ANATOMICAL MODIFICATION OF CYPRUS ROOTS IN RESPONSE TO DIFFERENT ECOLOGICAL ZONES OF PUNJAB PAKISTAN

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خلاصہ

پودے اپنے آپ کو اندرونی اور بیرونی حالات کے مطابق ڈھالتے رہتے ہیں۔ یہ تحقیقی کام سائپرس کی جڑ کو مد نظر رکھ کر کیا گیا۔ اس مقصد کے لیے پنجاب بھر سے مختلف زمینی حالات میں پروان چڑھتے ہوئے سائپرس کی جڑ کے اندرونی حصوں کا جائزہ لیا گیا۔ جس سے یہ واضح ہوا کہ ان پودوں کو کیسے حالات کا سامنہ رہا۔ موٹی جڑیں خشک سالی اور پانی کی کمی کو ظاہر کرتی ہیں۔ اسی طرح جڑ کے اندرونی حصے درجہ حرارت اور پانی کی تبدیلیوں کو بھی ظاہر کرتے ہیں۔

Abstract

Plants adopt different morphological and physiological strategies for their survival while their anatomical characters are mostly unidentified. Angiosperm and herbaceous plants developed insignificant water transporting channels and storage tissues called parenchyma to survive against environmental stresses. Detailed surveys were conducted throughout the Punjab region for the collection of different species of sedges from different soils. The purpose of the study was to investigate the root anatomical adaptation to salinity stress. The densely spread roots help in plant growth in both temporal and tropical regions. Thick epidermis and endodermis make them drought-resistant by restricting water loss during a wide variety of temperature fluctuations. Larger vascular bundles and thicker cortical area in roots are also significant features of these species to store and transport maximum water from the soil. Each population displayed unique modifications of anatomical characteristics, suggesting its adaptability capacity to a specific environmental situation. Water deficient area showed Intensive sclerification in the root vascular zone, large metaxylem vessels, vascular area and stomatal density

Keywords: Cyperaceae, Cyperus, Sedge, Root, parenchyma.

Introduction

Cyperaceae is the second most important C4 plant family consisting of 4000 to 5000 species and 70 to 110 genera all over the world. 22 genera are distributed in Pakistan, mostly they are herbs and use for agriculture purposes (Kukkonen, 2001).They are mostly aquatic plants and can grow up to 0.5 cm in water, mostly they are annual or sometimes perennial (Govaerts *et al*., 2007). Cyperaceae is commonly called sedge family and plants of this family are herbs giving a significant environmental variation from sea level to high altitude

The genus *Cyperus* is further divided into two different subgenera on the basis of their anatomical modifications, one genus have Kranz anatomy with C_4 photosynthesis while another genus is with C_3 type of photosynthesis and without Kranz anatomy. Sedges mostly contain organized spikelets. (Soros & Dengler, 2001).

Punjab is surrounded by other provinces of Pakistan. Its area is 1078 km from south to north and from the east, to west; its length is approximately 616km. Its total geographical area ranges from about 20.63 million hectares (Hussain *et al*., 2003).

Uchhali complex (Khabeki, Uchhali, and Jahlar lakes) is of universal significance in light of the fact that these wetlands are the wintering places of uncommon species, particularly the white-headed duck (Nawazish *et al*., 2006). Uchhali Lake is the biggest of them, where the water is mostly saline

Special types of a root called dauciform root clusters are developed in monocotyledon sedges that are carrot-shaped and possessing longer root hairs (Shane and Dixon.2005a). This special type of root cluster may refer to highly branched and are seen in many families (Lambers *et al*., 2003) e.g. 'proteoid roots' in Proteaceae and Fabaceae. These types of root are special adaptation that enhance the uptake of phosphorus and other nutrients from the nutrient-poor soil (Lambers *et al*., 2006) The roots of sedges called dauciform root because they are carrots shapes and have swollen lateral roots and found mostly in the form of clusters (Daucus is Latin word used for *Daucus carota*) (Neumann and Romheld 2002)

The roots of Cyperaceae do not contain-mycorrhiza (Lambers *et al*., 2006) .Roots cluster formation usually happened when a plant is facing low Phosphorus availability in soil (Lamont, 2003). Many sedges species grown in the nutrient-deficient soil so they form dauciform roots (Shane *et al*., 2005b) root cluster are the modifications of sedges in the deficiency of Phosphorus (Vence *et al*., 2003) because roots clusters are very efficient for solubilization of phosphorus particularly when Phosphorus is immobilized by other cations such as Al, Ca and Fe (Neumann and Romheld 2002).

Sedges have great significance in food web because it recycles the nutrients and a source of food for many consumer and decomposer. It is economically important in the food industry for making food flavors, drinks, and animal food and also uses in the manufacturing of mats, medicine, shoes, paper, ropes, and perfume boats. Mostly sedges tubers and rhizomes are eaten by wildlife animals (Bryson *et al*., 2008).

Materials and Methods

Detailed surveys were conducted throughout the Punjab region including Faisalabad, Sahianwala, Rawalpindi, Sargodha, Murree, the Salt Range Nowshera, Khushab, Mianwali, Lahore, Jhang and some other districts for the different types of Soils of Punjab. The soil samples were collected from various ecological zones and chemical analysis of soil samples was also done in the Laboratory. The soil samples were analyzed for Electrical conductivity and Na^{+}, K^{+}, Ca^{2+}, Cl_2 ions.

Three types of soils were encountered in the Sahianwala region. (1) Wetland (2) Dry saline soil (3) Highly saline soil. Electrical conductivity (EC) was measured using a conductivity meter. Anatomical parameters were measured under a compound microscope with the help of an ocular micrometer, along with a calibrated stage micrometer.

FAA (formalin Acetic Acid) solution was used for material fixation containg 10% Acetic acid, 5% formalin, 50% ethyl alcohol and 35 % distilled water. Long term preservation was done in Acetic Alcohol solution (25% acetic acid and 75% ethyl alcohol).

The double-stained standard technique was used for the preparation of the slide of the transverse section**.** Following formula was used to calculate Area of different cells and tissues (It was modified from the area of a circle, πr2):

$$\text{Area} = \frac{\text{Maximum length x Maximum width}}{28} \times 22$$

Statistical Analysis

The data was subjected to analysis of variance (ANOVA) through complete randomized design (CRD) with two-factor factorial arrangement

Results and Discussion

The detailed analysis of root anatomy from various soil regions of Punjab showed that the Cyperus species growing in the soils of head Rasool area have maximum root area, thickest epidermis, maximum endodermal cell area, large cortical cell area, smaller aerenchymatous cell area, minimum vascular region, and maximum phloem cell region. These include *Cyperus nutans*, *C.glaber*, and *C. squarrosus* species. *C.alopecuroides* collected from the soils of Balloki produced roots with thicker epidermis and minimum endodermal cell area. Another plant *C.alternifolia* from the soils of the botanical garden showed root growth with minimum epidermal cell area and maximum aerenchyma cell area, minimum cortical area, and maximum pith area. The *laevigatus* species collected from dry land and wetland soils of Sahianwala, Faisalabad have root anatomy with maximum epidermal cell area, thickest sclerenchyma and larger metaxylem cell area. Another plant *C .rotundus* collected from the University of Agriculture Faisalabad, showed thin sclerenchyma. *Scirpus maritimus* growing near Khabeki lake showed root growth with minimum root area and thicker vascular region. The plant *C.haspans* growing in the soils of Chiniot showed root anatomy with the thicker cortical area while the *Cyperus compressus* species growing in Kalar kahar showed maximum aerenchyma and pith area. *Cyperus esculentus* from Pakkana showed thin epidermis and least pith area.

Table 2. Root anatomical characteristics of some species of family Cyperaceae from the Punjab region

Species	*C. Glaber*	*C.difformis*	*C.Squarossus*	*C. Iria*	*C.haspans*	*C.Longus*	*C. Lwet*	*C. Ldry sal*	*C. L highly*	*C. Nutans*	*C. Alopercuroides*	*C. Rotundus*	*C. Compressus*	*C. Alternifolia*	*C. Escultantus*	*Scripus maritimus*
Root anatomical parameters																
Root area (μm^2)	677886.3104	580527.90	1379573.0	700980.6	399232.9	503999.6	221433.8	358641.3	563773.2	1409007	998417.4	230490.4	460691	969508.7	71818.2	19890
Epidermal thickness (µm)	1394.71	688.3	2372.82	2517.73	434.71	525.28	2626.41	1992.45	1793.2	3115.46	3350.94	217.35	163.01	217.35	108.67	353.2
Epidermal cell area (μm^2)	571.08	480.43	149.56	226.62	213.02	335.39	598.27	1223.75	389.78	149.56	276.47	217.55	154.1	22.66	77.05	101.97
Cortical cell area(μm^2)	607.34	321.8	380.72	571.08	770.51	335.39	285.54	362.59	294.6	362.59	339.93	430.57	299.13	249.28	380.72	305.93
Aerenchyma cell area (μm^2)	0	0	1450	0	0	0	0	0	0	272	0	0	1042	1586	0	1720
Sclerenchyma thickness (µm)9	69.33	0	0	0	0	0	131.73	108.16	55.46	0	0	15.25	28.53	83.2	0	0
Endodermal cell area (μm^2)	390.78	45.32	49.85	45.32	54.38	131.44	90.64	49.85	54.38	36.25	27.19	86.11	176.76	58.92	31.72	33.99
Vascular bundle area(μm^2)	679.86	10877.81	8201.41	12373.5	6558.41	8271.66	5352.78	9037.64	8176.48	6705.714	9336.78	17318.37	15278.78	8670.518	12350.84	16282.72
Metaxylem area (μm^2)	901.95	0	36.25	163.16	589.21	45.32	1667.93	1885.48	330.86	435.11	584.68	362.59	1124.04	0	920.08	734.25
Phloem cell area(μm^2)	27.19	18.12	190.36	45.32	36.25	27.19	63.45	63.45	45.32	190.36	27.19	58.92	36.25	31.72	67.98	61.18
Pith area(μm^2)	0	0	0	163.16	3988.52	0	0	0	0	190.36	0	99.71	5833.22	7056.97	40.79	95.18

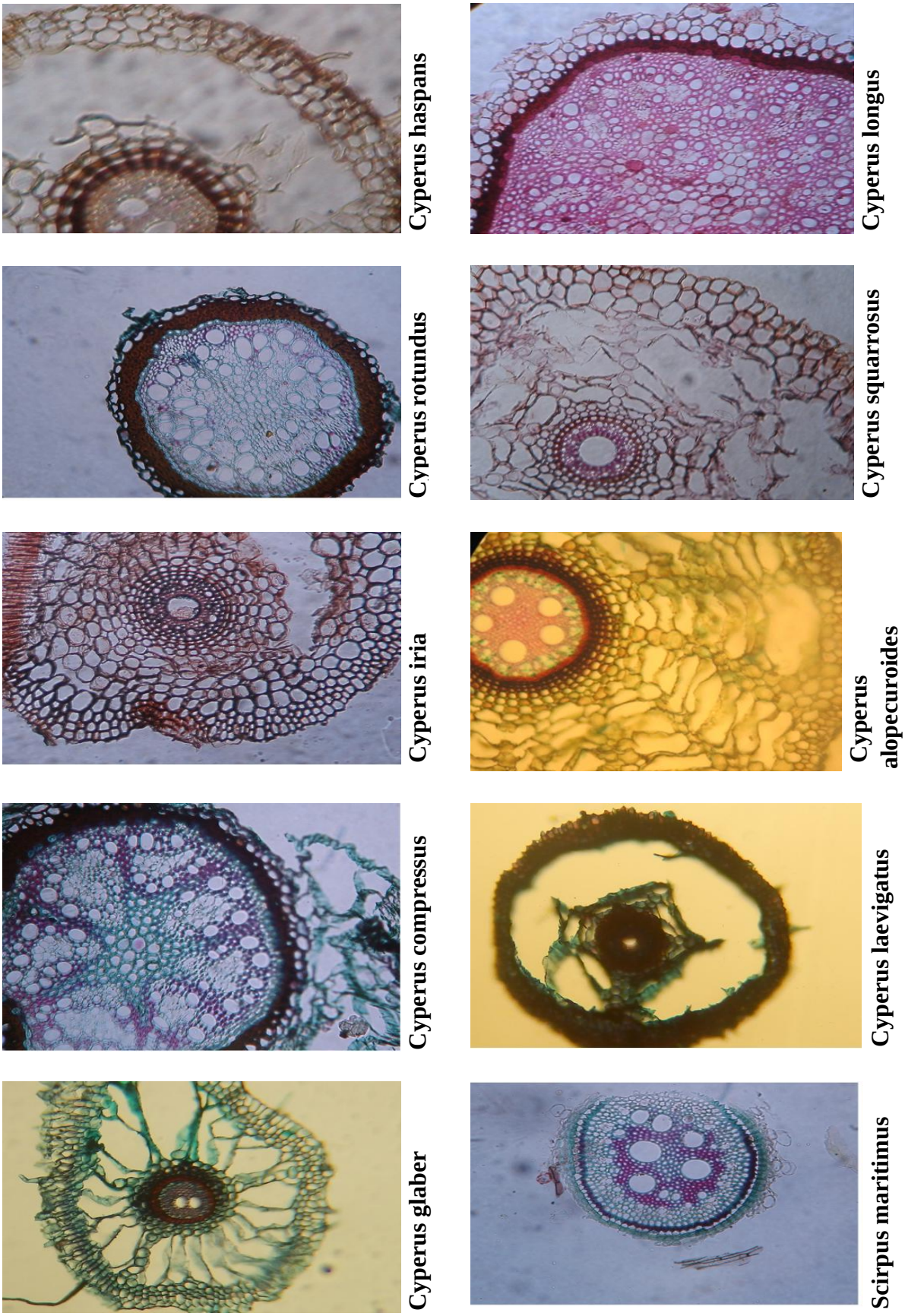

Figure: TS of the root of some species of family Cyperaceae from Punjab.

Along the head rasul region of Punjab, there was a wide-dispersal of *Cyperus nutans, C.glaber,* and *C. squarrosus* species because of multiple modifications in root anatomy suitable for a variety of climates and soil conditions. The densely spread roots help in plant growth in both temporal and tropical regions. Thick epidermis and endodermis make them drought-resistant by restricting water loss during a wide variety of temperature fluctuations. Larger vascular bundles and thicker cortical areas in roots are also significant features of them to store and transport maximum water from the soil(Taleisnik, Peyrano, CÓRdoba, & Arias, 1999).

Common *Cyperus* species in Faisalabad include *laevigatus* and *rotundus.* The soil of Faisalabad is saline-sodic with acidic pH in the presence of silica; alkaline soil pH is due to the presence of limestone. It has the highest saturation percentage and electrical conductivity. That is why in this region there is a site-specific dominance of *Cyperus laevigatus* with characteristic salt-tolerant thick sclerenchyma and larger epidermal and metaxylem cell area in roots. The root diameter decreases in the species found in the Faisalabad region because of this soil salinity. Largely spread roots are not suitable for soil with high salinity. Other *Cyperus* species show moderate growth in this region because of root features not ideal for soil salinity. The minimum cortical cell area also helps these species to avoid harsh soil salinities. Kallar kahar region also has saline soil so the dominant Cyperus species *compressus* has root anatomy of maximum aerenchyma cell area and larger pith area. The root anatomy of all Cyperus species in saline soil shows modification to tolerate high salt concentrations in soil. The Cyperus plants lacking these root modifications are not commonly observed in these regions of Punjab.

The sandy habitat of the Chiniot region has a dominance of *C.haspans* species which are more drought-resistant due to their thicker cortical area in roots. The large cortical area in roots is needed to absorb and store maximum water from the soils which help in survival during water shortage. This species is uncommon in the saline regions of Faisalabad. Other Cyperus species *esculentus* collected from dry soils of the pakkana region had root modifications of the thin epidermis and small pith area to tolerate water shortage during droughts(Stoller & Sweet, 2017).

Conclusion

The Cyperus family adopts diverse anatomical modifications for distribution in a wide variety of habitat. Differentiation of root is a key factor determining the growth and survival of the plant in specific soil conditions. Densely spread roots are observed in species growing in both tropical and temperate regions. The modifications of exodermis and endodermis are crucial for the selective transport of nutrients between the roots and the soil. Vascular bundles and pith cells adapt to store water in drought conditions. Adaptations of phloem area, metaxylem, sclerenchyma thickness, and epidermal cell area are the characteristic features of species growing in saline soil. This study showed different root anatomies of Cyperus species growing in different soils of various regions of Punjab. The distribution of these species was based on the root anatomy of plants modified according to the soil characteristics.

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