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USING GRAINS AS AN EVIDENCE FOR TAXONOMY OF SOME SPECIES OF POACEAE.

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ABSTRACT

Taxonomic relationships using the grains of 14 poaceous wild and cultivated species belong to 6 genera and 5 tribes of Poaceae were studied. Species are; Wild oat (*Avena fatua* L.), Common oat (*Avena sativa* L.), Animated oat (*Avena sterilis* L.), Sudan-grass (*Sorghum x drummondii* Nees ex Stendel), Sorghum (*Sorghum virgatum* (Hack.) Stapf.), Rye-grass (*Lolium multiflorum* Lam.), Rye-grass (*Lolium perenne* L.), Boarded Rye-grass (*Lolium temulentum* L.), Wild millet (*Echinochloa colona* (L.) Link.), Barnyard-grass (*Echinochloa crus-galli* (L.) P. Beauv.), Bristle-grass (*Setaria pumila* (Poiret) Roemer & Schultes), Cannary-grass (*Phalaris canariensis* L.), Lesser cannary-grass (*Phalaris minor* Retz.) and Hood Cannary-grass or White-grass (*Phalaris paradoxa* L.).

The aim of this study was to introduce a classification reflecting the relationships between some wild and cultivated species of Poaceae by using the morphological characters and Scanning Electron Microscope (SEM) characterizations of the grain surface (48 characters) of these species. The numerical method of analysis (Single Linkage Clustering technique) was used to analyze the morphological features and grain surface characteristics.

Morphological description results indicated that the two species; *Sorghum x drummondii* and *Sorghum virgatum* are more close to each other than to any of the other species and could be categorized to the tribe level. The other twelve species ranked in separate tribe levels. *Setaria pumila* was split away from both *Echinochloa* species and ranked in separate tribe called Setarieae. Grain shape and size are considered the most important characters in differentiating between the studied species. Scanning grain of surface revealed twelve features of discriminoting potentiol between studied species. The numerical analysis shows that the studied species are split, in the higher similarity level (1.41), into two groups; one includes both *Sorghum* species and the other includes the remaining species. The proposed keys and classification of species are presented.

INTRODUCTION

Family Poaceae (Gramineae) is one of the largest families of the flowering plants, the number of species only being exceeded by the families Orchidaceae, Asteroceae and Fabaceae. If judged by the number of individuals, the area, which they are covered and the great variety of habitats they are frequent, the grasses are among the most successful of all the angiosperms.

Poaceae comprise about 620 genera and 10000 species, constitute a natural and homogeneous family. Widely dispersed in all parts of the world where plants can survive. Grass plants occur from the equator to near the

poles, often dominating the vegetation in savannas, prairies, steppes and meadows. They extend from sea level to the limit of permanent snow on mountains. They grow in wet and dry regions, from brackish and fresh water to deserts with all situations between the two extremes (Clayton and Renvoize, 1986).

Grasses differ markedly from the rest of plants. Tackholm (1974) reported, that Poaceae represented by 93 genera including 224 species. While, Khnagrey (2000) stated that, the number of genera is 95, which comprise 230 species.

The grass family is of greater importance than any other family of the flowering plants (Jones and Luchsinger (1987), as indicated by the following: (1) food crops for human consumption, rice, wheat, corn, barley, millet, rye, oats, milo and sugar cane; (2) forage and grain for domesticated animals; (3) range forage (in North America - big bluestem, little bluestem, Indian grass, switch grass, blue grama and buffalo grass); (4) industrial uses, ethyl alcohol and starch; (5) shelter bamboo; (6) soil conservation; (7) turf-Bermuda grass, St. Augustine grass, centipede grass, rye grass and bent grass; (8) ornamental plants and (9) wildlife food.

The taxonomic position of family Poaceae was a subject of argument by many taxonomists for a long time (Watson *et al.*, 1985). Therefore, the present study is an attempt to trace the taxonomical relationships among some species of Poaceae that may support or oppose the idea, which suggested that these taxa were ranked in two or more sub-families.

The objective of this study was to obtain a classification reflecting the taxonomical relationships among 14 species of Poaceae using modern taxonomic evidences. The study comprised of three parts each is dealing with particular taxonomic evidence as follows: Morphological descriptions of each species, Scanning Electron Microscope on the grain surface of each species and analyzing the data obtained by using the Single Linkage Clustering technique (Abbott *et al.*, 1985 and Sneath and Sokal, 1973).

The reasons for choosing these species of Poaceae are; the great economic importance of these plants in human consumption or as animals feeds; the necessity of grain identification for Gene Bank purposes, *e.g.* grains of *Lolium temulentum* considered poisonous and it is very important to distinguish these from the other editable grains of *L.perenne*, *L.multiflorum*, *Triticum spp.* and many other Poaceae grains and finally, the taxonomic position problems of some species under some genera, *e.g.* the two species under *Sorghum* and the great similarity between *Echinochloa*, *Phalaris* and *Setaria*, which lead to put them under one genus; *Panicum*. Therefore, this study was undertaken as an attempt to solve these problems.

MATERIALS AND METHODS

In this study, fourteen species belonging to family Poaceae and representing 5 tribes and 6 genera were studied (Table 1). The herbarium specimens and grains of all these species were obtained from the Herbarium and the Gene Bank of the Flora and Phyto-taxonomy Researches Department (CAIM), Horticultural Research Institute, Agricultural Research Center, Dokki, Giza.

The general morphological descriptions for each species were studied and described by using 10 herbarium specimens representing each species. The herbarium specimens were matched against the current text Flora books and the scientific theses in plant taxonomy to ensure that the identification is correct [e.g. Täckholm and Drar (1941), Täckholm (1974), Davis (1985), Naomi (1986), Clayton (1970), Townsend and Evan (1966 & 1988), James (1990), Stace (1992), El-Sahhar (1997).

Grain dimensions were measured by binocular stereo-microscope using ocular micrometer. The general morphological features of the grains were examined using the same microscope. The detailed surface scan features were examined by using Scanning Electron Microscope with different magnifications at 25 kv. The SEM-micrographs were taken after mounting of the completely mature dry grains with SPI supplies on copper stubs and coated with a thin layer of gold palladium in Edwards Sputter Coater Unit, S 150 B. Scanning was carried out by JEOL-JSM T 100 Model Scanning Electron Microscope, Centeral Laboratory, Zagazig University.

Table (1): The studied taxa and their habit according to Albina's Classification 1999.

Tribe		Species	Habit
Aveneae	1.	*Avena fatua* L.	Wild
	2.	*Avena sativa* L.	Cultivated
	3.	*Avena sterilis* L.	Wild
Andropogoneae		*Sorghum x drummondii* (Nees ex Stendel) (synm. *S. sudanense* Piperr Stapfin Prain)	Cultivated
	5.	*Sorghum virgatum* (Hack) Stapf.	Wild
Hordeae	6.	*Lolium multiflorum* Lam.	Cultivated
	7.	*Lolium perenne* L.	Cultivated
	8.	*Lolium temulentum* L.	Wild
Paniceae	9.	*Echinochloa colona* (L.) Link (synm. *Panicum colnum* L.)	Wild
	10.	*Echinochloa crus-galli* (L.) P.Beauv. (synm. *P. crus-galli* L. *P. hispidum* Forssk.)	Wild&Cultivated
		Setaria pumila (Poiret) Roemer & Schultes. (synm. *S. gluca* auct. Non (L.) P. Beauv.) (synm *Panicum glueum* L.)	Cultivated
Phalarideae	12.	*Phalaris canariensis* L.	Cultivated
	13.	*Phalaris minor* Retz.	Wild
	14.	*Phalaris paradoxa* L.	Wild

The SEM-micrographs were used to facilitate the description of grain morphology. The magnification power was expressed by (x) for each SEM photograph. In this investigation, it should be mentioned that the magnification power was in between (x=10) to (x=1000) according to the grain sizes to show the clear and finest details of different surface sculptures.

In case of large-sized grains, which were out of SEM field; *e.g. Avena fatua, A. sativa, A. sterilis, Lolium multiflorum, L. temulentum* and *Sorghum x drummondii,* the stereo-microscope photographs were taken. The stereo-microscope photographs were carried out at National Information and Documentation Center (NIDoC), Dokki, Giza.

Numerical analysis (known also as Phenetic analysis), in this study will be concentrated on the infraspecific level, the rank of Operational Taxonomic Unit (OTU) will be the individual specimens representing species. It should be added that equal number of specimens or OTU of each species (10 specimens) were studied and recorded.

The number of characters used in this study was 48. All these characters should have equal importance. After choosing the characters and the OTUs, the resemblance between the OTUs was calculated using Cluster method; the technique used was Single Linkage Clustering. Data in Table (2) show the 48 characters and character states and codes for numerical analysis.

RESULTS AND DISCUSSION

The present study is devoted to investigate the morphological and surface scan attributes by using light and scanning electron microscopes on grains representing 14 species belonging to 6 genera and 5 tribes of Poacaeae.

Morphology of gains and plants, grain surface scan and the numerical analysis on the studied species are presented in the forms of cumulative tables and plates as well as micro-photographic pictures from stereo microscopy in order to facilitate observation of variations, similarities, correlations and differentiation among the studied species.

Morphological description results indicated that the two species; *Sorghum x drummondii* and *Sorghum virgatum* are more close to each other than to any of the other species and could be categorized to the sub-family or tribe level. While, the other twelve species ranked in a separate tribe level. These species of the following of each genus are; *Lolium* (*L.multiflorum, L.perenne* and *L.temulentum*); genus *Phalaris* (*Ph.canariensis, Ph.minor* and *Ph.paradoxa*); genus *Avena* (*A. fatua, A.sativa* and *A.sterilis*) and the two of genus *Echinochloa* (*E. colona* and *E.crus-galli*) in addition to genus *Setaria* (*S.pumila*).

The results of the morphological descriptions of species can be summarized as follows (Tables 2 and Fig 1).

1- The grouping of *Sorghum x drummondii* and *S.virgatum* at the tribe level is confirmed.

2- The grouping of the remaining twelve species; *Avena fatua, A. sterilis, A.sativa, Phalaris canariensis, Ph.minor, Ph.paradoxa, Echinochloa crus-galli, E.colona, Setaria pumila, Lolium perenne, L.multiflorum* and **L.temulentum is confirmed at the tribe levels**:

A- The grouping of *Avena fatua*, *A.sterilis* and *A.sativa* at the tribe level; Aveneae.

II- The grouping of *Lolium perenne*, *L.multiflorum* and *L.temulentum* at the tribe level; Hordeae.

III- The grouping of *Phalaris canariensis*, *Ph.minor* and *Ph.paradoxa* at the tribe level; Phalarideae.

Table (2): Descriptions of 48 Characters and Character States for Morphological and Numerical Analysis.

Species / Characters	*Avena fatua*	*Avena sterilis*	*A.sativa*	*Phalaris canariensis*	*Phalaris minor*	*Phalaris paradoxa*	*Echinochloa crus-galli*
1- Plant duration	annual	annual	annual	annual	annual	annual	annual
2- Stem position	erect	erect	erect	erect	erect or kneed at base	erect or kneed at base	erect
3- Stem surface	glabrous	course	glabrous	glabrous	glabrous	glabrous	glabrous
4- Branching	lower & upper part	lower & upper	lower part	lower part	lower part	lower part	Lower part
5- Stem thickness	thin	thin	thick	thin	thin	thin	Thin
6- Stem length cm.	100	100	100	60	70	50	90
7- Base colour	coloured	coloured	coloured	coloured	coloured	coloured	coloured
8- Node colour	coloured	coloured	coloured	coloured	coloured	coloured	coloured
9- Leaf length cm.	less than 15	15 or more	15 or more	15 or more	15 or more	15 or more	less than 15
10- Leaf width mm.	less than 5	more than 5	more than 5	more than 5	more than 5	more than 5	less than 5
11- Midrib	not prominent	not prominent	Not prominent	not prominent	not prominent	not prominent	not prominent
12- Leaf blade edge	glabrous	hairy	hairy	glabrous	glabrous	glabrous	labrous
13- Leaf blade texture	hairy	glabrous	glabrous	glabrous	glabrous	glabrous	glabrous
14- Leaf blade glossy	dull	dull	dull	dull	dull	dull	Dull
15- Leaf sheath situation	wide	wide	wide	wide	wide	wide	narrow
16- Leaf colour	pale	pale	pale	pale	pale	pale	Dark
17- Ligule presence	present	present	present	present	present	present	absent
18- Auricles presence	absent	absent	absent	absent	absent	absent	absent
19- Sheath shape	cylindrical	cylindrical	cylindrical	cylindrical	cylindrical	cylindrical	compressed
20- Sheath texture	hairy	hairy	glabrous	glabrous	glabrous	glabrous	glabrous
21- Sheath edge	membranous	membranous	membranous	membranous	membranous	membranous	unmembranous
22- Inflorescence types	open panicle	open panicle	open panicle	closed panicle	closed panicle	closed panicle	closed panicle
23- Cylindrical in inflor.	absent	absent	absent	present	present	present	absent
24- Pyramidical inflor.	present	present	present	absent	absent	absent	absent
25- Lanceolate inflo.	absent	absent	absent	absent	absent	absent	present
26- Arrangement of spikelets	regular	regular	regular	irregular	irregular	irregular	regular
27- Rachis texture	glabrous	glabrous	smooth	smooth	smooth	smooth	smooth
28- No. of flower per spikelet	2-3	2-3	2-3	3	3	3	2
29- Second glumes presence	present	present	present	present	present	present	present
30- Glume texture	glabrous	glabrous	glabrous	glabrous	Glabrous or few hairs	glabrous	glabrous
31- Lemma texture	hairy	hairy	hairy	hairy	Hairy	hairy	glabrous
32- Awn presence	present	present	absent	absent	absent	absent	Absent
33- Ellipsoid shape	absent	absent	absent	absent	absent	absent	Present
34- Grain shape	linear-oblong	linear-oblong	linear-oblong	oblanceolate-obovate	narrowly ovoid	broadly elliptic	Elliptic
35- Grain length mm	6.0	8.0	8.5	4.0	1.0	2.0	2.0
36- Grain width mm	1.5	2.0	2.5	2.0	1.0	1.0	1.5
37- Grain texture	densely hairy	few hair	few hair	smooth	smooth or few hair	smooth	smooth
38- Grain colour	cream	cream to brown	brown	cream to black	black	Cream	Black cream to brown
39- Grain mature glossy	dull	dull	dull	shiny	dull	Shiny	shiny
40- Grain grade	large	large	large	large	small	Small	small
41- Grain mature stage	dehesent	dehesent	indehesent	indehesent	dehesent	dehesent	indehesent
42- Oblong shape	present	present	present	present	present	present	absent
43- Ellipsoid shape	absent	absent	absent	absent	absent	present	present
44- Narrowly ovoid shape	absent	absent	absent	absent	present	absent	absent
45-Outer perclinal wall shape	flattenedd	clearly depressed	more deep	shallow depressed	smooth	disintedrated	shallow raised
45- Epidermis appearence	favulariate	rugose	rugose	scalariform	punctuate	rugose	favulariate-foveate
47- Anticlinal wall level	slightly raised	rounded end	sharply raised	sharply raised	smooth	slightly raised	slightly depressed
48- Anticlinal wall texture	densely hairy	sparsely hairy	sparsely hairy	smooth	sparsely hairy	smooth	smooth

(cont.)

Table 2 cont.

Species Characters	*Echinochloa colona*	*Setaria pumila*	*Lolium perenne*	*Lolium multiflorum*	*Lolium temulentum*	*Sorghum x drummondii*	*Sorghum virgatum*
1- Plant duration	annual	annual	perennial	perennial or annual	annual	annual	perennial or annual
2- Stem position	kneed at base	erect or kneed at base	erect	erect	erect	erect	erect
3- Stem surface	glabrous	glabrous	glabrous	glabrous	glabrous	Glabrous	glabrous
4- Branching	lower part	lower part	lower part	lower part	lower &upper parts	lower part	lower part
5- Stem thickness	thin	Thin	thin	thin	thin	thick	thick
6- Stem length cm.	40	60	90	100	60	300	200
7- Base colour	coloured	uncoloured	coloured	coloured	coloured	uncoloured	uncoloured
8- Node colour	coloured	colourless	coloured	coloured	coloured	coloured	coloured
9- Leaf length cm.	less than 15	less than 15	less than 15	larss than 15	less than 15	15 or more	15 or more
10- Leaf width mm.	less than 5	less than 5	less than 5	less than 5	less than 5	more than 5	more than 5
11- Midrib	not prominent	not prominent	not prominent	not prominent	not prominent	prominent	prominent
12- Leaf blade edge	galbrous	hairy	galbrous	glabrous	glabrous	hairy	hairy
13- Leaf blade texture	glabrous	hairy	glabrous	glabrous	glabrous	hairy	hairy
14- Leaf blade glossy	dull	dull	shiny	shiny	dull	dull	dull
15- Leaf sheath situation	narrow	narrow	narrow	narrow	narrow	wide	wide
16- Leaf colour	dark	pale	pale	pale	dark green	dark	dark
17- Ligule presence	absent	absent	present	present	present	absent	absent
18- Auricles presence	absent	absent	present	present	present	absent	absent
19- Sheath shape	compressed	cylindrical	cylindrical	cylindriacl	cylindrical	cylindrical	cylindrical
20- Sheath texture	glabrous	glabrous	glabrous	glabrous	glabrous	glabrous	glabrous
21- Sheath edge	unmembranous	unmembranous	unmembranous	unmembranous	unmembranous	unmembranous	unmembranous
22- Inflorescence types	closed panicle	closed panicle	spike	spike	spike	open panicle	open panicle
23- Cylindrical in inflor.	absent	present	absent	absent	absent	absent	absent
24- Pyramidical inflor.	absent	absent	absent	absent	absent	present	present
25- Lanceolate inflo.	present	absent	present	present	present	absent	absent
26- Arrangement of spikelets	regular	irregular	regular	regular	regular	regular	regular
27- Rachis texture	smooth	hairy	smooth	smooth	smooth	hairy	hairy
28- No. of flower per spikelet	2	2	several	several	several	2	2
29- Second glumes' presence	present	present	absent	absent	absent	present	present
30- Glume texture	glabrous	glabrous	glabrous	glabrous	glabrous	hairy	hairy
31- Lemma texture	glabrous	glabrous	glabrous	glabrous	glabrous	glabrous	glabrous
32- Awn presence	absent	absent	absent	present	present	present	present
33- Ellipsoid shape	present	present	absent	absent	absent	present	absent
34- Grain shape	elliptic	broadly elliptic	linear-oblong	linear-oblong	linear-oblong	elliptic	lanceolate-ovoid
35- Grain length cm	less than 1	less than 1	less than 1	less than 1	less than 1	less than 1	less than 1
36- Grain width mm	less than 2	less than 2	less than 2	less than 2	2	2	2
37- Grain texture	glabrous	glabrous	glabrous	glabrous	glabrous	glabrous	glabrous
38- Grain colour	gray	black maroon	cream	black	brown	brown	brown
39- Grain mature glossy	dull	shiny	dull	dull	dull	shiny	dull
40- Grain grade	small	small	large	large	large	large	small
41- Grain mature stage	dehescent	indehiscent	dehescent	dehescent	indehiscent	indehiscent	dehiscent
42- Oblong shape	absent	absent	present	present	present	absent	absent
43- Ellipsoid shape	present	present	absent	absent	absent	present	absent
44- Narrowly ovoid shape	absent	absent	absent	absent	absent	absent	absent
45- Outer perclinal wall shape	disintegrated forming geometrical holes	raised	raised disintegrated forming holes	shallow raised with some radiated structures	disintegrated forming square holes	sharp toothed or smooth	toothed
46- Epidermis appearence	rugose-punctate	favulariate -striate	weak scalariform	reticulate-foveate	rugose-crocked	reticulate-rugose	sulcate-reticulate
47- Anticlinal wall level	slightly raised	depressed	slightly depressed	slightly depressed formed small groove	slightly raised	sharply depressed	deeply grooved
48- Anticlinal wall texture	smooth	smooth	smooth	smooth	smooth	smooth	smooth

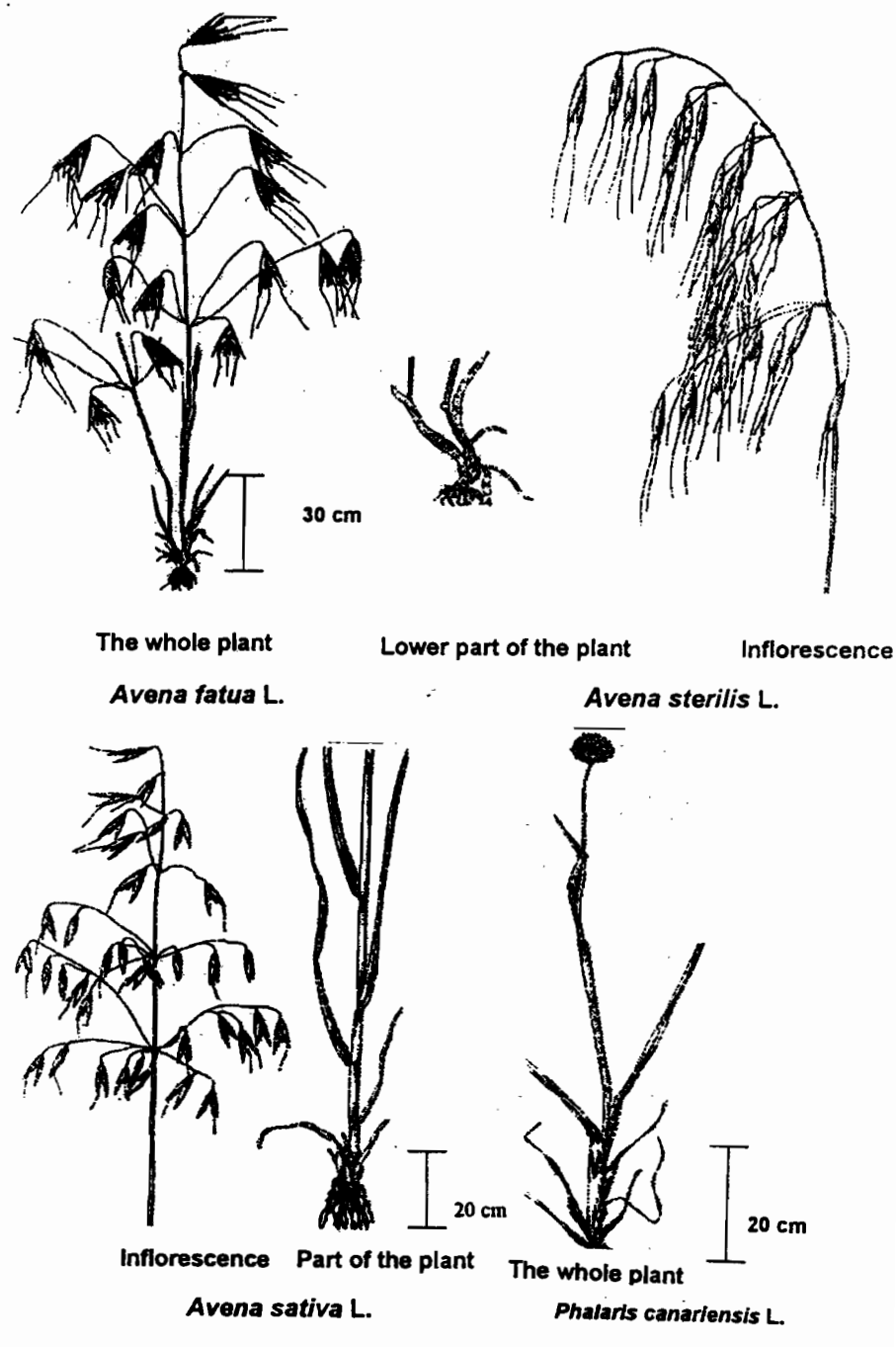
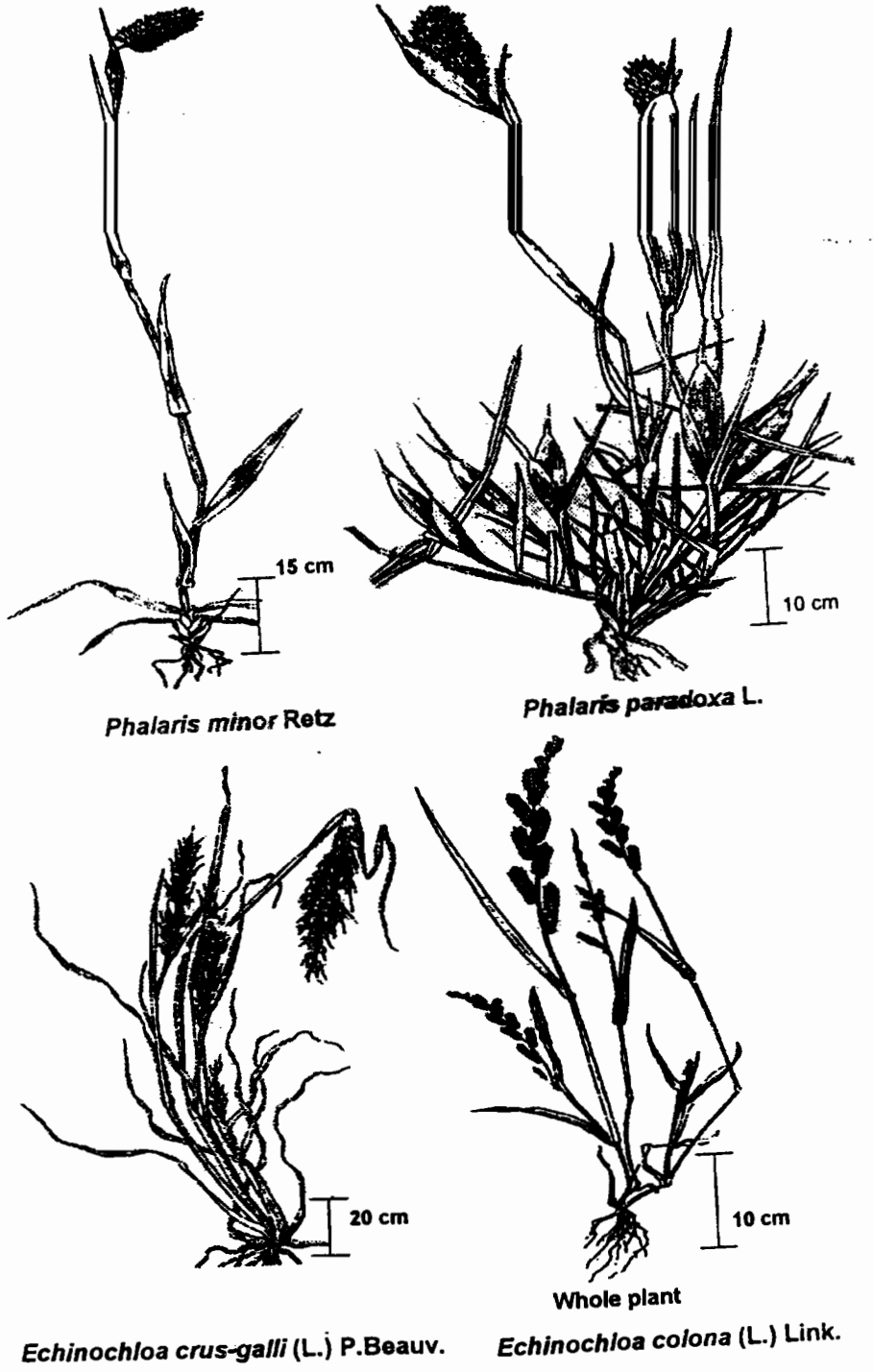


Fig. (1): Drawings illustrating habit of mature plants and inflorescences under investigation. (cont.)



Phalaris minor Retz

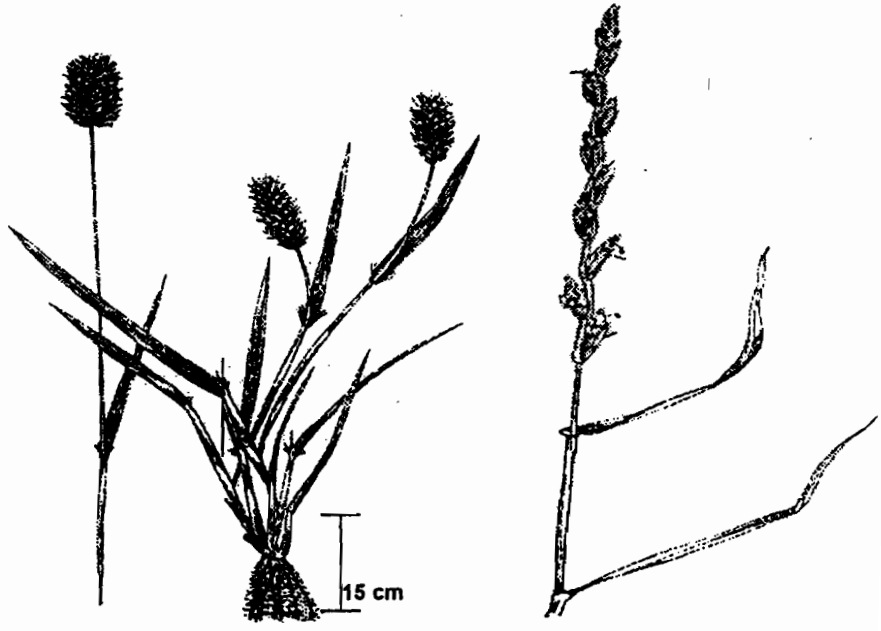
Phalaris paradoxa L.

Echinochloa crus-galli (L.) P.Beauv.

Whole plant

Echinochloa colona (L.) Link.

Fig. (1 Cont.)



Inflorescence Whole plant

Setaria pumila (Poiret) Roerner ex Schultes

Inflorescence

Lolium perenne L.

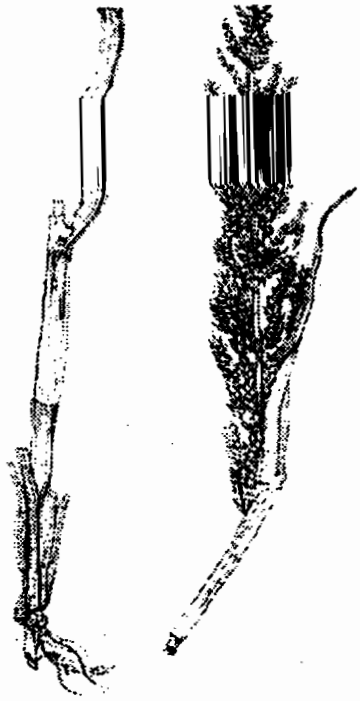
Inflorescence

Lolium multiflorum Lam.

Whole plant.

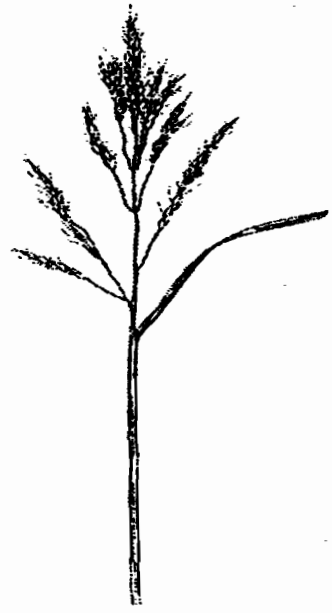
Lolium temulentum L.

Fig. (1 Cont.)



Lower part of the plant Inflorescence

13- *Sorghum x drummondii* (Nees ex Steudel.) Millsp ex Chase



Inflorescence

14- *Sorghum virgatum* Hack.

Fig.1 cont.)

IV- Both *Echinochloa* species; *Echinochloa colona* and *E. crus- galli* are clearly delimited at the tribe level; Paniceae.

V- *Setaria* is distinguished as a tribe by itself defined as tribe Setarieae and included *Setaria pumila.*

From morphological descriptions of the grain of the studied species; grain shape, colour, length, width, dimensions and grade were found the most importantant characters in differentiating among the studied species (Table 3, Plate 1).

Results of morphological descriptions and grain surface features of each species are significant provide good taxonomic evidences for differentiating the species of Poaceae at different levels. In this work, relatively large number of qualitative and quantitative grain aspects was recorded to evaluate the taxonomic relationships among the studied species.

Some workers (Chung & Heckard, 1972 and Tantawy & Rabie, 2000) used the grain colour in their classifications and supported the present results. While, others (Hussein, 1995) considered the grain colour has a very limited taxonomic value. He stated also that, this aspect is not considered among the good ones for its possible fluctuation with the same taxon at different duration.

Furthermore,the justification of this rejection is supported by the fact that the grain colour is an attribute, which depends largely on the metabolic activities within the plant and the acting environmental conditions(Karakish, 1996).

Stebbins (1974) agreed with the present results and emphasized that the precise adjustment of grain size is often highly adaptive and the reproductive success is dependent upon strong buffering and canalization of the processes involved in grain development.

Table (3): Morphological descriptions of the grain of the studied species.

Species	Shape	Colour	Length mm	Width mm	L x W mm^2	Grade
Avena fatua	Linear-oblong	Cream	6	1.5	9	L
Avena sterilis	Linear-oblong	Cream to Brown	8	2	16	L
Avena sativa	Linear- oblong	Cream	8.5	2.5	21.25	L
Sorghum x drummondii	Elliptic	Brown	4.5	2.5	10.25	L
Sorghum virgatum	Lanceolate-ovoid	Brown	3	4.5	4.5	S
Lolium perenne	Linear- oblong	Cream	4.5	1.5	6.75	L
Lolium multiflorum	Linear- oblong	Black	5	1.5	7.5	L
Lolium temulentum	Linear- oblong	Brown	6.5	2.5	16.25	L
Echinochloa crus-galli	Elliptic	Cream	2	1.5	3	S
Echinochloa colona	Elliptic	Gray	2	1	2	S
Setaria pumila	Broadly elliptic	Black maroon	3	2	6	L
Phalaris canariensis	Oblanceolate obovate	Cream to Black	4	2.0	6	L
Phalaris minor	Narrowly ovoid	Black	2.5	1	2.5	S
Phalaris aradoxa	Broadly elliptic	Cream	2	1	2	S

S: less than 6 mm. L: equal to or greater than 6 mm

While, others; *e.g.* Thompson (1992), Mourad (1988), and Powell & Armstrong (1980) disagreed and stated that, such an attribute is subjected to ecological and physiological variations and is unreliable for both identification and differentiation.

Results of Moreno *et al.* (1994), Petrova *et al.* (1993) and Bernard (1998) on grain morphology, cuticle surface and thickness, spacing between macro and micro-sclereids and testa characters indicated that, these characters were useful in distinguishing between bean species. These results were in accordance with the present results on grain morphology and testa characters. Duke (1961) reported that, the grain structure, in general, provides a rather critical indication of the systematic positions of the grains or seeds.

Voughan (1968) suggested that the structure of the mature seeds or grains, especially the testa structure, considered the more taxonomic useful information. Corner (1976) stated that, grains are considered the most strongly inherited part of the plant and the taxonomic significance could not relate to the environmental selections.

Yeh and Kakuma (1990) agreed with the present results and suggested 'that grain characters (shape, colour, coat patterns, size, and outer arils) lead to better criteria for species identification and support the taxonomical positions of taxa. Peinado *et al.* (1971) provided a key to 13 species of *Trifolium* based on size and weight of seeds.

Sharma *et al.* (1983) studied the surface features of seed coats of some species of Fabaceae by scanning electron microscope. They reported that the grouping of populations based on seed coat pattern confirmed by the classification proposed based on the multivariate statistical analysis. In the last 25 years, seed data significantly employed as a criterion for taxonomic treatments. More detailed structural information about seeds obtained by using the Scanning Electron Microscope (Stace, 1984).

The general features of epidermis, anticlinal walls (level, texture) and the outer periclinal wall were represented in Table 4 & Plate 2. The descriptive terms of seed surface scan as cited by Murley (1951) and modified by Stearn (1983).

The results revealed that there are twelve features of the grain surface (Table 4 – Plate 2), could be recognized on the studied species as follows: epidermal cell favulariate in *Avena fatua*; rugose in *A.sterilis, A.sativa* and *Phalaris paradoxa*; rugose associated with crocks allover the surface in *Lolium temulentum*; favulariate-striate regular with structures looks like chains in *Setaria pumila*; favulariate-foveate in *Echinochloa crus-galli*; scalariform in *Phalaris canariensis;* weak scalariform in *Lolium perenne*; punctate in *Phalaris minor*; rugose-punctate in *Echinochloa colona*; reticulate-foveate in *Lolium multiflorum*; reticulate-rugose in *Sorghum x drummondii* and sulcate-reticulate in *Sorghum virgatum*.

Hussein (1995) agreed with the present results on the epidermis features and on the anticlinal walls, and stated that, under Scanning Electron Microscope analysis, grain characters used as a key to distinguish taxa and handled by botanists and sometimes archeologists.

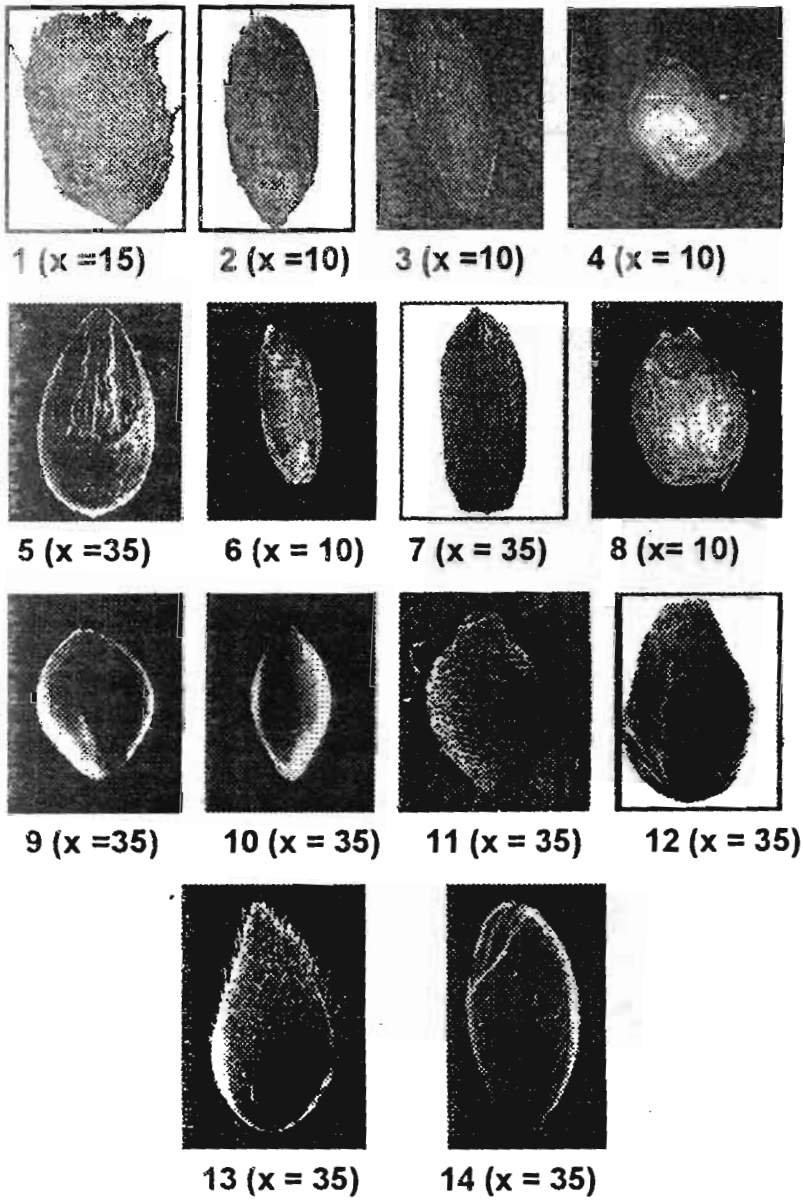


Plate 1: Grain Shape as shown by SEM and Stereo Microscope
Key : 1- *Avena fatua*, 2- *A.sativa*, 3- *A.sterilis*, 4- *Sorghum x drummondii*, 5- *S.virgatum*,, 6- *Lolium multiflorum*, 7- *L.perenne*, 8- *L.temulentum*, 9- *Echinochloa colona* 10- *E.crus-galli*, 11- *Setaria pumila*, 12- *Phalaris canariensis*, 13- *Ph.minor*, 14- *Ph.paradoxa*.

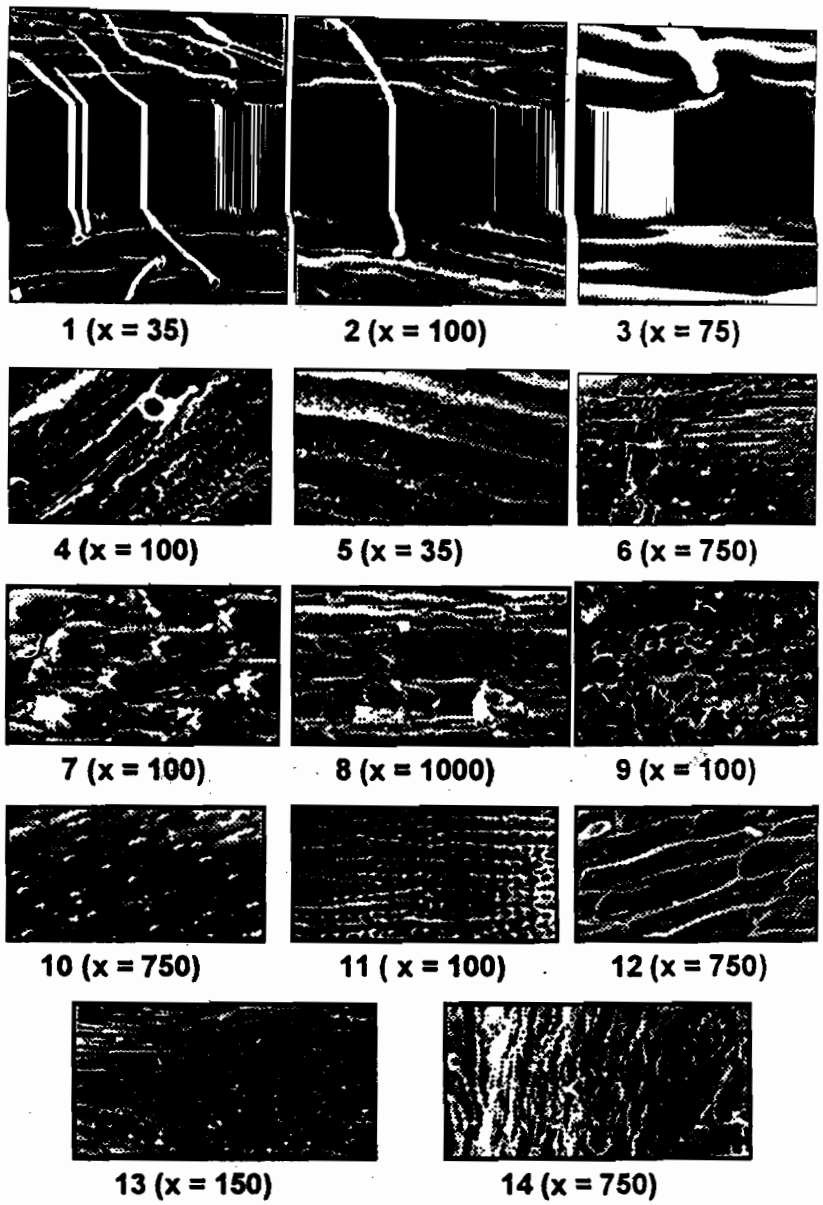


Plate 2: Grain surface scan shape as shown by SEM.
Key : 1- *Avena fatua*, 2- *A.sativa*, 3- *A.sterilis*, 4- *Sorghum x drummondii*, 5- *S.virgatum*, 6- *Echinochloa colona*, 7- *Lolium multiflorum*, 8- *L.perenne*, 9- *L.temulentum*, 10- *E.crus-galli*, 11- *Setaria pumila*, 12- *Phalaris canariensis*, 13- *Ph.minor*, 14- *Ph.paradoxa*.

Barthlott (1981), Barthlott and Frolich (1984) and Clougher (1990) pointed that, based on SEM examinations of about 5000 seeds as a survey on their epidermal surface characters to be applied in taxonomy.

Numerical analysis

The descriptions of the 48 characters used for computation and their codes, in addition to the morphological characters and grain scan features were given earlier. The phenogram (Fig.2) produced by the species have highest average taxonomic similarity value of 1.41. At this level, the studied species are divided into two groups; the first group, which is distinguished at level 0.93, includes *Sorghum x drummondii* and *S.virgatum*. Within that group, *Sorghum x drummondii* is distinguished at level 0.90 and *Sorghum virgatum* at level 0.88. The second group is divided into two sub-groups at the 1.37 level; *Avena* is splitted as a first sub-group at the 1.06 level. Within sub-group *Avena*; *A. fatua* is distinguished at level 1.02, *A. sterilis* at the level 0.86 and *A.sativa* at level 0.92. While, the second major sub-group is distinguished at the 1.37 level and is divided into two clusters; one includes *Phalaris* species, which is distinguished at level 0.98 (*Ph.canarensis* at level 0.91, *Ph.minor* at level 0.82 and *Ph.paradoxa* at level 0.96) and the other cluster includes *Echinochloa* species at level 0.85 (*E.colona* at level 0.82, *E.crus-galli* at level 0.76) and *Setaria pumila* at level 1.10). The other cluster, includes group of *Lolium* species, which is distinguished at level 0.99. Within that group; *Lolium multiflorum* is distinguished at level 0.75; *Lolium perenne* at level 0.90 and *Lolium temulentum* at level 0.98.

Table (4): Morphological Descriptions of the Studied Species Using SEM.

Characters / Species	Features of epidermis	Anticlinal walls Level	Anticlinal walls Texture	Outer periclinal walls
Avena fatua	Favulariate	Slightly raised	dense Hairy	Flattened
Avena sterilis	Rugose	Rounded end	few Hairy	Clearly depressed forming wide groove
Avena sativa	Rugose	Sharply raised	few Hairy	More deep forming clear groove
Sorghum x drummondii	Reticulate-rugose	Sharply depressed	Smooth	Sharp toothed or smooth
Sorghum virgatum	Sulcate-reticulate	Deeply grooved	Smooth	Toothed
Lolium perenne	Weak scalariform	Slightly depressed	Smooth	Raised- disintegrated forming holes
Lolium multiflorum	Reticulate-foveate	Slightly depressed Formed small Groove	Smooth	Shallow raised with some radiated structures
Lolium temulentum	Rugose crocked	Slightly raised	Smooth	Disintegrated forming square holes
Echinochloa crus-galli	Favulariate-foveate	Slightly depressed	Smooth	Shallow raised
Echinochloa colona	Rugose-punctate	Slightly raised	Smooth	Disintegrated forming geometrical holes
Setaria pumila	Favulariate striate	Depressed	Smooth	Raised
Phalaris canariensis	Scalariform	Sharply raised	Smooth	Shallow depressed
Phalaris minor	Punctuate	Surface smooth with few hairs at apex and no sharp difference between both anticlinal and outer periclinal walls		Smooth
Phalaris paradoxa	Rugose	Slightly raised	Smooth	Disintegrated forming deep grooves

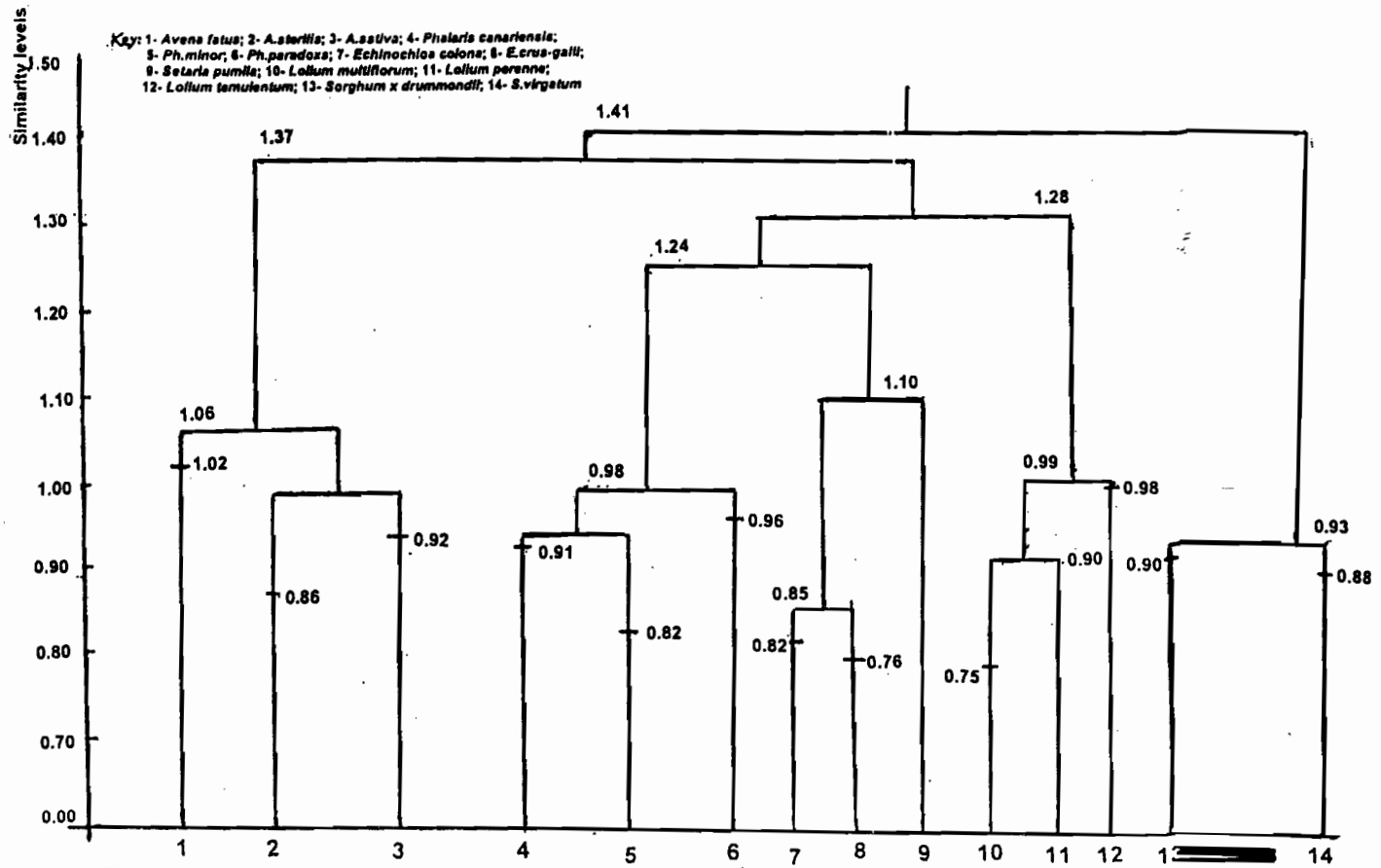


Fig. (2) : Cluster dendrogram of 14 OTUs based on similarity matrix using Single linkage analysis technique.

The cluster, which includes *Phalaris* species is linked with the cluster includes both *Echinochloa* species and *Setaria pumila* at similarity level 1.24. In turn, this exclusive cluster is linked with the cluster includes *Lolium* species at level 1.28. *Avena* species cluster is linked with the cluster of *Phalaris, Echinochloa, Setaria* and *Lolium* at level 1.37. Finally, and at similarity level 1.41 *Sorghum* cluster is linked with the large cluster, which includes the rest of species.

The present results on numerical analysis are in accordance with those published in the previous taxonomic treatments of taxa by Airyshow (1985), Clayton and Renvioze (1986) and Albina (1999),

The following keys were proposed to distinguish the studied species. Keys that already considered based on the general morphological features; the caryopsis and caryopsis without lemma and palea with different surface scan patterns.

- Key based on the general morphological characters of the studied species.

A. Inflorescence a spike, auricles present.
  B. Branching in lower and upper parts, lamina is dark green and dull ——— *Lolium temulentum*
  BB. Branching in lower part only, lamina is shiny.
    C. Awn usually absent ——— *L. perenne*
    CC. Awn present ——— *L. multiflorum*

AA. Inflorescence a panicle, auricles absent.
  D. Sheath hairy, lemma hairy.
    E. Stem glabrous, base reddish, nodes green leaf < 15 mm ——— *Avena fatua*
    EE. Stem coarse, base and nodes reddish, leaf > 15 mm ——— *Avena sterilis*
  DD. Sheath glabrous, lemma glabrous.
    F. Stem thick, nodes green, inflorescence pyramidical, spikelet awned.
      G. Branched in lower and upper parts, sheath margin membranous, mid-vein not prominent, rachis and glumes glabrous ——— *A.sativa*
      GG. Branched in lower part only, sheath margin not membranous, mid-vein prominent, rachis and glumes hairy.
        H. Rizome absent, panicle large and hairy ——— *Sorghum x drummondii*
        HH. Rhizome present and short, panicle long and narrow ——— *Sorghum virgatum*
    FF. Stem thin, nodes reddish, lower lemma often awned, sheath compressed, spikelets regular in ranks, ligule absent ——— *Echinochloa crus-galli*
    FFF. Stem kneed at base, thin, nodes reddish, spikelets awnless.
      I. Inflorescence lanceolate, spikelets regular in ranks, ligule absent, sheath compressed ——— *Echinochloa colona*
      II. Inflorescence cylindrical, spikelets irregular not in ranks, ligule present, sheath cylindrical.

J. Lamina hairy, rachis hairy, erect or kneed at base
---------- *Setaria pumila*
JJ. Lamina glabrous, rachis glabrous.
K. Inflorescence with fertile and Sterile spikelets
---------- *Phalaris paradoxa*
KK. Inflorescence of fertile spike only.
L. Culm erect, glumes sensitive, glabrous
----------*Ph. canariensis*
LL. Culm erect or kneed at base, glumes
few toothed upwards ----------*Ph.minor*

- Key based on caryopsis (outline)

A. Caryopsis awned
B. Caryopsis hairy.
C. Caryopsis solitary ----------*Avena fatua*
CC. Crayopsis in pairs ---------- *A. sterilis*
BB. Caryopsis glabrous
D. Caryopsis shiny, ellipsoid shaped, indehiscent.
----------*Sorghum x drummondii*
DD. Caryopsis dull, oblong shaped
E. Caryopsis indehescent, thick, awn short.
----------*Lolium temulentum*
EE. Caryopsis dehescent, thin
F. Width 2 mm, long and kneed awn.
----------*Sorghum virgatum*
FF. Width < 2 mm, straight awn
G. Awn short ----------*L. perenne*
GG. Awn long ---------- *L. multiflorum*
AA. Caryopsis awnless
H. Caryopsis dull
I. Caryopsis insehescent, oblong, width > 2 mm, length > 1 cm ---------- *A.sativa*
II. Caryopsis dehescent, width < 2 mm, length ? 1 cm
J. Shape oblong, nacked glumes ---------- *Phalaris minor*
JJ. Shape boardly elliptic, plano-convex in profile.
---------- *Echinochloa colona*
HH. Caryopsis shiny
K. Caryopsis dehescent, oblong with narrow groove, cream palea, enclosed in the glumes, small, width about 1 mm
---------- *Ph. paradoxa*
KK. Caryopsis indehescent, width > 1 mm
L. Shape oblong, width about 2 mm, cream to black colour ----------*Ph. canariensis*
LL. Shape ellipsoid, width < 2 mm
M. Colour dark cream to brown
----------*Echinochloa crus-galli*
MM. Colour black maroon---------- *Setaria pumila*

- Key based on caryopsis without lemma and palea with different scan patterns

A. Caryopsis hairy

B1. Surface pattern favulariate; anticlinal wall slightly raised dense hairs, the outer periclinal wall some what flattened, oblong shape ---------- *Avena fatua*

B2. Surface pattern rugose, oblong shape

C. anticlinal wall sharply raised; outer periclinal wall more deep forming clear groove, thick grain ---------- *A. sativa*

CC. anticlinal wall rouded end; outer periclinal clearly depressed forming wide groove, thin grain ---------- *A.sterilis*

B3. Surface pattern punctuate, few hairs, ovoid shape. ---------- *Phalaris minor*

AA. Caryopsis glabrous

D1. Surface pattern rugose; anticlinal wall slightly raised

E. Grain oblong shape, thick, shallow, outer periclinal wall disintegrated forming square holes ---------- *Lolium temulentum*

EE. Grain broadly elliptic shape, thin, outer periclinal wall disintegrated forming deep grooves ---------- *Phalaris paradoxa*

D2. Surface pattern rugose-punctate; anticlinal wall slightly raised; outer periclinal wall disintegrated forming geometrical holes, grain elliptic shape ---------- *Echinochloa colona*

D3. Surface pattern favulariate-foveate; anticlinal wall slightly depressed, the outer periclinal wall shallow raised, grain elliptic shape ---------- *E. crus-galli*

D4. Surface pattern favulariate-striate, anticinal wall depressed, the outer periclinal wall raised. Grain broadly elliptic---------- *Setaria pumila*

D5. Surface pattern scalariform

F. Anticlinal wall sharply raised, the outer periclinal wall shallow depressed, oblanceolate obovate. ---------- *Phalaris canariensis*

FF. Anticlinal wall slightly depressed, the outer periclinal wall raised and some of them disintegrated forming holes, weak scalariform, narrowly oblong shape ----------*Lolium perenne*

D6. Surface pattern reticulate-foveate, anticlinal wall slightly depressed forming groove, the outer periclinal wall shallow raised with some radiated structures, narrowly oblong shape ----------*Lolium multiflorum*

D7. Surface pattern reticulate-rugose, anticlinal wall sharply depressed, the outer periclinal wall consists of sharp toothed or smoothed, elliptic shape ---------*Sorghum x drummondii*

D8. Surface pattern sulcate-reticulate, anticlinal wall deeply grooved, the outer periclinal wall toothed, lanceolate ovoid.
----------*Sorghum virgatum*

CONCLUSION

In conclusion, a classification for the studied species of Poaceae is proposed being as follows:

Family : Poaceae (restricted to 14 studied species)
- I) Sub-family : Festucoideae
  - 1- Tribe : Aveneae
    - : *Avena*
      - *Avena fatua* L.
      - *Avena sativa* L.
      - *Avena sterilis* L.
  - 2- Tribe : Hordeae
    - : *Lolium*
      - *Lolium multiflorum* Lam.
      - *Lolium perenne* L.
      - *Lolium temulentum* L.
  - 3- Tribe : Phalarideae
    - : *Phalaris*
      - *Phalaris canariensis* L.
      - *Phalaris minor* Retz.
      - *Phalaris paradoxa* L.
- II) Sub-family : Panicoideae
  - 1- Tribe : Andropogoneae
    - : *Sorghum*
      - *Sorghum x drummondii* Nees ex Stendel
      - *Sorghum virgatum* (Hack) Stapf
  - 2- Tribe : Paniceae
    - : *Echinochloa*
      - *Echinochloa colona* (L.) Link.
      - *Echinochloa crus galli* (L.) P.Beauv
  - 3- Tribe: Setarieae
    - : *Setaria*
      - *Setaria pumila* (Poiret) Roemer & Schulter

The sub-family Panicoideae, according to the previous review, was divided into two tribes; the first is Andropogoneae (with both *Sorghum* species) and the second tribe is Paniceae (with both *Echinochloa* species and *Setaria pumila*). It is worthy to notice from the proposed classification mentioned above, that the tribe Paniceae included only both *Echinochloa* species for their similarities in most of the studied characters. While, the *Setaria pumila* ranked separately away from them under different tribe called Setarieae. This new proposed classification based on the great differences in

most of the characters studied in this investigation between both *Echinchloa* species and *Setaria pumila* as mentioned earlier.

The present information about the studied species of Poaceae could be handled by further studies in the field of grain bank, plant genetic resources and biodiversity data management. Thus, this study is considered as complementary contributions in the modern trends.

The present study is considered as a survey on the morphological features, scanning electron microscope on the grain surface and phenetic analysis of the chosen species, which may be useful for further studies on grains and/or gene bank requirements.

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استخدام الحبوب كدليل تقسيمى لبعض الانواع من الفصيلة النجيلية.

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أجريت دراسة للعلاقات التصنيفية بين أربعة عشر نوعا نباتيا من الفصيلة النجيلية وكانت الانواع تمثل ستة أجناس وخمس عشائر. والانواع هى : الدوسر أو الشوفان – الزمير أو الزيوان – حشيشة السودان – حشيشة الفرس أو الجراوة – الرجلة – الجازون – الشيلم – أبوركبه أو حشيشة أتارب – الدنيبة أو دهنان – ذيل الفأر – أكل العصفور – شعر الفأر – الخرفار.

ويهدف هذا البحث الى وضع نظام تقسيمى يظهر العلاقات التصنيفية بين الانواع (الوحدات التصنيفية) تحت الدراسة باستخدام الصفات المورفولوجية وخصائص سطح الحبوب (٤٨ صفة) فى التعرف على تلك العلاقات لتداولها كمعايير ودلائل مستقبلية فى التقسيم. وقد أمكن عرض النتائج المورفولوجية المظهرية للحبوب وأصفات المسح السطحى لها باستخدام المجهر الضوئى والمجهر الماسح الالكترونى والتحليل العنقودى العددى فى جداول ولوحات مجمعة وايضاح هذه النتائج بالصور الفوتوغرافية الدقيقة للحبوب فى محاولة لتسهيل ملاحظة اوجه الاختلاف والتشابه بين الوحدات المدروسة.

أوضحت نتائج الوصف المورفولوجى للانواع تحت الدراسة الى أن النوعين حشيشة السودان وحشيشة الفرس كانا من أكثر الانواع تشابها لبعضهما البعض عنه لبقية الانواع الاخرى وتم تصنيفهم فى مستوى عشيرة منفصلة. وكذلك الحال بالنسبة الى الانواع الاخرى حيث وضعت الانواع التابعة لجنس واحد فى عشيرة مستقلة. وقد انفصل النوع ذيل الفأر عن النوعين أبوركبه والدنيبه كلا فى عشيرة منفصلة. تبعا للصفات المورفولوجية المظهرية للحبوب وجد أن صفتى شكل وحجم الحبة تمثل صفات تشخيصية رائدة للفصل بين الوحدات تحت الدراسة. اوضحت نتائج المسح السطحى للحبوب باستخدام المجهر الماسح الالكترونى أن هناك أحدى عشر شكلاً مختلفاً لسطح حبوب بعض الانواع تحت الدراسة بالاضافة الى وجود ثلاثه أشكال متشابهة لسطح حبوب الزمير والزيوان والخرفار.

أمكن التمييز بين الفئات التصنيفية باستخدام التحليل العنقودى العددى للصفات لاختلاف ارتباط الخصائص بين المجموعات تحت الدراسة. حيث اتضح من التحليل أن الانواع المدروسة انقسمت الى مجموعتين رئيسيتين عند مستوى تشابة ١,٤١:

- المجموعة الاولى: وتضم الانواع حشيشة السودان وحشيشة الفرس. ويدخل هذة المجموعة انفصل النوع الاول عند مستوى تشابة ٠,٩٠ فى حين انفصل النوع الاخر عند مستوى تشابة ٠,٨٨.
- المجموعة الثانية: وتضم باقى الانواع الاثنتا عشر الباقية والتى انقسمت الى تحت مجموعتين عند مستوى تشابة ١,٣٧ حيث اشتملت تحت المجموعة الاولى على الشوفان عند مستوى ١,٠٢ والزمير عند مستوى ٠,٨٦ وأخيرا زيوان عند مستوى ٠,٩٢. فى حين انقسمت تحت المجموعة الثانية والتى تميزت عند مستوى تشابة ١,٢٨ الى تحت تحت - مجموعتين. ضمت الاولى أكل العصفور - شعر الفأر - والخرفار حيث تميزوا عند مستوى تشابة ١,٢٤ وكذلك الانواع أبو ركبة والدنيبة عند مستوى ٠,٨٥ واخيرا ذيل الفأر عند مستوى ١,١٠. فى حين ضمت الثانية كلا من الرجلة – الجازون - الشيلم وتميزوا عند مستوى تشابة ٠,٧٥ - ٠,٩٠ - ٠,٩٨ على التوالى.

هذا وقد تم اقتراح مفاتيح على أساس الخصائص المظهرية للحبوب والمسح السطحى لها وكذلك الصفات المورفولوجية. وكذلك تم وضع اقتراح لنظام تقسيمى للانواع المدروسة. لذلك يمكن أعتبار هذة الدراسة بمثابة حصر معلوماتى للانواع تحت الدراسة من الناحية المورفولوجية والمسح السطحى الالكترونى لسطح الحبوب والتحليل العنقودى العددى يفيد فى دراسات أخرى مستقبلية فى مجالات دراسة الحبوب والاصول الوراثية والتنوع البيولوجى.