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Morphological and Anatomical Studies on Some Monocot Xerophytes of District Karak, Pakistan

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Abstract: The present article is comprised of morphology and anatomy of the some selected xerophytes (monocot) of district Karak. 5 monocot plant species belonging to 3 families,were collected during the survey. Morphologically, the characters of leaves, stems, roots, fruits and seeds were observed. The family Poaceae was dominant followed by the Polygonaceae and Xanthorrhoeaceae. Similarly, the plant *Eragrostis curvula* (Poaceae)was dominant followed by *Calligonum polygonoides* (Polygonaceae) and *Asphodelus tenuifolius (*Xanthorrhoeaceae*)*. The plants were found to be well adapted to the environment of district Karak. The morphological adaptations were presence of dense hair, powder and cuticle layer on leaves and stem. The leaves were found to be leathery, needle like and elongated. Sometimes, the leaves were found to be modified into thorns and spines. Similarly, thick and short rhizome, sunken stomata, compact epidermis, wide cortex and many water storing tissues were observed during this study. During the study, it was also reported that xerophytes have numerous cortical cells to store large amount of water, as to compensate the harsh and dry environment. It was concluded that the studied plant species of district Karak were well adapted in the extreme environment.

Key words: Xerophytes · Morphology · Anatomy · 5 monocot species · Karak · Pakistan

INTRODUCTION

0Morphological and Anatomical studies are concerned with the external and internal structure of plants. It is a source of fascination for correct identification of plant taxa. Xerophytes are the plants which are able to survive in an environment with a limited supply of water as compared to hydrophytes and mesophytes. Phillips and Comus and Philips (2009) [1] stated that xerophytes might be adapted shapes and forms (morphology) or internal functions (physiology) that reduce their water loss or store water during long periods of dryness. Plants with such adaptations are called xeromorph *(*Parolin (2009) [2]. Islam *et al.* (2008) [3] reported differences in anther types of Dicots within Flora of Karachi. McCleary (1968) [4] discussed that, xerophytes have many lateral roots accompanied by very long tape roots which can develop tens of meters along roots. Such tape roots reach the deep layers of soil where water is permanently present. Szarek *et al*. (1973) [5] explained that drought stems are often the primary photosynthetic organs in desert species. Stem of some xerophytes is modified to leaf like, flattened and fleshy structures, which are called phylloclades. Comus and Phillips (2009) [1] discussed that in some xerophytes, a number of axillary branches become modified into small needle like green structures which look like leaves and are called cladodes. Xerophytes show high stomata resistance, to reduce water loss. Hameed *et al*. (2008) [6] found variation in types of stomata, stomatal frequency, stomatal density and stomatal index among different species of family. The flowers of xerophytes usually develop in favourable conditions and they complete their reproduction in very short period of time. Fruits and seeds

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are protected by very hard coverings and they can remain dormant for a long period of time. Islam *et al.* (2008) [7] studied different types of anther in dicots, which included *Alhagi maurorum*. Anatomically, xerophytic epidermal cells are small compact with thick cuticle of single layer. Wax, tannin, resin, cellulose etc. are deposited on the surface of epidermis. It is a protective measure against high intensity of light. Wahid (2003) [8] discussed some physiological adaptation that in case of reduced leaves, the photosynthetic activity is taken up by outer chlorenchymatous cortex.The mesophyll cells is very compact and intracellular spaces are reduced.. Nazir *et al.* (2013) [9] studied the epidermal layers as an aid to the identification of grasses of tribe Andropogoneae (Poaceae) from Potohar region of Pakistan. It proves that anatomical study is valuable for identification of the plants and their ontogeny. Gostin (2011) [10] reported that, the vegetative organs of Ranunculaceae show some xerophytic charactures in their morphological and anatomical structures. Smilarly Dawar *et al.* (2010) [11] reported the morphology of *Daturaalba* and stated that it is an annual and bushy herb. This study might be helpful for the future research. Effect of different stresses should be studied upon the internal structure of these plants as Hameed *et al*. (2012) [12] discussed five sedge species (*Bulboschoenus affinis, Cyperus alternifolia*, *C. conglumeratus*, *Fimbristylis dichotoma* and *Schoenoplectus litoralis*), to investigate the leaf anatomical modifications to withstand environmental stresses. Morphological and anatomical data are easily applied to improving classification and can often be used in making identification. Karak is dry and rainfed area but having very diverse flora. Many authors have studied the plants in different ways but no one reported attention towards the morphological and anatomical studies which were the basic Botany. It was important to determine that how these plants tolerate the dry environment and adapt themselves accordingly. Therefore it was the first attempt to explore such type of plants adaptation in Karak.

MATERIALS AND METHODS

Karak is the district of the Khyber Pakhtunkhwa, Pakistan, at an altitude of 70.40°-70.30°N and the longitude of 32.48°-33.23°E. It is situated at 340m above the sea level. The district Karrak is 123 km from the provincial capital, Peshawar (Khan *et al.* 2012).

During the survey in May-June 2011, the important xerophytes (monocot) were collected and identified.

Sampling and Collection of Plant Specimens: During the collection, xerophytes from the area were folded in news papers and then put into plastic bags. Two samples of each plant of 05 xerophytes were collected.

Drying and Preservation of Plant Specimens: The xerophytic plants were properly sprayed with mercuric chloride, $CuSo_4$ and spirit to protect them from the decomposition. After complete dryness and poisoning, all the plants were mounted on standard herbarium sheets with proper taxonomical identification as Gostin (2011) [10].

Taxonomical Studies: The proper identification and taxonomy of each and every xerophyte was carried out with the help of available literature (Jafri, 1966; Qureshi and Khan, 1972) [13-14]. The identification was confirmed and authenticated by Mr. Abd- ur-Rehman, Professor of Botany, Govt Post Graduate College Bannu and Dr. Jan Alam, Assistant Professor, Department of Botany, Hazara University, Mansehra.

Morphological Studies: The general morphological descriptions of the characters like habit, root, stem, leaves and flowers were done according to method of Gostin (2011) [10]. Fresh material of the collected xerophytes was recorded along with their photographs.

Anatomical Studies: Study of the anatomy and histology of the collected species through preparing the safranine stained slides of transverse sections of leaves, stem and roots of the collected plants were managed. T.S of leaves, stem and roots were examined under power microscope. Microphotographs of the prepared sections were made by using digital camera.

RESULTS

The plants of district Karak were collected, identified and studied for their morphological and anatomical features. The detailed description is given below:

Botanical Name: *Asphodelus tenuifolius*

Voucher Number: 3613

Local Name: Piozakaye.

Distribution: Common throughout the area.

Morphology
Habit: Herb (Fig.1).

Leaf: Simple, radical, sheathing at the base, long and mucilaginous.

Stem: Reduced, condensed and underground.

Roots: Adventitious and fibrous.

Inflorescence: Recemose.

Flower: White, regular, hermaphrodite and actinomorphic. Fruit, rounded capsule. Seeds rounded and small.

Anatomical Description: The transverse sections of leaf, stem and root showed the following anatomical features.

Leaf: Cuticle layer around the epidermis. Next to the epidermis, a large parenchymatous cell. Large number of scattered vascular bundles present in the central zone showing the monocotyledonous character of the plant (Fig. 1).

Stem: Epidermis composed of compactly arranged cells. Next to the epidermis, a large parenchymatous cortex. Large number of scattered vascular bundles, present in the central zone (Fig. 2).

Roots: Thick epidermis present. Vascular bundles radially arranged. Wide parenchymatous cortex which retains moisture (Fig.3).

Botanical Name: *Calligonum polygonoides*

Voucher Number: 3614

Local Name: Balanza

Distribution: Ahmad Abad, Chukara, Musakan, Hamidan Banda, Bahadur Khel, Mita Khel, Sabir Abad, Banda Daud Shah, Soor Dag and Latamber.

Morphology
Habit: A small shrub, found in sandy areas (Fig. 2). It is an endangered plant species and has been included in Red Data Book of IUCN.

Leaves: Simple, needle like and stipulate.

Stem: Stem and branches, conspicuously jointed having nodes and internodes.

Roots: Tape roots, deep and branched.

Inflorescence: Spike.

Flower: Small, regular, white and bisexual. Fruit, oblong nut.Seeds rounded and small.

Anatomical Description: Transverse sections of leaf stem and root of *Calligonum polygonoides* showed the following features.

Leaf: Outermost layer of cells is epidermis, below which paranchymatous mesophyll tissues are found. Vascular bundles clear, showing star like apearance. In the center, water storing tissues (Fig 4).

Stem: A cuticle layer around the epidermis. Beneath the epidermis, parenchymatous ground tissue. Pericycle separating the cortex from the vascular region and pith (Fig. 5).

Roots: Thick epidermis enclosing the cortex. Cortex comprised of dense parenchymatous cells. The cortical parenchyma store large quantity of water. Protoxylems and metaxylems, clear (Fig.6).

Botanical Name: *Eragrostis curvula*

Vaucher Number: 3620
Local Name: Sargara.

Distribution: Ahmad Abad, AmberiKela, TakhteNusrati, Bogara, Hamidan Banda, Sabir Abad, Mita Khel, Soor Dag, Latamber.

Morphology
Habit: Herb (Fig. 3).

List of Morphological Figures:

Fig. 1: Fig. 2: Fig. 3:

Fig. 1: *Asphodelustenuifolius* Fig. 2: *Calligonum polygonoides* Fig. 3: *Eragrostiscurvula*

Fig. 4: Fig. 5:

Fig. 4: *Kochiaindica* Fig. 5: *Heteropogancontortus*

List of Anatomical Figures:

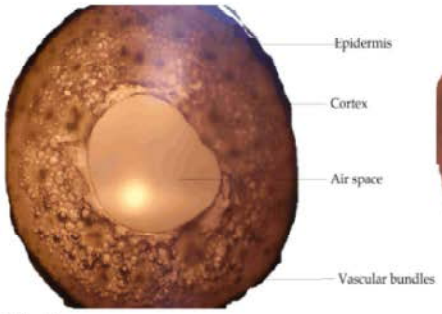


Fig 1

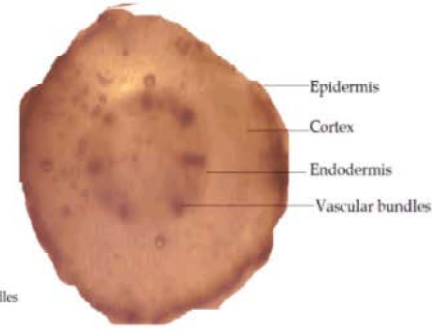


Fig 2

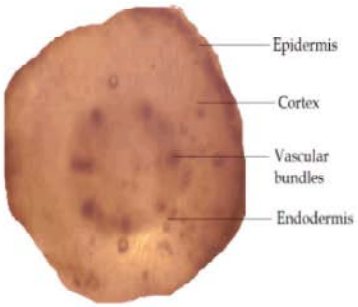
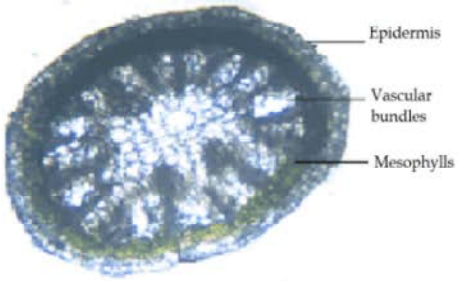
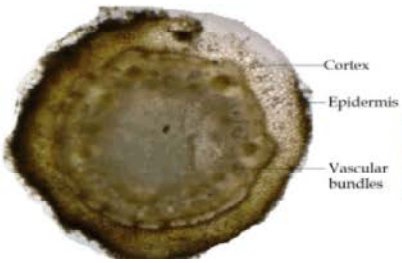


Fig 3

Fig.1: T.S of leaf of *Asphodelus tenuifolius* Fig.2: T.S of leaf of *A. tenuifolius* Fig.3: T.S of leaf of *A.tenuifolius*





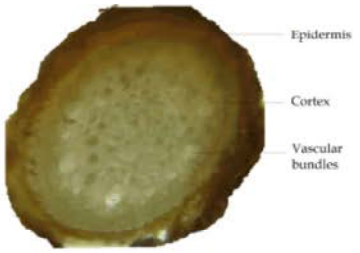


Fig. 4 Fig. 5 Fig. 6

Fig. 4: T.S of leaf of *C.polygonoides* Fig. 5: T.S of stem of *C.polygonoides* Fig. 6: T.S of root of *C.polygonoides*

Leaf: Leaves long, sessile and simple. Leaf bases, sheathed. Lamina, narrow.

Stem: Underground corm.

Roots: Fibr9us and adventitious.

Inflorescence: Compound of several spikelets.

Flower: Flowers incomplete, bisexual and zygomorphic. Colour, creamy.Fruit, drup.Seeds, small and rounded.

Anatomical Description: Transverse sections of leaf, stem and roots showed the following features.

Leaf: Transevers section of leaf showed the various internal tissues. The first row of cells is epidermis, epiderms water retention and conservation tissues in the center. Photosynthetic mesophyll tissues, below the epidermis (Fig. 7).

Stem: A cuticle layer around the epidermis. Beneath the epidermis, parenchymatous ground tissue. Endodermis separating the ground tissue from the vascular region.Vascular bundles, numerous (Fig. 8).

Roots: Epidermis around the cortex.Cortical zone wide. Vascular tissues, radial.Pith, composed of ground tissue (Fig. 9).

Botanical Name: *Kochia indica*

Vaucher Number: 3623

Local Name: Qurashka.

Distribution: Ahmad Abad, Chukara, Musakan, Hamidan Banda, Bahadur Khel, Mita Khel, Sabir Abad, Banda Daud Shah, Soor Dag and Latamber.

Morphology
Habit: An annual bushy herb (Fig. 4).

Leaves: Alternate, simple, extipulate, longer, leaf bases sheathed and sessile.

Stem: Herbaceous, green and much branched

Roots: Tape roots, deep in the soil.

Inflorescence: Spike.

Flower: Regular, bisexual, zygomorphic and brown in colour. Fruit shizocarp. Seeds, small and flat.

Anatomical Description: Transverse sections of leaf, stem and roots show the following anatomical features.

Leaf: Outer layer epidermis, below paranchymatous mesophyll tissues. Vascular bundles in rings.Arround the vascular tissues, bundle sheathed cells (Fig. 10).

Stem: A cuticle layer around the epidermis. Beneath the epidermis, parenchymatous ground tissue.Vascular bundles in the form of rings (Fig. 11).

Roots: Epidermal layer around the cortex. Extra thick collenchymatous cortical layers of rounded cells with the ability to store large amount of water. Endodermis and pericycle, clearly developed. Vascular bundles at the periphery of the small pith (Fig. 12).

Botanical Name*:* *Heteropogan contortus*

Vaucher Number: 3622

Local Name: Sermal

Distribution: Bahadur Khel, Ahmad Abad, Hujaki, Sabir Abad, Bogara, Babal Khel.

Morphology
Habit: Small, erect and perennialgrass (Fig. 5).

Leaves: Leaves simple, sessile, sheath leaf bases, alternate and narrow lamina.

Stem: Cylindrical and herbaceous.

Roots: Roots fibrous and adventitious.

Inflorescence Compund spike.
Flower: Incomplete, bisexual and zygomorphic. Colour brown. Fruit small, droop.Seeds, very small and rounded.

Anatomical Description: Transverse sections of leaf stem and roots showed the following features.

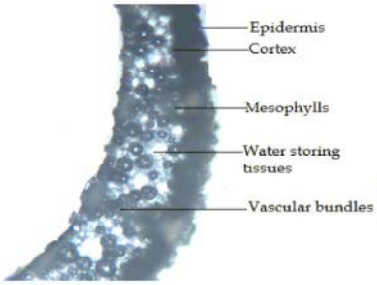


Fig. 7

Fig. 7: T.S of leaf of E. curvula

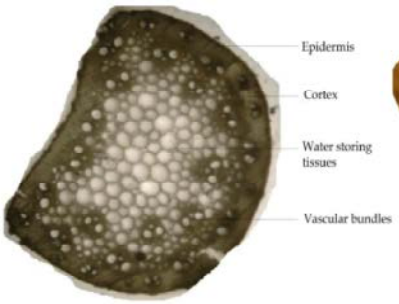


Fig. 8

Fig. 8: T.S of stem of E.curvula

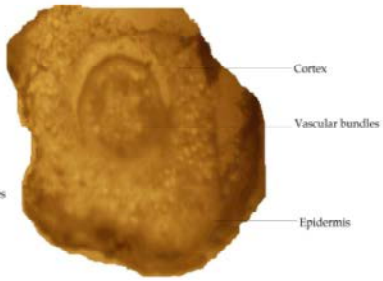


Fig. 9

Fig. 9: T.S of root of E.curvula

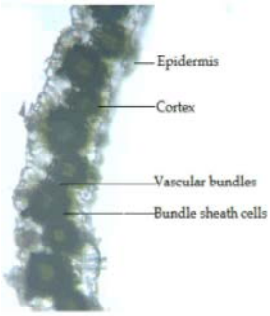


Fig. 10

Fig. 10: T.S of leaf of Kochia indica

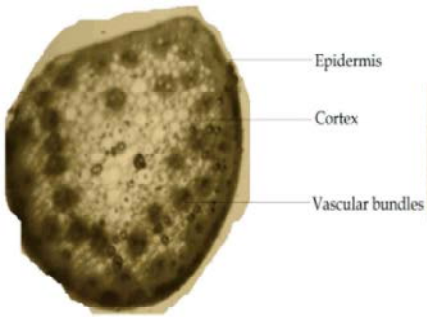


Fig. 11

Fig. 11: T.S of stem of Kochia indica

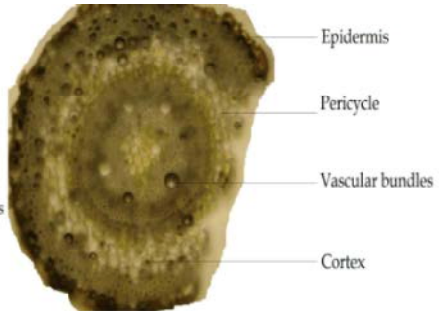


Fig. 12

Fig. 12: T.S of root of Kochia indica

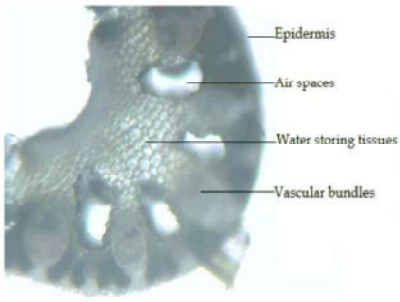


Fig. 13

Fig. 13: T.S of leaf of H. contortus

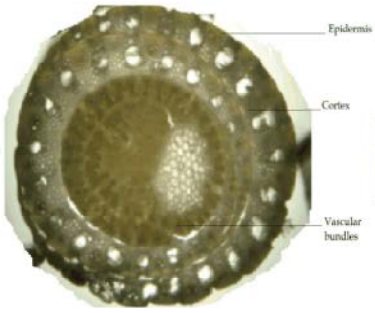


Fig. 14

Fig. 14: T.S of stem of H. contortus

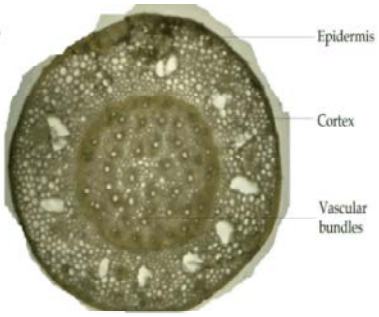


Fig. 15

Fig. 15: T.S of root of H. contortus

Leaf: Thick cutical above the epidermis. The epidermis enclosing mesophyll region. Vascular bundles in the ring form. Rounded air spaces below the epidermis. Prominant water storing tissues, the main property of xerophytes (Fig. 13).

Stem: A cuticle layer around the epidermis. Beneath the epidermis, parenchymatous cortex. Many vascular bundles (Fig. 14).

Roots: Epidermal layer consists of closely elongated cells. Tick parenchymatous cortex with capacity to store profound amount of water. Protoxylems towards the centre while metaxylems towards the cortex (Fig. 15).

DISCUSSION

Asphodelustenuifolius was studied as small erect herb having adventitious and fibrous roots. Simple leaves

Systematic Classification of the plants.

Kingdom	Division	Class	Order	Family	Genus	Species	Botanical name
Plantae	Angiospermae	Monocotyledoneae	Asparagales	Xanthorrhoeaceae	*Asphodelus*	*tenuifolius*	*A.tenuifolius*
Plantae	Angiospermae	Monocotyledoneae	Caryophyllales	Polygonaceae	*Calligonum*	*polygonoides*	*C.polygonoides*
Plantae	Angiospermae	Monocotyledoneae	Cyperales	Poaceae	*Eragrostis*	*curvula*	*E. curvula*
Plantae	Angiospermae	Monocotyledoneae	Chenopodeales	Chenopodeceae	*Kochia*	*indica*	*K. indica*
Plantae	Angiospermae	Monocotyledoneae	Poales	Poaceae	*Heteropogon*	*contortus*	*H. contortus*

with rhizome stem, sheathing at the base and long, mucilaginous. Inflorescence, recemose, flowers white, regular, hermaphrodite and actinomorphic. Seeds, rounded. Cuticle on epidermis, wide parechymatus cortex, vascular bundles in centre. The results of present studies are agreement with Samocha (2009) [15] who reported that the *A.tenuifolius* has short rhizome and tubers around the roots. It remains dormant in the summer due to unfavorable conditions. The dormancy occurs due to unfavorable environmental condition. Vascular bundles are scattered and air spaces are present.

Calligonum polygonoides an endangered species in IUCN Red Data Book.Small prostrate shrub with branched roots. Stem branched, jointed, nodes and internodes. Leaves simple, reduced to scale. Inflorescence spike. Flowers small, white, regular, bisexual and seeds, rounded. Thick epidermis, wide parenchymates cortex, pericycle in ring and radial vascular tissues. Al-Khalifah (2006) [16] studied anatomy of the *C. polygonoides.* The planthas narrower vessels in wood, growth rings, the conducting phloem is of narrow depth and higher specific mass of green photosynthetic shoots. All these modifications are perhaps due to intense drought.

Wahid (2005) [8] stated that the transverse section of leaf including stem and roots of *C. polygonoides* show thick epidermis and very widespread cortex. Similarly, the endodermis is double layered but thin from the epidermis.The results of present study are agreement with Al-Khalifa *et al* (2006) [16] who reported that the cortex in xerophytes is widespread. The present studies are different from Al-Khalifa *et al.* (2006) [16] in leaf morphology who reported that *C. polygonoides* has reduced leaves, while, in the present study, long needle like leaves were observed. The difference in leaves structure is might be due to variation in temperature. Perhaps the temperature of the study area was high than the present study area, therefore the leaves are reduced in order to minimize the loss of water.

Kochia indica Wight, an annual bushy herb, with deep tape roots. Leaves alternate, simple, estipulate, sessile, longer and bases are sheething. Stem herbaceous. Inflorecese spike.Flowers brown, regular, bisexual and zygomorphic.Seeds, rough and flat. Cuticle found on leaf and stem with wide and loosely arranged cortex. Pith in centre, vascular tissues at periphery of pericycle. The results of the present studies are agreement with Turki *et al.* (2003) [17] who reported that vascular bundles are at the same distance from the center and thick cuticle is present at the surface of epidermis. Colour of the stem, yellow and somewhat hard.

The present study shows that the stem of the *K. indica* is green, soft and herbaceous. The difference in the stem colour and thickness might be due to soil composition and fertility. The soil of the present study area is sandy and dry, with low nutrients than the aforesaid study area *Eragrostiscurvula* a herb, with fibrous and adventitious roots. Stem, corm.Leaves long, narrow lamina, sessile and simple. Inflorescence compound and spike. Flowers white, incomplete, bisexual and zygomorphic. Seeds, small and rounded.Cuticle layer on epidermis and parenchymatous cortex. Endodermis found. Pericycle separating the cortex from the vascular region. Pith composed of ground tissues.The results of present studies do not coincide with the work of Colom and Vazzana (2002) [18]. They stated that the *E.curvula* has low palatability to water stress because of thin leaves, small cortex and less number of vascular tissues. The plant in the previous work is not palatable to stress because it was grown in non xeric environment, therefore its morphology was more adapted.

CONCLUSION

The research revealed that people use these plant species for various purposes as medicinal and non-medicinal. The plants are well adapted to the environment where water is in scarcity and the area is rain fed. The documented species have much developed cortex for water storage and developed vascular bundles. Some have underground stem as *A. tenuifolius* and *H. contortus*.It was concluded that the plants are drought resistant therefore drought resistant gens should be identified and isolated in these plant species for breeding purposes in order to get drought resistant verities of crops.

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