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Research article

STUDIES ON MORPHOLOGICAL DIVERSITY AND FREQUENCY OF PHYTOLITHS OF UNDERUTILIZED GRASS SPECIES OF POACEAE

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ABSTRACT: The phytoliths are micrometric particles protect the plant from various stresses; in past provides mechanical support and durability to the plant. Meticulous research towards phytoliths particularly in Underutilized grasses in scanty therefore the present study is aimed at to the find out the morphology and distribution of phytoliths present in twenty two Poaceae grass species by using wet-oxidation method. The results revealed that the most frequent types were the Elongate and Bilobate structures with highest frequency and measurements. Based on these observations it is concluded that the phytoliths produced by Poaceae grass species posses taxonomic values and major role in past environmental reconstructions.

Key words: Poaceae, Silica, Phytolith, Grasses

INTRODUCTION

Silicon (Si) is the second most abundant element in the earth's crust after oxygen (28% vs. 47%). In nature Si exists mostly as silicon dioxide and is available to plants silicic acid. Large accumulations of Si are found in the Poaceae and Cyperaceae plant families [1]. Silicon represents a major mineral constituent of plants, and is present in plants in concentrations similar to that of the other macronutrients. At 0.1 percent, Si is equivalent to the levels of macronutrients, Ca, Mg, P and S; while the upper levels of 10 percent exceed the concentrations of the mineral nutrients like K and N [2]. Poaceae forms the most fascinating family and plays a significant role in the lives of human beings and animals [3]. Phytoliths are found in many plant families though not all, but their production is most abundant in grasses, possibly 20 times that in other plant opal-producing families [4].

Phytoliths (Greek, *phyto*= plant, *lithos*= stones) or Plant stones are amorphous form of Silicon dioxide (known as "opal") deposition found in many plants [5]. Opal phytoliths are created when hydrated silica dissolved in ground water is absorbed through the roots of a plant and carried throughout its vascular system. The term "phytolith" refers only to microscopically recognizable shapes, not amorphous pieces or traces of silica detectable only by microchemical methods that would not be recognized as discrete types [6]. As some plants were found to produce distinguishable or characteristic or "diagnostic" shaped phytoliths, they are well established as useful tools in archaeology, angiosperm taxonomy [7] and recently for Nanotechnology [8]. The occurrence of silicon as silica bodies or phytoliths in many plants has been correlated with mechanical support, stiffness, protect the plant from various biotic and abiotic stresses, reduction of water loss, protection from herbivores, prevention of the entry of pathogens, protection from metal toxicity, root elongation, increased capture of light for photosynthesis and in the cooling of leaves [9]. Silica bodies make some plants distasteful or give their tissues a prickly texture [10]. Silica bodies also conserve water during moisture stress or drought [11] and they have been shown to influence stomatamovement on the plant leaf epidermis and reduce the transpiration rate of water inmaize. Plant silica bodies promote cell elongation in the growing zone and decrease cell-wall extensibility in the basal zone of stellar tissues in the roots and thereby enhance root elongation of plants [12]. Silica bodies also improve plant tolerance to fungal diseases, andmetal toxicity [11]. Cells filled with silica bodies allow the plant to capture more light, thus aiding photosynthesis [12], perhaps in the manner of light piping that has been hypothesized for colonial diatoms [13]. At longer wavelengths, in the infrared, silica bodies aid cooling of leaves [14]. In summary, silica helps a plant to survive many a biotic stresses, such as salt, metal toxicity, nutrient imbalance, drought, radiation, high temperature, freezing and ultraviolet [15] and reduce the impact of plant predators.

The grass family (Poaceae) in particular, produce abundant opaline silica bodies with diagnostic morphological features that permit identification to subfamily, or in some instances, lower taxonomic levels [11]. The size of the silica bodies that are deposited in the plant tissues mostly ranges between 10 and 30 µm and is occasionally up to 200 µm [16]. Phytoliths helps the formation of muscles in the animals.

The cell-wall deposits of silica often replicate the morphology of the living cells. The objective of the present study was to find out the occurrence and morphology of phytoliths in twenty two poaceae grass species which used as feed for livestock.

MATERIAL AND METHODS

Twenty two Underutilized grass species of Poaceae distriabution South India in wastelands *Alloteropsis cimicina* L., *Aristida hystrix* L.F., *Aristida setacea* Retz., *Brachiaria racemosa* L., *Chloris barbata* Swartz., *Cymbopogon coloratus* (Hook.f) Stapf., *Cynodon dactylon* (L.) Pers., *Dactyloctenium aegyptium* (L.) Willd., *Digitaria sanguinalis* (L.) Scop., *Dinebra retroflexa* (vahl.) Panz., *Echinochloa colona* (L.) Link., *Eleusine indica* (L.) Gaertn., *Eragrostiella bifaria* Bor., *Eragrostis amabilis* (L.) Wight & Arn., *Eragrostis viscosa* (Retz.) Trin., *Heteropogon contortus* (L.) P. Beauv, *Panicum repens* L., *Paspalidium flavidum* (Retz.) A. Campus., *Perotis indica* (L.) O. Kuntze., *Setaria pumila* (Poir.) Roem & Schult., *Sporobolus coromandelianus* (Retz.) and *Sporobolus wallichii* R.Br. were collected from different meadows during March to September 2010 to 2014 and all the grass species were uprooted by digging the soil and preserved in plastic bags. The samples of each grass species were immediately pressed in paper bags for herbarium specimen and the species were identified with the help of Gamble (1915-36) and compared, authenticated with the specimens of BSI (Coimbatore, Tamil Nadu).

Phytoliths were extracted by wet oxidation method of [5]. All the collected plant samples were cleaned with distilled water in an ultrasonic water bath to remove adhering particles. Leaves of each species were placed in 20 ml of saturated nitric acid for one night to oxidize organic materials completely. The solutions were centrifuged at 2000 rpm for 10 min, decanted, and then boiled in 10 % Hydrochloric acid in water bath to remove calcium, then, washed with distilled water many times to remove the acid. The processed materials were then centrifuged with acetone at 2000 rpm for 10 minutes each time and dried with Acetone. The phytolith sediments were transferred to storage vials. The residual subsamples were mounted onto microscopic slides in Canada balsam medium for photomicrography and in liquid (glycerol) medium for counting and line drawing. A minimum of 350 phytolith grains were counted in each sample. Slides were observed under light microscope and photographed using Olympus digital camera attached with Olympus trinacular microscope. Observations and photography were taken under oil immersion objective (400x). Measurements were taken from surface view of phytoliths using Motic Image Analyzer software. Various features of phytoliths noted including length, width and shape. In addition to measurement, frequency of phytolith assemblages was also noted. About 1000 phytoliths from each species were counted and frequency determined. For both frequency and measurement range, average and standard error were calculated. Measurements were made along the longest axis of the phytoliths all the dimensions of phytoliths were studied for taking measurements surface view of phytoliths were considered. Phytoliths morphotypes were classified and described using the International Code of phytolith nomenclature [17]. Silicon content estimated through the ICP- OES (Perkin Elmer 7000DV, USA).

RESULTS AND DISCUSSION

The phytoliths of each species were measured and shown in Table 2; frequency assemblages in table 3; and distribution in table 4; Photograph of different types of phytoliths are given in figure 1. The data obtained from the frequency of phytolith assemblages as well as measurements were utilized for the preparation of an identification key for grasses upto species level. Length and width dimensions and frequency of about 1000 phytoliths were measured from each species. The results of present study on phytoliths applies the rules of International Code for Phytolith Nomenclature. Various types of phytoliths observed and their abbreviations used are given in Table 1.

Table 1: Different types of phytoliths observed and their abbreviations.

S.No	Type	Abbreviation
1	Bilobate short cell (dumbbell)	BSC
2	Trapeziform short cell (rectangle)	TSC
3	Cylindrical polylobate (polylobate)	CP
4	Elongate echinate long cell (elongate and spiny)	ELC
5	Cuneiform bulliform cell (fan shaped)	CBC
6	Parallepipedal bullifrom cell (bulliform)	PBC
7	Acicular hair cell (point shaped)	AHC
8	Cross	C
9	Rondel	R
10	Saddle	S

Bilobate phytoliths is represented in the species of *Alloteropsis cimicina, Aristida hystrix, Aristida setacea, Brachiaria racemosa, Dactyloctenium aegyptium, Dinebra retroflexa, Echinochloa colona, Eleusine india, Heteropogon contortus, Panicum repens, Perotis indica* and *Setaria pumila*. Whreas highest frequency and measurements in *Heteropogon contortus*. The dumbbell (lobate) phytoliths originates from the epidermal cells (short cell) of Panicoideace and Oryzoideae, some Arundinoideae, Chloridoideae subfamilies [18]. Trapeziform short cell phytoliths is represented in *Aristida setacea, Brachiaria racemosa, Cymbopogon coloratus, Digitaria sanguinalis, Echinochloa colona, Eleusine indica, Eragrostiella bifaria* and *Perotis indica*. Frequency and measurements maximum in *Brachiaria racemosa* and *Cymbopogon coloratus*. These are phytoliths with three or poly equal lobes. Their margins may be concave or flattened.

Cylindrical polylobate phytoliths are in *Alloteropsis cimina, Aristida hystrix, Aristida setacea, Brachiaria racemosa, Chloris barbata, Dactyloctenium aegyptium, Digitaria sanguinalis* and *Paspalidium flavidum*. Highest frequency and measurements in *Dactyloctenium aegyptium*. Elongate structures are silicified long cells of the epideumis with echinate or sinuate walls. Elongate shaped phytolihs characteristrises the family of poaceae were forund to be the dominant type in all the selected species. The highest frequency and measurements were observed in *Chloris barbata* and *Cynodon dactylon*. Elongate phytoliths forms are well preserved. These phytoliths are flat rectangular plates, some with pitted and others with smooth surfaces.

Fan shaped phytoliths are silicified bulliform cells of the epidermis which were found in *Alloteropsis cimicina, Aristida hystrix, Aristida setacea, Cymbopogon coloratus, Digitaria sanguinalis, Echinochloa colona* and *Setaria pumila*. Highest frequency and measurements in *Echinochloa colona* and *Alloteropsis cimicina*. These cells are usually found in the epidermis of the leaves and they are larger than the typical epidermal cells and characteristic of the family poaceae and other monocotyledons.. Some workers hypothesized that bulliform cells have an important role in the opening of the leaves from the bud, whereas others suggested that they are involved in the rolling and unrolling of mature leaves. [19] Proposed that bulliforms act as water storage cells. Parallepipedal bulliform cell phytoliths are silicified bulliform cells, these are observed in *Aristida hystrix* and *Aristida setacea*. Highest frequency and measurements in *Aristida hystrix* and *Aristida setacea*. Acicular hair cell phytoliths are in *Alloteropsis cimicina, Aristida hystrix, Aristida setacea, Brachiaria racemosa, Chloris barbata, Dactyloctenium aegyptium, Dinebra retroflexa, Echinochloa colona, Eragrostis viscosa, Perotis indica, Setaria pumila* and *Sporobolus coromandelianus*. Highest frequency and measurements in *Alloteropsis cimiciana* and *Echinochloa colona*.

Table. 2 Diversity in structures and Measurements of phytolith (μm) of Poaceae grass species

Name of the species	Shape Dimension		BS	TS	CP	ECL	CBC	PBC	AHC	C	R	S
Alloteropsis cimicina	L	Average	8.5±1.3	-	10.9 ± 0.9	48.6 ± 2.3	22.4 ± 3.1	-	5.1 ± 0.2	7.5 ± 1.4	-	-
		Range	4.4to13.2	-	10.6to11.1	42.3 to 51.9	20.8to23.2	-	4.6 to 5.9	4.2to10.6	-	-
	W	Average	5.9±0.8	-	4.1±0.2	8.5 ± 0.4	5.1 ± 0.8	-	3.1 ± 0.1	8.7 ± 0.6	-	-
		Range	3.6to7.2	-	3.6 to4.7	7.9 to 9.6	3.6 to 6.4	-	2.1 to 3.4	4.6to10.2	-	-
Aristida hystrix	L	Average	10.2±1.3	-	9.6 ± 1.4	40.3 ± 5.1	12.5 ± 1.5	16.5 ± 2.5	9.8 ± 2.1	-	8.9± 1.7	9.5 ± 2.1
		Range	6.7to14.1	-	8.3to12.6	17.6 to 58.1	10.6to17.3	15.6 to 25.9	8.1 to 14.2	-	6.3to14.9	4.1 to 14.4
	W	Average	8.2 ± 1.6	-	5.1 ± 0.2	9.7 ± 1.4	7.8 ± 2.1	14.5 ± 2.5	7.4 ± 0.8	-	8.1 ± 1.3	5.1 ± 0.5
		Range	3.4to 13.2	-	4.7 to 5.8	8.3 to 10.2	6.8 to 8.1	12.7 to 21.4	6.2 to 10.4	-	5.8to12.4	2.4 to 6.3
Aristida setacea	L	Average	9.5± 1.3	10.2±2.4	14.5±1.6	42.3 ± 2.1	7.9 ± 0.3	10.2 ± 0.9	10.5 ± 1.2	-	-	5.8 ± 0.4
		Range	7.5to16.7	8.3to17.3	13.7to24.6	20.6to69.2	4.3 to 12.6	13.3 to 18.6	12.5to16.4	-	-	3.5 to 8.4
	W	Average	6.9 ± 0.2	8.9± 0.4	6.1± 0.1	9.7 ± 0.5	7.9 ± 0.4	9.1 ± 0.5	8.5 ± 0.6	-	-	5.8 ± 0.2
		Range	5.2to9.6	5.6to10.7	5.3 to 6.9	6.4 to 12.3	3.9 to 9.3	8.2 to 10.2	7.1 to 9.3	-	-	3.1 to 6.9
Brachiria racemosa	L	Average	15.3±1.3	15.2±0.4	19.5±1.0	49.2 ± 1.4	-	-	14.2 ± 0.6	-	9.7 ± 0.6	5.9 ± 0.2
		Range	14.6to16.9	9.2to18.6	13.1to26.5	26.4 to 69.1	-	-	8.6 to 19.2	-	4.1to16.2	3.8 to 7.9
	W	Average	6.2± 0.8	8.5± 0.4	5.8± 0.5	8.5 ± 0.1	-	-	6.2 ± 0.7	-	8.5 ± 1.2	4.2 ± 0.1
		Range	3.9 to 9.6	6.3to12.4	4.3to6.9	4.7 to 13.2	-	-	4.1 to 8.7	-	3.6to13.1	2.9 to 5.6
Chloris barbata	L	Average	-	-	9.5± 0.8	35.4 ± 1.9	-	-	8.6 ± 0.3	-	-	-
		Range	-	-	4.6to14.7	26.2 to 41.9	-	-	7.6 to 13.2	-	-	-
	W	Average	-	-	7.2 ± 0.6	9.5 ± 0.1	-	-	5.8 ± 0.3	-	-	-
		Range	-	-	3.2 to0.4	8.9 to 11.4	-	-	4.9 to 6.3	-	-	-
Cymbopogon coloratus	L	Average	-	18.2±1.4	-	28.3 ± 0.9	16.2 ± 0.7	-	-	-	12.5±0.2	8.3 ± 0.5
		Range	-	8.3to26.5	-	20.5 to 36.1	11.6to19.3	-	-	-	2.9to19.6	6.3 to 12.1
	W	Average	-	8.6± 0.5	-	9.6 ± 0.6	10.8 ± 0.8	-	-	-	8.5 ± 1.2	7.5 ± 0.3
		Range	-	5.2to2.4	-	6.5 to 12.4	8.7 to 12.1	-	-	-	2.1to10.3	4.2 to 9.3
Cynodon dactylo	L	Average	-	-	-	56.8 ± 1.8	-	-	-	-	-	9.7 ± 0.6
		Range	-	-	-	19.2 to 76.2	-	-	-	-	-	4.6to 15.9
	W	Average	-	-	-	9.6 ± 0.1	-	-	-	-	-	4.8 ± 0.2
		Range	-	-	-	5.1 to 12.4	-	-	-	-	-	3.1 to 6.3

Table-2: Cont.....

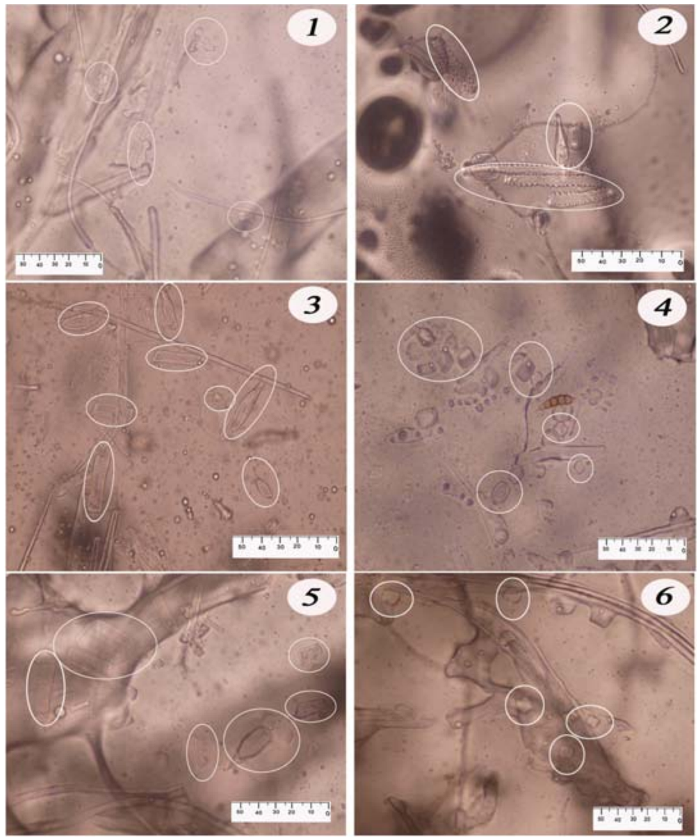
Name of the species	Shape Dimension		BS	TS	CP	ECL	CBC	PBC	AHC	C	R	S
Eragrostis viscosa	L	Average	-	-	-	36.2 ± 1.8	-	-	14.8 ± 0.9	-	10.2 ± 0.7	15.6 ± 0.8
		Range	-	-	-	22.4 to 56.3	-	-	8.6to 19.2	-	4.7 to 16.3	5.3 to 26.4
	W	Average	-	-	-	9.3 ± 0.1	-	-	8.5 ± 0.2	-	8.5 ± 0.9	12.5 ± 0.7
		Range	-	-	-	5.9 to 12.4	-	-	5.7to 12.7	-	3.6 to 13.7	4.9 to 19.7
Heteropogon contortus	L	Average	18.3 ± 1.4	-	-	41.3 ± 5.6	-	-	-	-	11.2 ± 0.4	-
		Range	12.4to 27.1	-	-	20.2 to 56.7	-	-	-	-	7.2 to 16.4	-
	W	Average	12.5 ± 0.1	-	-	9.3 ± 0.3	-	-	-	-	8.2 ± 1.3	-
		Range	8.2 to 14.7	-	-	5.9 to 11.6	-	-	-	-	4.2 to 12.1	-
Panicum repens	L	Average	13.0 ± 0.7	-	-	35.2 ± 3.2	-	-	-	-	-	-
		Range	8.7 to 16.3	-	-	21.3 to 54.1	-	-	-	-	-	-
	W	Average	10.4 ± 0.7	-	-	7.1 ± 0.4	-	-	-	-	-	-
		Range	7.1 to 12.3	-	-	4.7 to 9.6	-	-	-	-	-	-
Paspalidium flavidum	L	Average	-	-	19.1± 1.7	34.5 ± 4.1	-	-	-	-	-	10.2 ± 1.4
		Range	-	-	15.7to21.9	17.9 to 49.1	-	-	-	-	-	6.3 to 17.3
	W	Average	-	-	10.4± 0.3	9.5 ± 0.7	-	-	-	-	-	6.8 ± 0.4
		Range	-	-	3.3to16.4	6.4 to 13.5	-	-	-	-	-	3.7 to 9.6
Perotis indica	L	Average	22.4 ± 1.9	14.8±0.9	-	47.9 ± 2.6	-	-	12.5 ± 0.5	-	-	12.4 ± 0.2
		Range	16.2to 24.1	8.1to 20.7	-	26.4 to 69.7	-	-	5.2to 18.9	-	-	4.2 to 20.5
	W	Average	10.4 ± 0.1	6.2 ± 0.2	-	9.2 ± 0.8	-	-	10.7 ± 0.6	-	-	7.1 ± 0.2
		Range	7.1 to 11.9	5.3to 7.9	-	5.1 to 12.7	-	-	4.9to 16.1	-	-	3.1 to 9.2
Seatria pumila	L	Average	15.8 ± 0.9	-	-	47.3 ± 4.6	14.9 ± 0.7	-	20.3 ± 1.7	-	-	14. ± 0.2
		Range	12.4to 19.6	-	-	16.3 to 74.8	8.3to 19.6	-	12.2to 26.1	-	-	4.9 to 21.9
	W	Average	11.5 ± 1.5	-	-	9.6 ± 0.5	10.2 ± 0.9	-	10.9 ± 0.7	-	-	9.4 ± 0.7
		Range	9.6 to 13.7	-	-	5.6 to 12.7	6.7to12.4	-	8.7to 12.6	-	-	3.6 to 14.6
Sporobolus coromandelianus	L	Average	-	-	-	44.9 ± 2.9	-	-	13.2 ± 1.4	-	-	14.2 ± 0.5
		Range	-	-	-	16.3 to 69.1	-	-	6.1to 19.7	-	-	8.3 to 19.6
	W	Average	-	-	-	10.8 ± 0.7	-	-	8.9 ± 0.5	-	-	12.6 ± 0.6
		Range	-	-	-	6.9 to 13.3	-	-	5.3to 14.6	-	-	7.3 to 15.7
Sporobolus wallichii	L	Average	-	-	-	39.5 ± 1.6	-	-	-	-	-	16.5 ± 2.1
		Range	-	-	-	13.1 to 59.6	-	-	-	-	-	6.1 to 24.1
	W	Average	-	-	-	10.2 ± 0.4	-	-	-	-	-	7.5 ± 0.8
		Range	-	-	-	3.7 to 16.2	-	-	-	-	-	3.6 to 9.3

Table: 3 Frequency (in percentage) of phytolith in twenty two Poaceae grass species

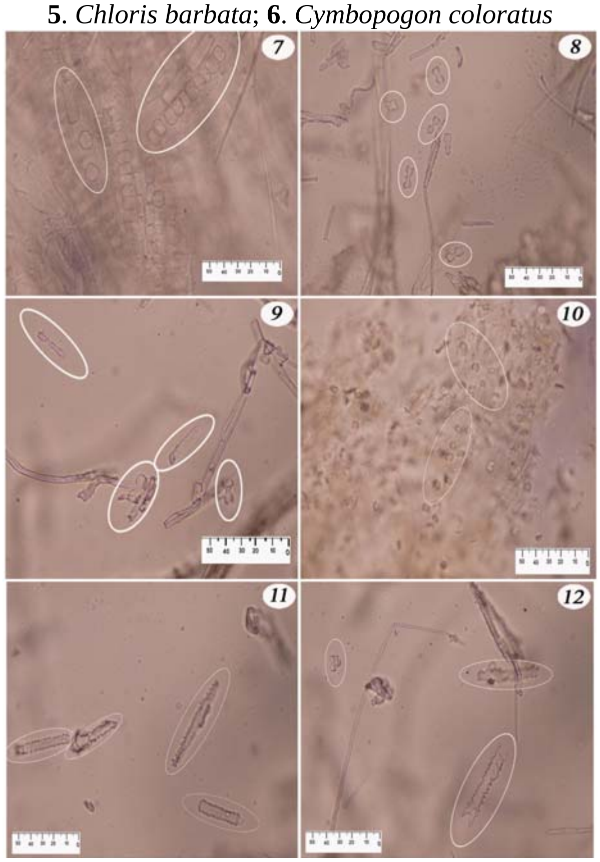
Structure of Phytolith	Grass species																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
BS	20.9	12.4	20.3	0.4	-	-	-	21.9	17.9	0.4	14.1	12.4	-	-	-	38.9	0.4	-	13.7	26.8	-	-
TS	-	-	4.6	15.5	-	5.3	-	-	10.1	-	4.6	3.1	0.4	-	-	-	-	-	0.2	-	-	-
CP	16.1	15.6	7.4	6.3	1.4	-	-	18.5	0.4	-	-	-	-	-	-	-	-	4.7	-	-	-	-
ECL	19.8	39.6	59.7	19.7	96.6	32.3	30.2	57.6	62.1	86.7	32.5	57.0	68.7	16.4	91.3	58.3	99.6	9.6	69.1	15.7	40.8	77.3
CBC	13.1	0.4	0.3	-	-	2.7	-	-	1.4	-	3.8	-	-	-	0.4	-	-	-	-	0.3	-	-
PBC	-	0.6	0.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
AHC	14.5	6.8	4.1	0.7	2.0	-	-	0.4	-	0.8	6.4	-	-	-	-	-	-	-	0.6	2.6	0.1	-
C	15.6	-	-	-	-	-	-	-	-	-	-	6.5	-	-	-	-	-	-	-	-	-	-
R	-	11.5	-	27.3	-	29.3	-	-	3.6	12.1	17.1	4.2	14.7	13.7	8.3	2.8	-	-	-	-	-	-
S	-	13.1	2.8	30.7	-	30.4	69.8	1.6	4.5	-	21.5	16.8	16.8	69.9	-	-	-	85.7	16.4	54.6	59.1	22.7

Table-4: Distribution of Phytolith types in grass species of Poaceae

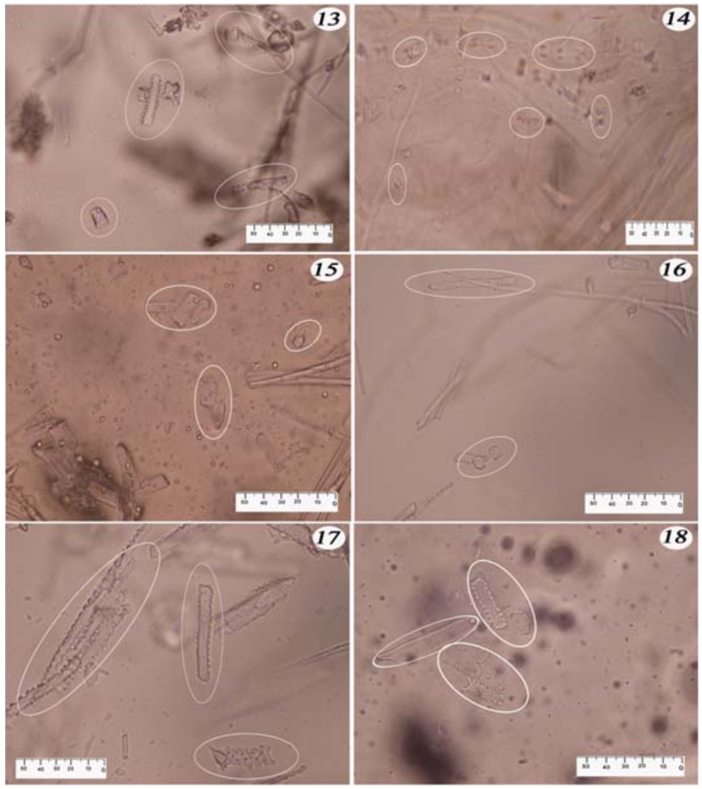
Name of Taxon	BS	TS	CP	ECL	CBC	PBC	AHC	C	R	S
Alloteropsis cimicina	A		C	C	R		R	R		
Aristida hystrix	C	R	A	C	R	R	R		A	A
Aristida setacea	R	R	A	C			R			R
Brachiaria racemosa		R	R	C			R		A	A
Chloris barbata			R	A						
Cymbopogon coloratus			R	C	R					
Cynodon dactylon				C						A
Dactyloctenium aegyptium	C		C	A			R			R
Digitaria sanguinalis	A	R		C					R	R
Dinebra retroflexa	R			A					C	
Echinochloa colonum	C			A	R		R		R	R
Eleusine indica	C	R		A				R	R	C
Eragrostiella bifaria				A					R	C
Eragrostis amabilis				C					R	A
Eragrostis viscosa				A	R				C	
Heteropogon contortus	C			A					R	
Panicum repens	R			A						
Paspalidium flavidum		R	R	C						A
Perotis indica	C			A			R			C
Setaria pumila	C			C			R			A
Sporobolus coromandelianus				C			R			A
Sporobolus wallichii				A						C



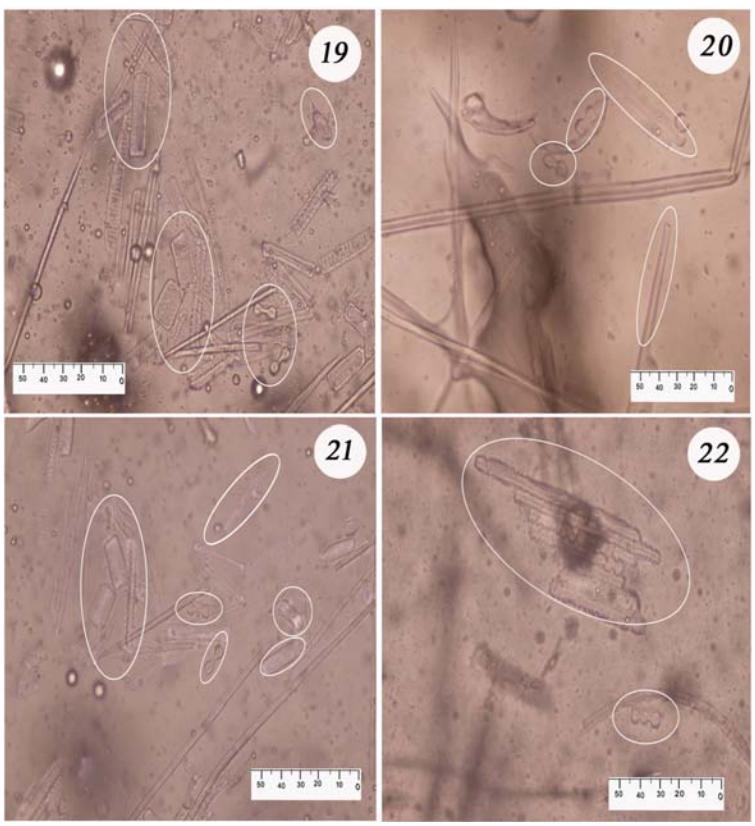
1. *Alloteropsis cimicina*; **2**. *Aristida hystrix*; **3**. *Aristida setacea*;**4**. *Brachiaria racemosa*
5. *Chloris barbata*; **6**. *Cymbopogon coloratus*



7. *Cynodon dactylon*; **8**. *Dactyloctenium aegyptium*; **9.** *Digitaria sanguinalis*; **10.** *Dinebra retroflexa*; **11.** *Echinochloa colona*; **12.** *Eleusine indica*



13. *Eragrostiella bifaria*; **14**. *Eragrostis amabilis*; **15**. *Eragrostis viscosa*; **16**. *Heteropogon contortus*; **17**. *Panicum repens*; **18**. *Paspalidium flavidium*



19. *Perotis indica;* ***20****. Setaria pumila;* ***21****. Sporobolus coromandelianus;* ***22****. Sporobolus wallichii*

Figure: 1 Phytoliths studies of twenty two Poaceae grass species

Cross phytoliths are found in *Alloteropsis cimicina* and *Eleusine indica* with highest frequency and measurements. Rondle shape phytoliths are observed in *Aristida hystrix, Brachiaria racemosa, Cymbopogon coloratus, Digitaria sanguinalis, Dinebra retroflexa, Echinochloa colona, Eleusine indica, Eragrostiella bifaria, Eragrostis amabilis, Eragrostis viscosa* and *Heteropogon contortus*. Highest frequency and measurements in *Cymbopogon coloratus* and *Echinochloa colona* only. Saddle shaped phytoliths are arranged vertically on the epidemis of *Aristida hystrix, Aristida setacea, Brachiaria racemosa, Cymbopogon coloratus, Cynodon dactylon, Dactyloctenium aegyptium, Digitaria sanguinalis, Echinochloa colona, Eleusine indica, Eragrostiella bifaria, Eragrostis amabilis, Eragrostis viscosa, Paspalidium flavidum, Perotis indica, Setaria pumila, Sporobolus coromandelianus* and *Sporobolus wallichii*. Highest frequency and measurements only in *Paspalidium flavidum* and *Sporobolus wallichii*. Highest silicon content in *Chloris barbata* followed the *Alloteropsis cimicina, Cynodon dactylon* and *Eragrostis amabilis*. Whereas lowest content observed in *Perotis indica*. Table-5.

Table: 5 Silica content in leaves grass species of Poaceae (ppm)

S.No	Name of the species	Silica content ppm
1	*Alloteropsis cimicina*	291.2 ± 12
2	*Aristida hystrix*	216.1 ± 05
3	*Aristida setacea*	222.9± 09
4	*Brachiaria racemosa*	229.7± 01
5	*Chloris barbata*	207.8± 15
6	*Cymbopogon coloratus*	272.2± 10
7	*Cynodon dactylon*	289.1± 02
8	*Dactyloctenium aegyptium*	234.5± 13
9	*Digitaria sanguinalis*	224.2± 11
10	*Dinebra retroflexa*	234.5 ± 19
11	*Echinochloa colonum*	220.0 ± 06
12	*Eleusine indica*	246.0± 04
13	*Eragrostiella bifaria*	301.9 ± 14
14	*Eragrostis amabilis*	284.6± 15
15	*Eragrostis viscosa*	266.1± 10
16	*Heteropogon contortus*	267.8 ± 17
17	*Panicum repens*	245.3± 11
18	*Paspalidium flavidum*	265.3± 12
19	*Perotis indica*	185.2 ± 14
20	*Setaria pumila*	188.1 ± 08
21	*Sporobolus coromandelianus*	265.6 ± 03
22	*Sporobolus wallichii*	249.6 ± 17

Frequency of phytolith assemblages and measurements are found to be consistent with in a species and have been useful for developing the key of identification. Even though phytolith multiplicity and redundancy occur in grasses, frequency assemblages reveal that a particular morphotype dominate over the other in a given species. The widespread production of phytoliths in leaves of grass species can therefore be most helpful for identifying plant species in archaeological or geological sediments, provided a reference collection of the surrounding area is available. Of the 22 leaf samples analysed in this study, *Aristida* species, *Digitaria sanguinalis* and *Echinochloa colona* contain the highest concentrations of phytoliths. Silicon dioxide may ameliorate the toxic effects of aluminium and other heavy metals, such as manganese, which are ingested by plants along with other substances in the ground water [20]. Protective functions have to do with an increased resistance to herbivores and pathogenic fungi that consume plant tissue or cause various diseases. It appears that these kinds of protection constitute some of the most important functions of phytoliths. The discovery of single genes that regulate the production of phytoliths adds a great deal to our understanding of this process [21]. In areas where dung accumulated, large amounts of phytoliths can be expected, provided that the animals were fed the whole plant. If only the stems of certain cereals and wild grasses that contain relatively few phytoliths were used as fodder, this would deplete the phytolith record significantly. In addition dung from goats, animals that prefer leaves in their diet, may also contain small amounts of phytoliths given that many dicot leaves do not contain large amounts of phytoliths.

A recent study by [22] also explored the possibility of using phytoliths as indictors of past water availability. Grasses highly mineralise parts of their cells and bodies with opaline silicates. These so-called phytoliths are considered to be a mechanical defense against herbivory by abrading mammalian tooth enamel and dentine [23].

However, their effectiveness to do so has not been resolved conclusively to date and there are ongoing discussions about the hardness of phytoliths compared to enamel [24]. Silica bodies in plants serve a variety of purposes, including lending the plant structural rigidity by supporting the shoot [25], giving lodging (falling over) resistance [16] and giving mechanical strength and rigidity to leaves [26]. Their hardness deters obvious predators [7] and owing to their ability to wear down tooth enamel, they might even provide some (indirect) resistance to mammals, such as Homosapiens [27]. The evolution of horse dentition correlates with increased phytolith content of grasses [28].

A brief survey of twenty two poaceae species has proved the usefulness of phytolith in the identification of grasses. The present paper represents only a preliminary study towards developing an identification key for all south Indian grass based on the morphological phytolith characteristics. Hence it can be assumed that presence of phytolith in poaceae grass species may help protect the plants to some extent by ameliorating the toxic effects of heavy metals. Outcome of the study it an evident that although phytolith produced by poaceae grass species posses a major role in environmental reconstruction and may help in future phytolith studies of the deltaic environments.

CONCLUSION

The phytolith record is the most robust and palential source of information available on the botanical archaeological record. Representative members of family poaceac produce considerable phytolith types, taxonomically some of the phytolith types have been found to serve as diagnostic types at different levels of taxonomic hierarchy and hence are useful to resolve taxonomic problems because taxonomists have been regularly using characters of silica bodies of grasses classification of angiosperms. Present systematic study will bring further enhancement to this knowledge and will also be helpful to palaebotanists and archaeologists in reconstructing the vegetation of plants. Silicon plays an astonishingly large number of diverse role in plants and does so primary when the plants are under stressful conditions and benign conditions its role is often minimal or even nonexistent. The quantitative and morphological analysis of phytoliths from grass species highlights some of the strengths and weaknesses when decoding the archaeological phytolith record. This information is much enhanced by the availability of a reference collection of new grass species that includes information on the morphotypes as well as the numbers of phytoliths weight of the grass species. Apart from their meticulous role in muscles in livestock the *Chloris barbata*, *Alloteropsis cimicina*, *Cynodon dactylon* and *Eragrostis amabilis* mitigate the heavy metal toxicity of drinking water.

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REFERENCES

[1] Currie, H.A., Perry, C.C. 2007. Silica in plants: Biological, biochemical and chemical studies. Ann Bot, 100, pp. 1383–1389.

[2] Epstein, E. 2005. Silicon Annu Rev. Plant Physiol Plant Mol Biol, 50, pp 641–664.

[3] Mitra, S, Mukherjee, S.K. 2005. Ethnobotanical usages of grasses by the tribal of West Dinajpur district, West Bengal, Indian J Trad Knowl, 4(4), pp. 396-402.

[4] Albert, R.M., Weiner, S. 2001. Study of phytoliths in prehistoric ash layers from Kebara and Tabun Caves using a quantitaive approach. In Meunier, J.D., Colin, F. (eds.), *Phytoliths: applications in earth scienses and human history*. A. Balkema Publishers, Lisse, Netherlands, pp. 251–266.

[5] Mazumdar, J., Mukhopadhyay, R. 2009. Opal Phytoliths in Three Indian Thelypteroid Ferns. Bionature 29(1), pp. 11-15.

[6]. Piperno, D.R., 2006. Phytoliths A Comprehensive Guide for Archaeologists and Paleoecologists. Altamira Press, Lanham, pp. 238.

[7] Piperno, D.R., 1988. Phytolith Analysis: An Archaeological and Geological Perspective. Academic Press, New York.

[8] Neethirajan, S., Gordon, R.,Wang, L. 2009. Potential of silica bodies (phytoliths) for nanotechnology. Trends in Biotechnology, 27(8), pp. 461-467.

[9] Mazumdar, J. 2011. Phytoliths of pteridophytes. South African Journal of Botany, 77, pp. 10-19.

[10] Skinner, H.C.W., Jahren, A.H. 2004. Biomineralization. In Biogeochemistry (Treatise on Geochemistry Vol. 8) (Schlesinger, W.H., ed.), pp. 117–184.

[11] Hodson, M.J, White, P.J, Mead, A, Broadley, M.R. 2005. Phylogenetic variation in the silicon composition of plants. Ann Bot, 96(6), pp. 1027–1046.

[12] Hattori, T. 2003. Silicon-induced changes in viscoelastic properties of sorghum root cell walls. Plant Cell Physiol, 44, pp. 743–749.

[13] Yoshida, S., Onishi, Y., Kitagishi, K. 1959. The chemical nature of silicon in rice plants. Soil and Plant Food (Tokyo), 5, pp. 127–133.

[14] Gordon, R. 2009. The Glass Menagerie: diatoms for novel applications in nanotechnology. Trends Biotechnol, 27, pp. 116–127.

[15] Wang, L.J. 2005. Biosilicified structures for cooling plant leaves: a mechanism of highly efficient midinfrared thermal emission. Appl Phys Lett, 87, pp. 194105.

[16] Ma, J.F., Yamaji, N. Silicon uptake and accumulation in higher plants. Trends Plant Sci, 11, pp. 392–397.

[17] Wilding, L.P., Drees, L.R. Biogenic opal in Ohio soils. Soil Sci Soc Am Proc, 35, pp. 1004–1010.

[18] Madella, M.M.K., Jones, P., Echlin, A., Jones Pand Moore, M. 2009. Plant water availability and analytical microscopy of phytoliths: implications for ancient irrigation in arid zones. Quaternary International, 193, pp. 32–40.

[19] Lu, H., Liu, K.B. 2003. Phytoliths of common grasses in the coastal environments of South Eastern USA. Estuarine Coastal and Shelf Science, 58, pp. 587-600.

[20] Fahn, A., Plant anatomy. Pergamon Press, Oxford.

[21] Sangster, A.G., Hodson, M.J. 1997. The State-of-the-Art of Phytoliths in Soils and Plants, eds. Pinilla, A., Juan Tresserras, J., Machado, M. J., (Centro de Ciencias Medioambientales, Madrid). pp. 113–121.

[22] Piperno, D.R., Holst, I., Wessel-Beaver, L., Andres, T.C. 2002. Evidence for the control of phytolith formation in *Cucurbita* fruits by the hard rind (*Hr*) genetic locus: Archaeological and ecological implications, Proc Natl Acad Sci, USA, 99, pp. 10923–10928.

[23] McNaughton, S.J., Tarrants, J.L. 1983. Grass leaf silicification: Natural selection for an inducible defense against herbivores, Proceedings of the National Academy of Sciences United States of America, 80(3), pp. 790-791.

[24] Sanson, G.D., Kerr, S.A., Gross, K.A. 2007. Do silica phytoliths really wear mammalian teeth. Journal of Archaeological Science, 34(4), pp. 526-531.

[25] Kaufman, P.B. 1979. Studies on silica deposition in sugarcane (*Saccharum* spp.) using scanning electron microscopy, energy dispersive X-ray analysis, neutron activation analysis, and light microscopy. Phytomorphology, 29, pp. 185–193.

[26] Namaganda, M., Lye, K.A., Friebe, B., Heun, M. 2009. Leaf anatomical characteristics of Ugandan species of *Festuca* L. (Poaceae). S Afr J Bot, 75, pp. 52–59.

[27] Fox, C.L. Phytolith analysis on dental calculus, enamel surface, and burial soil: information about diet an paleoenvironment. Am J Phys Anthropol, 101, pp. 101–114.

[28] MacFadden, B.J. 2005. Terrestrial mammalian herbivore response to declining levels of atmospheric CO_2 during the Cenozoic: evidence from North American fossil horses (family Equidae). In A History of Atmospheric CO_2 and its Effects on Plants, Animals, and Ecosystems (Cerling, T.E. and Dearing, M.-D., eds), pp. 273–292.

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