectively [9,10]. R. Geesink (1969) proposed the term race for many varieties of *Portulaca* but the term race is rather confusing and sometimes assumes to be subspecies, hence V.V. Sivarajan (1980) proposed varietal rank for the so-called 'races' and consequently new combination was proposed in *Portulaca* [11,12]. The most common species of *Portulaca* i.e. *P. oleracea* was divided in *P. oleracea* var. *oleracea* for type species and *P. oleracea* var. *linearifolia* for an endemic species by Sivarajan & Manilal (1977) [13]. In the last two decades, many authors (A. Danin & J. A. Reyes-Bentancort 2006; InSun Kim 2012; Jagdish V. dalavi et al 2019) put light on the importance of seed morphology & testa characteristics in the species of *Portulaca* to delimit the taxa to understand the inter-species inter-relationship [14,15,16]. In the present investigation, the author has carefully analyzed both the varieties and has experienced that the variety *linearifolia* has an adequate amount of different characteristics than the type variety in concern to habit & habitat, leaf shape, flower opening time, size, and shape of operculum and seed testa characteristics which strongly suggest it to as a separate species of *Portulaca* rather than a variety. Hence accordingly, the new combination has been made as *Portulaca linearifolia* (Sivarajan & Manilal) Dheeren Panwar com. nov. The detailed notes are given on both varieties of *P. oleracea* as a separate species with digital images of every part of the plant to understand the difference between type species and new combination.

MATERIAL AND METHODS

Collection of plants: Both sp. of *Portulaca* were collected during the monsoon season in the year 2018-2020 in Jodhpur district from Jodhpur city, Mathania, Tinwari, and Osian. Regular field trips were conducted to observe the plants in natural conditions. Seeds were collected from many individuals from different localities for comparative study.



Taxonomy: Field characters were noted down in the field book viz. habit, habitat, nature of plants, flower color, diameter, flower opening time, size and longevity of the plant, etc. The whole plants were dug out with roots and were brought to the laboratory for further examination. Standard taxonomic terminologies (Lawrence 1951) were used to describe the plants [17]. Herbarium sheets were prepared using standard protocol.

Photographs: Digital photographs of plants & their parts were snapped by Canon EOS 1300 D digital camera. Olympus OIC dissecting microscope was used to observe floral and seed characters. Microphotographs were snapped at 5 X, 10 X, 20 X zoom. For SEM studies, one seed per species was coated with gold/palladium for 75 s on a Quorum SC7620 sputter coater and examined under TESCAN VEGA 3 scanning electron microscope (Department of Botany, Shivaji University, Kolhapur) at 192 X, 196 X, 496 X, 505 X and 2.01 KX magnification with 5.0 kV power. Observations on entire seed, testa ornamentation and cell were made at different magnifications. Adobe Photoshop 7 was used to edit the photographs.

Identification: The species were identified with the help of an authentic herbarium sheet preserved in the Regional Center of Botanical Survey of India Jodhpur (BSJO), online Kew herbarium catalog, online global biodiversity Information facility and by the help of "Flora of Indian Desert" by M.M. Bhandari (1990) and "Flora of Eastern Ghat Vol. I" by Pullaiah et al. (2002) [6,18].

RESULT

Key to the type species and new combination

1a. Leaf obovate, style > 0.5 mm, operculum obovate, testa with blunt tubercle and irregular cells..... *P. oleracea*

1b. Leaf linear, style ≤ 0.5 mm, operculum conical, testa with prominent tubercle and stellate cells *P. linearifolia*

[1] *Portulaca oleracea* L. Sp. Pl. 445. 1753; Fl. Brit. India. 1:246. 1874; Rao in Flora of India 3:4. 1993.

Type: *Portulaca oleracea* L. Mauritius: 04.09.1889, Coppinger, Kew herbarium catalog no. K000313629.

Native Range: India, Pakistan, Arabian Peninsula and Tropical Africa.

Description:

A perennial, prostrate, or decumbent, or sub erect, glabrous somewhat succulent herb. Stem cylindrical, soft, fleshy, fragile, glabrous, radial spreading, red-brown due to high amount of anthocyanin. Leaves opposite or sub opposite, very minutely petiolate, crowded near the end of branches and form a rosette or crown, obovate, apex truncate, base cuneate, glabrous on both sides, fleshy, few white hairs at axils, 1-3 x 0.5-1.3 cm, green with red-tinged. Flowers 2-10 in a cluster at terminal position form a capitulum, which is surrounded by a whorl of 4-5 leaves, sessile, bracteate, bract deltoid, caudate, 2.5 x 1 mm, and white transparent. Sepals two, 2.5-3 x 1 mm long, enlarged in fruit, united at the base in a short tube and free part are distinctly separate from the tube by annular ringed lines, lobes boat shape, concave inside, keeled outside which extended into a short mucro, fleshy and green with white membranous margins. Petal 5, discoid, jointed near at base and attached to ovary wall, obovate, truncate, cuneate at base, retuse or emarginated at apex, minute sinus or mucro at mid-top, sticky, fleshy or macerate, 4 x 2.5 mm long, bright yellow. Stamen 10-15, unequal, arranged on a gelatinous ring which surrounded the base of style, epipetalous, filament yellow, longer 3-4 mm and shorter 2.5-3 mm long, white viscid hairs at base, anther sac oblong, dorso-basifixed. Ovary half superior half inferior, light green, lower half obconical or goblet shape, 1 x 1 mm, upper half conical 0.5 mm long; style 1.5 mm, curved; stigma five, 1 mm long, ligulate, glandular-hairy, yellow. Fruit a capsule, roughly obovate, distinctly separate into two parts, lower goblet shape 1.5 mm, and upper 3 mm long operculum and consists of two lateral parts, one of them overlapped another and beaked at the top, bigger is of 4-5 mm long and shorter is of 2.5-3.5 mm long, initially green but at maturity become straw color or blackish brown. Seed numerous 50-65 in per capsule, fully mature black, while immature red-black, suborbicular, discoid, constricted near the hilum, outer peripheral surface tuberculate, tubercle very short or blunt, irregular stellate cells on the lateral surface, 0.4-0.45 x 0.5-0.7 mm.

Flowering and Fruiting: Throughout the year

Specimen collected: Jodhpur, Mathania, Osian (In Jodhpur District) from roadside and waste place.

Field note: Very common weed on the roadside and often gregarious on the lawn

Specimen examined: INDIA: Rajasthan, Jodhpur, Osian, 14.10.1976, A.N. Singh, BSJO 2224; Jodhpur, Kaylana lake rest house, 24.11.1972, Ratan Singh, BSJO 319; NEPAL, June 1841, Wallich N., Kew herbarium Catalogue no. 6841, K001124958.

[1b] *Portulaca linearifolia* (Sivarajan & Manilal) Dheeren Panwar **com. nov.**



Basionym :

Portulaca oleracea var. linearifolia Sivarajan & Manilal, New Botanist 4: 30, 1977

Type: *Portulaca oleracea* var. *linearifolia*, catalogue no. 42790, Chandra, Herbarium of Forest Research Institute Dehra Dun, India.

Native: Endemic to India

Description:

A prostrate or sub-erect or decumbent perennial herb, branches radiating up to 6-8 inch length. Stem cylindrical, light green or very little amount of anthocyanin, glabrous, fragile. Lower few leaves alternate, then become sub opposite, at terminal position form a rosette or crown, petiolate, petiole short 2 mm, blade linear, obtuse, fleshy, 1.5-2.5 x 0.3-0.5 mm, few intraaxillary stipular hairs, margin entire with micro tubercle. Inflorescence initially solitary terminal later on clustered in 2-5 flowers capitulum. Flowers 8-10 mm in diameter, bracteate, bract membranous, deltoid, caudate, slightly keeled, transparent white, 1.5 x 1 mm long. Sepals two, jointed at base and form a short tube which is distinctly margined by a ringed annular lines, unequal, one overlaps to another and slightly beaked, fleshy green, dorsally keeled, boat shape, concave inside, if opened and spread 3 x 3 mm more or less orbicular. Petals 5, joined together at the base and attached to the ovary wall, discoid, obovate, truncate and retuse at apex, cuneate at base, very minute or no mucro at the tip, membranous, marcescent, sticky, 4 x 3 mm, glabrous both side, bright yellow. Stamen 10-12, epipetalous, unequal, 3 mm long, attached to a gelatinous ring with viscid hairs at base, yellow, anther sac dorso-basifixed. Ovary half superior, half inferior, lower base obconical or goblet shape, 1.5 mm long, upper half conical, 1 mm long, style short 1 mm, stigma 5 (-6), ligulate, viscid hairy, 1.5 mm long. Fruit a capsule, ovate in shape, distinctly separate into two parts, lower goblet shape 2 mm long, upper conical shape 4 mm long operculum which is consist of two-part, green at young stage later on straw-color or blackish brown at maturity. Seed sub orbicular, discoid, compressed or constricted near the hilum, peripheral surface tuberculate, tubercle long pointed, testa cells stellate at the lateral surface with central tuberculate projection, black, and 0.6 x 0.65 mm long.

Flowering and Fruiting: Throughout the year

Specimen collected: Mathania, Tinwari, Osian, Samrau (In Jodhpur District) from waste place

Field note: Not very common, few plants were seen in waste place after the first rain but can easily identify by leaf shape in the very juvenile stage. Often found near water drains off or marshy area.

Specimen examined: INDIA: Rajasthan, Jodhpur, Mokeri, 12.10.1976, A.N. Sing, BSJO 3213; Jaisalmer, along Phalsund, Pokran road, 24.08.1976, B.V. Shetty, BSJO 3312; Pali, Khokhra Dam Side, B.V. Shetty, BSJO 1848.

Discussion: Many differential characteristics were observed in both the varieties and accordingly based on these differences a new combination has been made. Following are the main differences that have been observed and discussed.

Habit & Habitat: *P. oleracea* was perennial and found more frequently along with the roadside and often on road dividers while *P. linearifolia* was annual or perennial and least frequent and were found as a weed in agricultural fields or waste place. Also *P. oleracea* was many dens rather than *P. linearifolia* (Fig. 1 A & B).

Stem: Not much difference was found in both species except the presence of high anthocyanin in *P. oleracea* in comparison to very low or no amount of anthocyanin in *P. linearifolia* (Fig. 2 B & N).

Leaf: R. Geesink (1969) placed *Portulaca oleracea* in subg. *Portulaca*, section *Portulaca* having middle cauline leaves are spiral and upper and basal one's sub opposite, in subsection *Portulaca* having obovate to spatulate leaves with distinctly carinate sepal [11]. In the present investigation, I have carefully observed phyllotaxy and the shape of the leaf in three successive generations in both species and found that *P. oleracea* undoubtedly has obovate leaves (Fig. 2 C & D), while the species *linearifolia* have linear leaves (Fig. 2 O & P). Phyllotaxy was almost same in both species i.e. sub opposite (Fig. 2 A, M). There is no deviation was found in the shape of leaves in both species even after many generations, which seems that both species certainly have distinct gene loci for the shape of leaves.

Inflorescence: According to Geesink (1969) the inflorescence in *Portulaca* is a terminal capitulum, surrounded by 3-18 involucreal leaves [11]. In the present investigation the inflorescence was found same in both species the only difference was found in both that in the *P. oleracea* number of flowers per capitulum may be up to 5-10 while in *P. linearifolia* initially was solitary terminal then number of flowers may rise up to 2-5 (Fig. 2 K & W). There was no difference found in bract of both species (Fig. 2 H, T).

Calyx: Minor difference was found in both species. In both the sepals were of boat shape and had a dorsal keel. When fully opened the sepals almost become orbicular in shape but slightly larger in species *linearifolia* (Fig. 2 I, F, R & U).

Corolla: Not many differences were found in both species. The only difference was observed that a minute mucro was found at the mid-top of the petal in *P. oleracea* while in *P. linearifolia* no or very obscurely mucro was found at mid-top. Also in species *linearifolia* the petals are found slightly larger than *oleracea*. (Fig. 2 G & S).

Androecium: No major difference was found in both species. Both have almost same type of stamen in number color and shape (Fig. 2 J & V).

Gynoecium: A clear difference was observed in both species. In *P. oleracea* upper part of the ovary was found shorter and less conical in comparison to *P. linearifolia* while the size of the style was larger than it (Fig. 2 L & X).

Fruit: According to Legrand 1962 the ratio between the height of the operculum and the total height of the fruit can be used to separate or distinction of a species [19]. However, the variation



Fig. 1. Plant habit: (A) *Portulaca oleracea* L. (B) *Portulaca linearifolia* (Sivarajan & Manilal) Dheeren Panwar

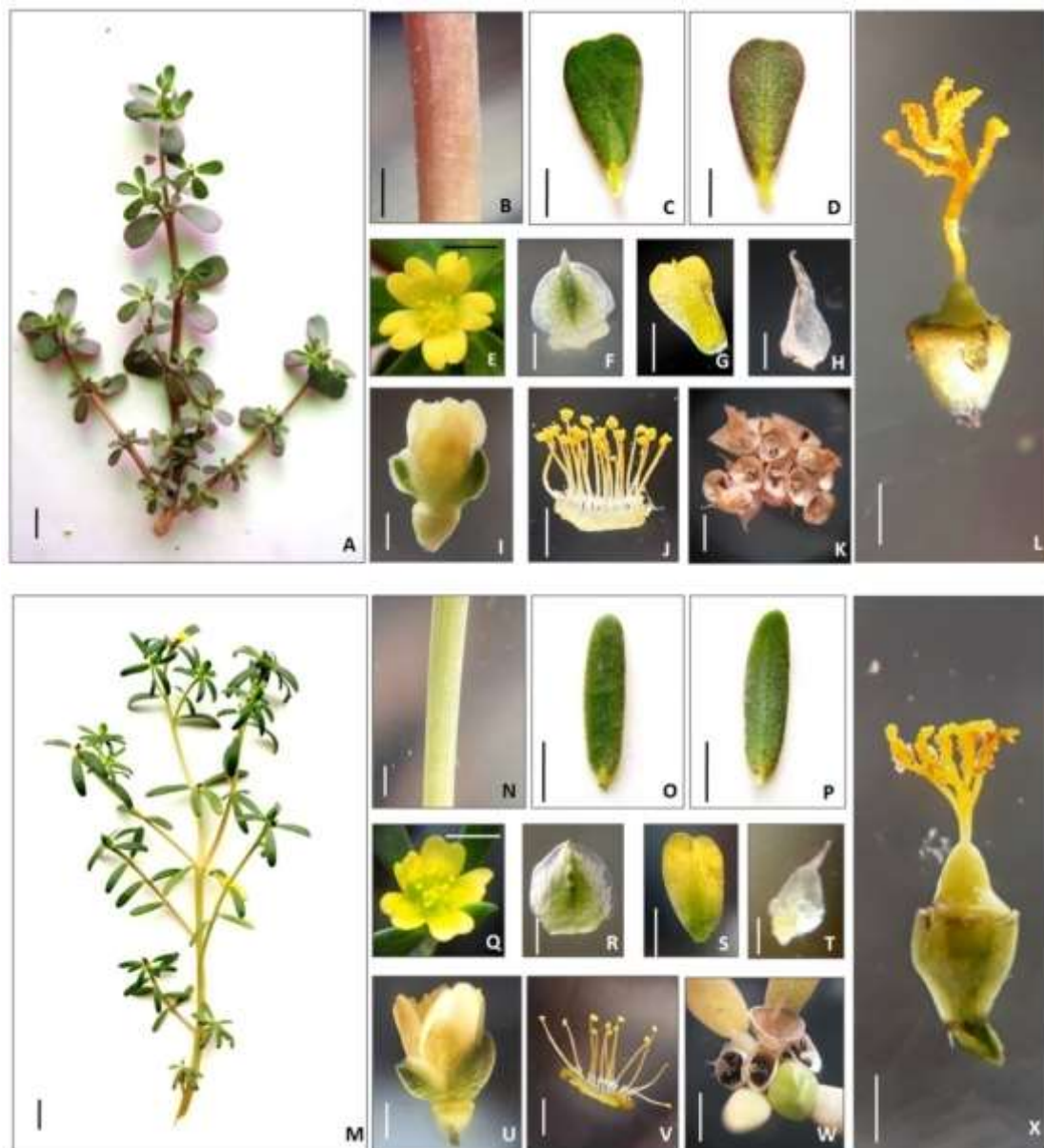


Fig.2. Morphology of plant parts : A to L *Portulaca oleracea* L.; & M to X *Portulaca linearifolia* (Sivarajan & Manilal) Dheeren Panwar: (A, M) Plant twig showing phyllotaxy; (B, N) Stem surface [note presence and absence of anthocyanin in both sp.]; (C, O) leaf dorsal side; (D, P) leaf ventral side; (E, Q) Open flower; (F, R) Dissected Sepal showing dorsal keel [note difference in dorsal keel in both sp.]; (G, S) Petal; (H, T) bract; (I, U) Unopened flower showing sepal position; (J, V) Androecium; (K, W) Inflorescence after fruit shedding [note number of flowers]; (L, X) Gynoecium [note difference in length of style and ovary]. [Bar = 1 cm in A, C, D, M, O, P; 4 mm in B; 3 mm in N; 5 mm in E, Q; 2 mm in F, G, J, R, S, V; 0.5 mm in H, L, T, X; 1.5 mm in I, U; 3.5 mm in K, 2.5 mm in W].

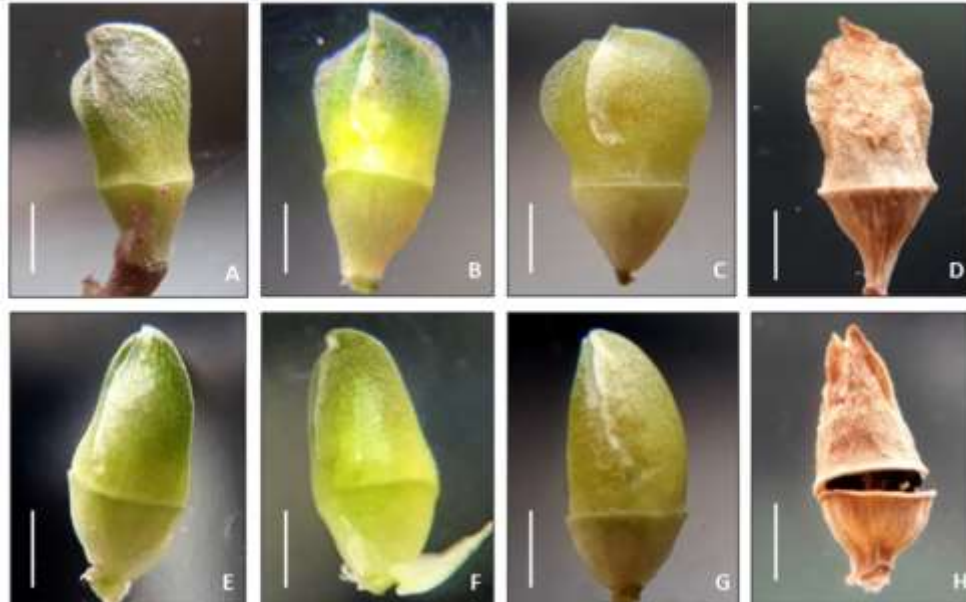


Fig.3. Fruit morphology: *Portulaca oleracea* L. [note minor difference in fruits (A-C) collected from different localities] (D) mature fruit; *Portulaca linearifolia* (Sivarajan & Manilal) Dheeren Panwar [note no difference in fruits (E-G) collected from different localities], (H) mature fruit. [Bar= 1.5 mm]



Fig.4. Seed morphology in light microscope (A-C) *Portulaca oleracea* L. & (D-F) *Portulaca linearifolia* (Sivarajan & Manilal) Dheeren Panwar : (A & D) lower half of fruit showing seeds arrangement on the placenta, (B & E) Seeds at 10 X , (C & F) Seed at 20 X (enlarged) showing surface [Bar= 0.5 mm in A & D, 0.3 mm in B & E, 0.1 mm in C & F]

In this ratio is too large to be very useful in many species. Geesink 1969 also assumed that shape of the operculum may be useful for the distinction between species [11]. In the present investigation, the shape of the operculum was found very useful in the distinction of two species rather than a ratio. In *P. oleracea* operculum was much broader and slightly flat at the apex and flanked

with membranous margin and a clear overlapped beak was found while in sp. *linearifloia* the operculum was narrow toward the apex and conical in shape. Minor variations were found in fruits shape in *P. oleracea* when plants were collected from the different localities but no difference was found in fruits of sp. *linearifloia* which were also collected from the different localities (Fig. 3 A-H). The same observations were found in fruit morphology even after many generations which were collected from plants grown in the laboratory.

Seed: Many authors assume the seed micromorphology or seed ornamentation can be used to circumscribe taxa at a species and intra species level within Portulacaceae (Geesink 1969^[11], Danin et al. 1978^[20], Legrand 1953^[21], 1958^[22], Mueller 1859^[23], Engelmann 1850^[24], Macbride 1937^[25], InSun Kim 2012^[15]). In the present investigation, I have found clear differences in seed ornamentation of both species. In light microscopy the size was a characteristic feature in both species; seeds of *P. linearifolia* were larger than *P. oleracea* and clear long tubercles at peripheral surface were observed in *P. linearifolia* while blunt in *P. oleracea* (Fig. 4 A to F). The SEM study shows more clear differences in both species. In *P. oleracea* very minute blunt tubercles at the peripheral surface and irregular undulate cells on the lateral surface with wax patches were observed (Fig. 5 A to C) while in *P. linearifolia* the peripheral tubercles were found more prominent than *P. oleracea* and the lateral surface have a clear stellate cell with central elongated tubercle with no wax layer was observed (Fig. 5 D to F).

Conclusion: It seems that the morphological differences viz. leaf shape, gynoeceum, operculum shape, and size of seed and testa characteristics are enough to distinguish both varieties to assume as separate species. The fruits are entirely different in both varieties and the seeds have unique ornamental sculptures which indicate that both varieties may have separate gene segments or loci for seed morphology (need of further analysis on a DNA basis). Hence, on the basis of these distinguishing characters I believe that the *Portulaca oleracea* var. *linearifloia* should be treated as a separate species of *Portulaca* as *Portulaca linearifolia* (Sivarajan & Manilal) Dheeren Panwar **com. nov.**

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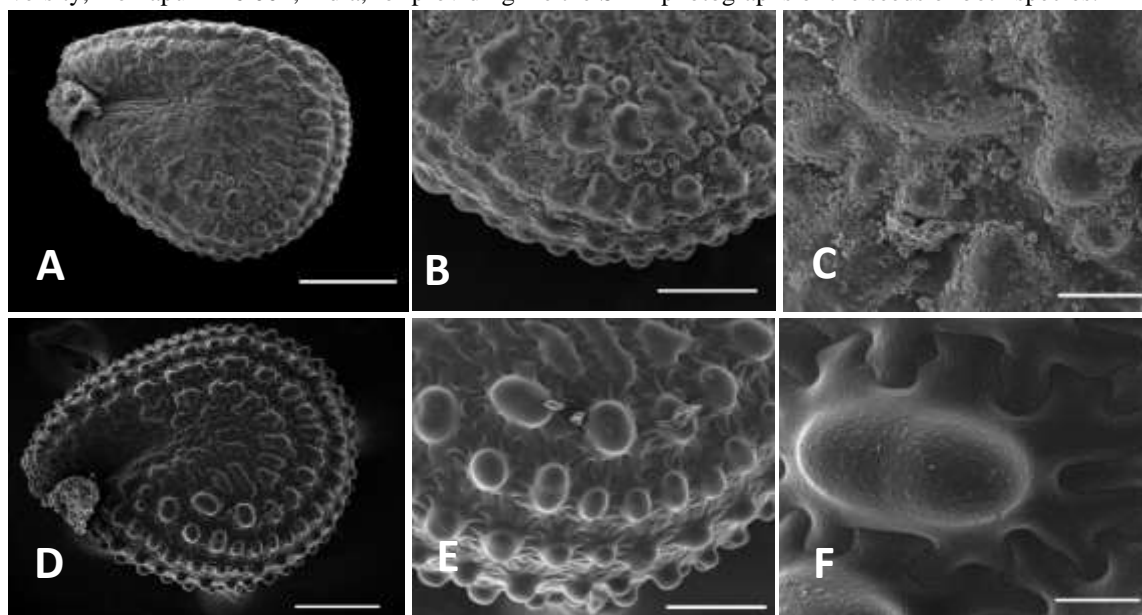


Fig.5. SEM images showing entire seed details with testal cells: (A-C) *Portulaca oleracea* L.; (D-F) *Portulaca linearifolia* (Sivarajan & Manilal) Dheeren Panwar [Bar= 200 µm in A & D, 100 µm in B & E, 20 µm in C & F]



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