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Taxonomic Relationships Between Some Species of *Dracaena* and Their Related Taxa

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In the present study, 350 macro-micro/morphological (222) and macro-micro/molecular (128) attributes were investigated in 16 species belonging to six genera *viz. Dracaena*, *Agave*, *Cordyline*, *Ruscus*, *Sansevieria* and *Yucca*. UPGMA clustering method was established by using the program NTSYS-pc 2.2. The morphological and anatomical characters as well as the produced bands profile by application each of the isozymes and PCR-ISSR techniques were species-specific; useful in delimitation of almost all the studied taxa. A reassessment of the taxonomic relationships was made by comparing the produced classification with the current systems.

Key words: *Dracaena* - *PCR-ISSR* - Isozymes - Cluster analysis - Molecular - UPGMA - Taxonomy.

Introduction

The genus *Dracaena* L. comprises about 60 species, mainly found in tropical and subtropical Africa (Mabberley, 2008). The center of its diversity is in West Africa, where at least 23 species occur in the Guinea-Congo region (Bos, 1998). *Dracaena* and its related genera especially *Agave* (300 species), *Cordyline* (15 species), *Ruscus* (6 species), *Sansevieria* (60 species) and *Yucca* (40 species) posses common features of

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morphology, inflorescence and grow in similar environments (Heywood, 1978). The relationships among the species of *Dracaena* and the related genera have always been a material of much confusion mainly because of the different approaches to species delimitation, resulted in overlapping of many taxa (Dalhgren *et al.*, 1985 & 1989, Sparg *et al.*, 2004 and Takhtajan, 2009). These were all placed in the family Liliaceae *sensu lato* (Bessey, 1915; Hallier, 1923; Pulle, 1938 and Englar & Diels, 1936). Sometimes, they were segregated in six families i.e. Agavaceae, Amaryllidaceae, Dracaenaceae, Laximanniaceae, Liliaceae *sensu stricto* and Ruscaceae (Dalhgren *et al.*, 1985 & 1989; APG II, 2003 and Takhtajan, 2009). Ambiguously, they are again regrouped but in another family i.e. Asparagaceae *sensu lato* based on the molecular criteria in spite of some clades are not yet completely resolved (APG III, 2009). On the other hand, inconsistency between gross morphology and molecular data at the infrageneric level is reported in *Dracaena* (Buerki *et al.*, 2009).

Many studies were performed on the taxonomic relationships of the genus *Dracaena* and their related taxa by using morphological, anatomical and molecular approaches. However, no combination of more than one line of taxonomic evidence with the molecular criteria was achieved. Thus, the present study consider data from each of the macro (i.e. gross morphology) and micro-morphology; macro-molecular or biochemical markers (i.e. Isozymes) alongside of micro-molecular markers (i.e. Inter-Simple Sequence Repeat; ISSR) in representative species of *Dracaena* and its related genera *viz. Agave*, *Cordyline*, *Ruscus*, *Sansevieria* and *Yucca* in order to: (1) test the consistency between their macro & micro-morphology and molecular characters, (2) shed more light on their leaf epidermal characteristics (LM & SEM), (3) examine diversity of their molecular criteria, and (4) reassessment their taxonomic treatments using numerical approaches.

Material and Methods

The present study comprised 16 taxa grown in Egypt, supplied by Egyptian Botanical Gardens, indicated in Table (1). Identification and nomenclature of the wild Egyptian species (*Dracaena ombet*) follows Täckholm (1974) and Boulos (2005), whereas those of the cultivated species follow Bailey (1949) and Bailey & Bailey (1976). Voucher specimens were kept at (CAIA) Herbarium at Botany Department, Faculty of Science, Ain Shams University, Cairo, Egypt.

Table 1. The studied taxa and their sources

No.	*Taxa*	Source
1	*Agave americana* L.	BGA
2	*A. franzosinii* Baker	BGA
3	*A. sisalana* Perrine	BGA
4	*Cordyline fruticosa* (L.) A. Chev. Kunth	BGA
5	*C. stricta* (Sims) Endl.	BGA
6	*Dracaena draco* (L.) L.	ZBG
7	*D. marginata* Lam.	BGA
8	*D. fragrans* (L.) Ker Gawl.	BGA
9	*D. ombet* Kotschy & Peyr.	OBG
10	*D. reflexa* Lam.	BGA
11	*D. sanderiana* hort. Sander ex Mast.	BGA
12	*D. surculosa* Lindl.	BGA
13	*Ruscus aculeatus* L.	BGA
14	*Sansevieria trifasciata* Prain var. *laurentii* (De Wild.) N. E. Br.	BGA
15	*Yucca aloifolia* L.	BGA
16	*Y. guatemalensis* Baker	BGA

BGA: Botanical Garden, Faculty of Science, Ain Shams University, Cairo, Egypt. OBG: Orman Botanical Garden, Ministry of Agriculture, Giza, Egypt. ZBG: Zohria Botanical Garden, Ministry of Agriculture, Gezzera, Cairo, Egypt.

Morphological description of the whole plant was made from the investigated living specimens or compiled from literature. Stem parts were collected and a portion of the middle lamina; including the midrib was cut from the mid. Cuttings were fixed in FAA and stored in 70% ethanol until use. Stems and lamina sections were prepared using hand microtome at 10-20µm; double stained using safranine and light green; mounted in Canda Balsam (Johansen, 1940); inspected by light microscope; photographed using a Reichert Microstar IV microscope. Ab and adaxial epidermal surfaces were carefully separated, stained in safranine, mounted in glycerin on a slide for LM investigation. For SEM sample preparations (abaxial surface), fresh small pieces (7 mm2) of the leaf material were fixed on SEM stubs with double-sided tape, coated with gold in SPI-Module sputter coater,

examined and photographed by Joel JSM 5200 scanning microscope at various magnifications.

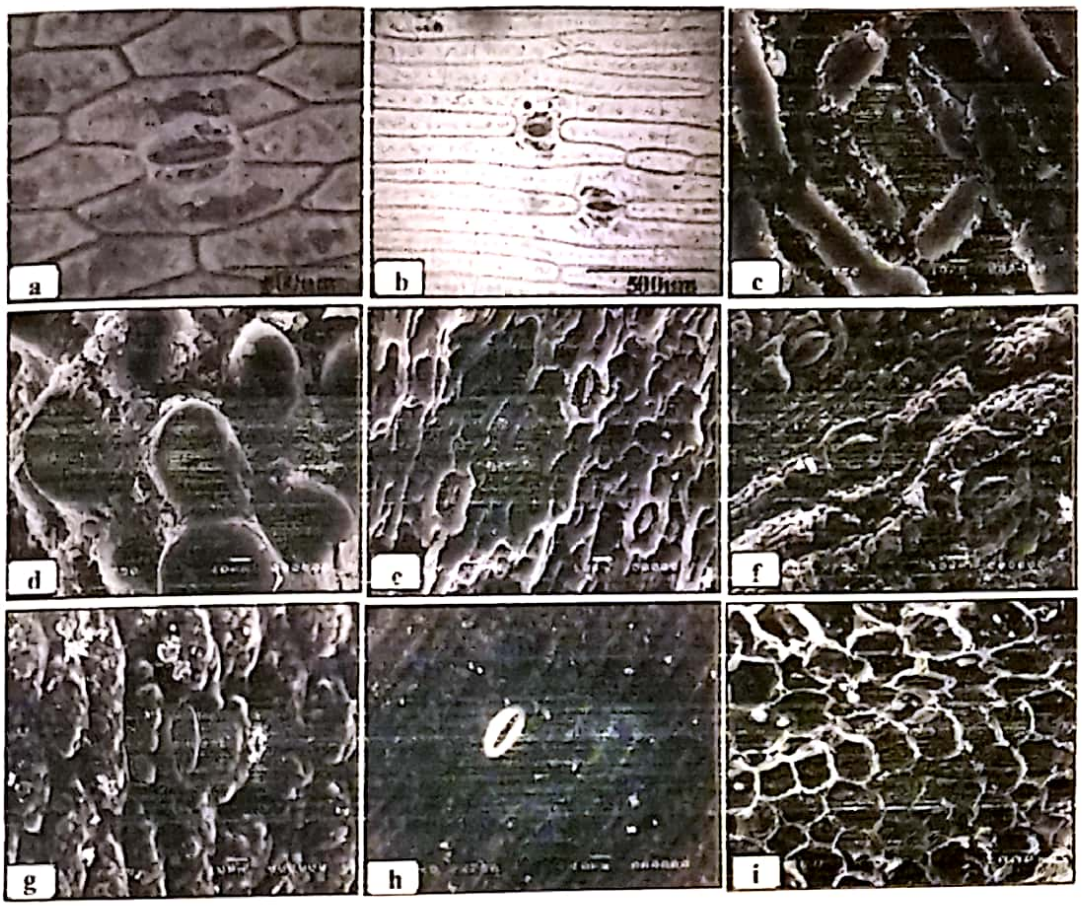
Native-polyacrylamide gel electrophoresis (Native-PAGE) was used to identify isozyme variation among the studied taxa using five isozyme systems; namely α- and β-esterase (*α- and β- Est*), acid phosphatase (*Acph*), alcohol dehydrogenase (*Adh*) and aldehyde oxidase (*Alo*) in fresh and young leaf samples as described by Stegemann *et al.* (1985).

Genomic DNA extraction was performed as suggested by DNA extraction kit's manufacturer Jena Biosciences, Plant DNA Preparation Kit, Genomic DNA purification from plant tissue (Martins *et al.*, 2003 and Zahuang *et al.*, 2004).

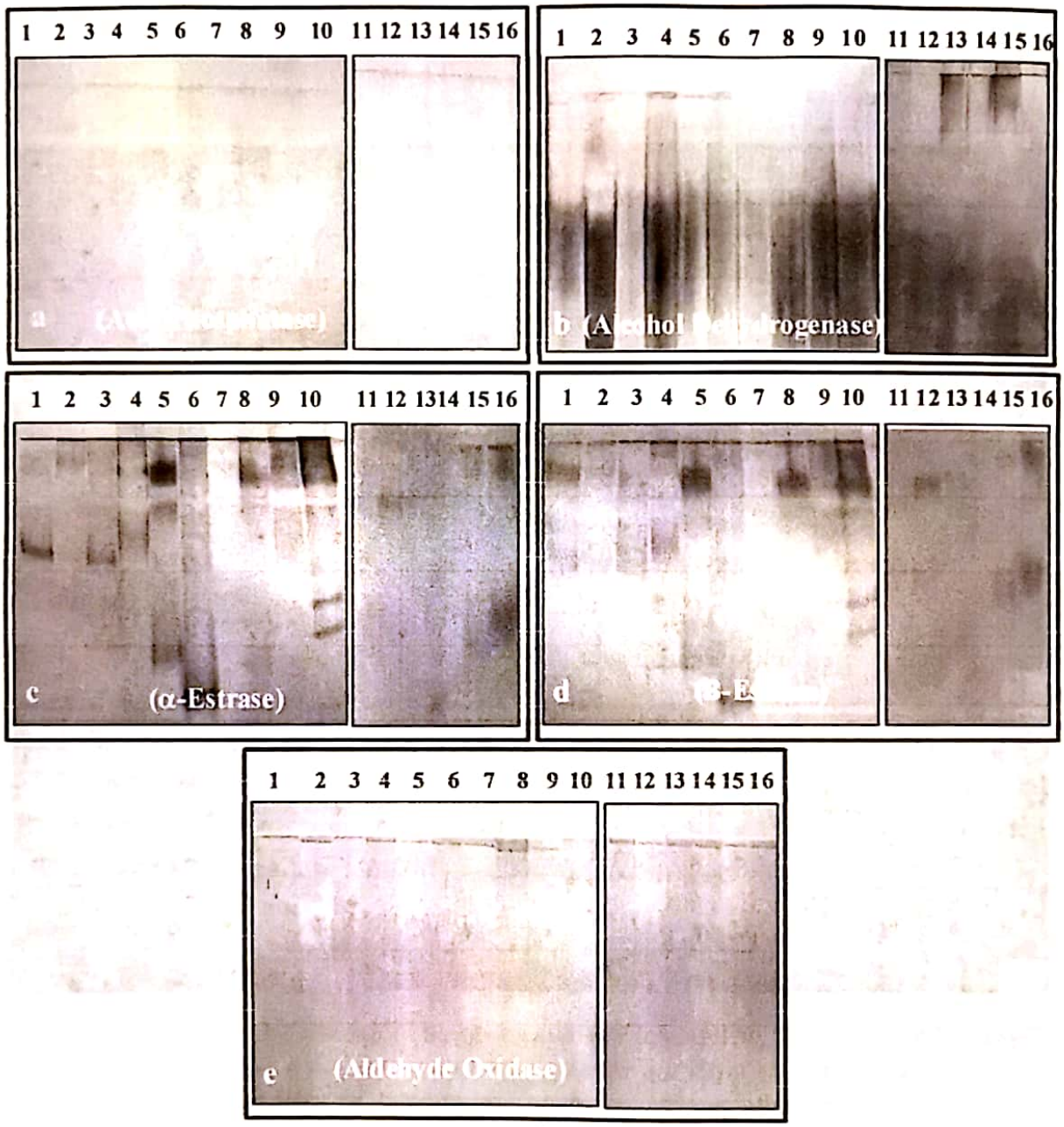
Each of the studied species was considered as Operational Taxonomic Unit (OTU). Multistate characters were transformed into two-state characters in coding i.e. pseudobinary characters (Sneath & Sokal, 1973). The data editor program NTEDIT 2.2 (Rohlf, 2005) was used to prepare two main sets of data matrices based on the macro/ micromorphological and macro/ micromolecular characters. The program NTSYS- pc 2.2 (Rohlf, 2005) was used to perform a cluster analysis for the above mentioned two data sets.

Results and Discussion

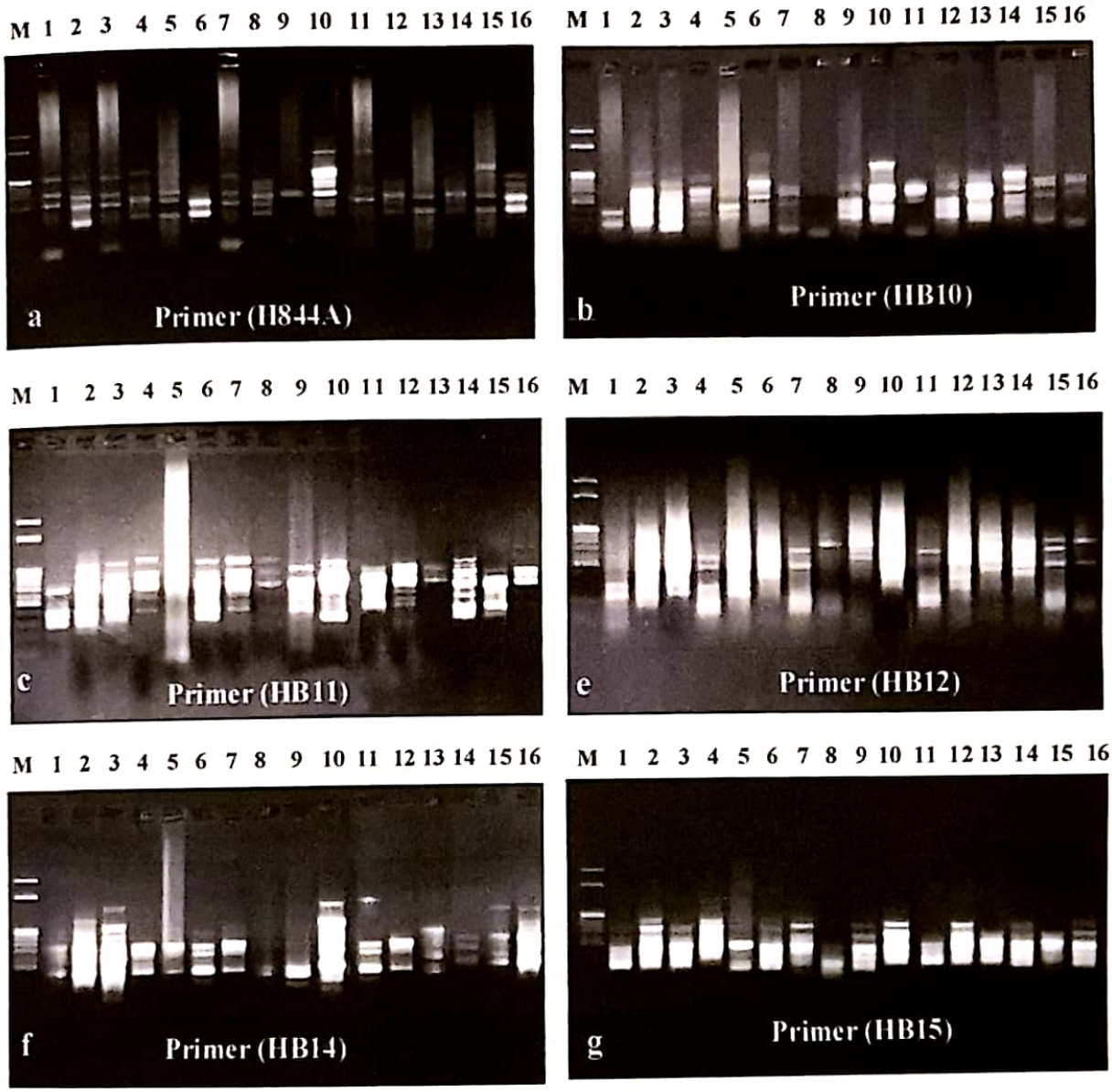
Microphotographs of the observed stomata types as revealed by LM are illustrated in Figures 1a-1b, wheras those of the lamina sculptures as revealed by SEM are illustrated in Figures 1c-1i. Photographs of the produced bands profile by application of the isozymes technique are illustrated in Figures 2a-2e, wheras those of the ISSR technique are illustrated in Figures 3a-3g. The scored 350 macro/micromorphological (141 of gross morphology; 76 of stem & leaf sections and striped off lamina epidermis; 26 SEM of lamina sculpture) and macro/micromolecular (42 isozymes & 86 PCR-ISSR) characters and their data matrix used in the phenetic analysis are given in Appendix 1. The produced UPGMA phenogram showing clustering of the studied taxa based on the used character states is given in Figure 4. A comparison between groups of the studied taxa and their corresponding tribes in the most common systems of classification are given in Table 2.



Figures 1a-1i. Two major types of stomata recorded in the studied taxa. **a:** Anomocytic type and **b:** Iris type. **c-i.** Microphotographs of **lamina sculpture by SEM. c:** rugose; **d:** tuberate; **e:** ruminate, **f:** sulcate; **g:** colleculate; **h:** lineate; **i:** reticulate.



Figures 2a-2e. Isozyme bands profile of the studied taxa; 1) *D. draco*; 2) *D. fragrans*; 3) *D. marginata*; 4) *D. ombet*; 5) *D.reflexa*; 6) *D. sanderiana*; 7) *Cordyline stricta*; 8) *Dracaena surculosa*; 9) *Cordyline fruticosa*; 10) *Sansevieria trifasciata*; 11) *Agave Americana*; 12) *A. franzosinii*; 13) *A. sisalana* 14) *Ruscus aculeatus*; 15) *Yucca aloifolia*; 16) *Yucca*



Figures 3a-3g. ISSR bands profile of the studied taxa; 1) *D. draco*; 2) *D. fragrans*; 3) *D. marginata*; 4) *D. ombet*; 5) *D.reflexa*; 6) *D. sanderiana*; 7) *Cordyline stricta*; 8) *Dracaena surculosa*; 9) *Cordyline fruticosa*; 10) *Sansevieria trifasciata*; 11) *Agave Americana*; 12) *A. franzosinii*; 13) *Yucca aloifolia*; 14) *Agave sisalana*;

The produced UPGMA - phenogram based on the 350 characters states (Figure 4) devided the studied taxa into three clusters. The first cluster (A) comprises three minor groups a_1, a_2 & a_3 that are grouped together at the similarity level of 0.29. The first minor group a_1 comprises three species *viz.* *Agave americana* and *A. franzosinii* are grouped together at the level of 0.51, and *A. sisalana* is clustered with them at the level of 0.44. The second a_2 is distinguished as a separate phenetic line including *Sansevieria trifasciata* at the level of 0.32. The third minor a_3 group comprised *Yucca aloifolia* and *Y. guatemalensis* at the level of 0.49, and clustered with *Sansevieria trifasciata* at the level of 0.32.

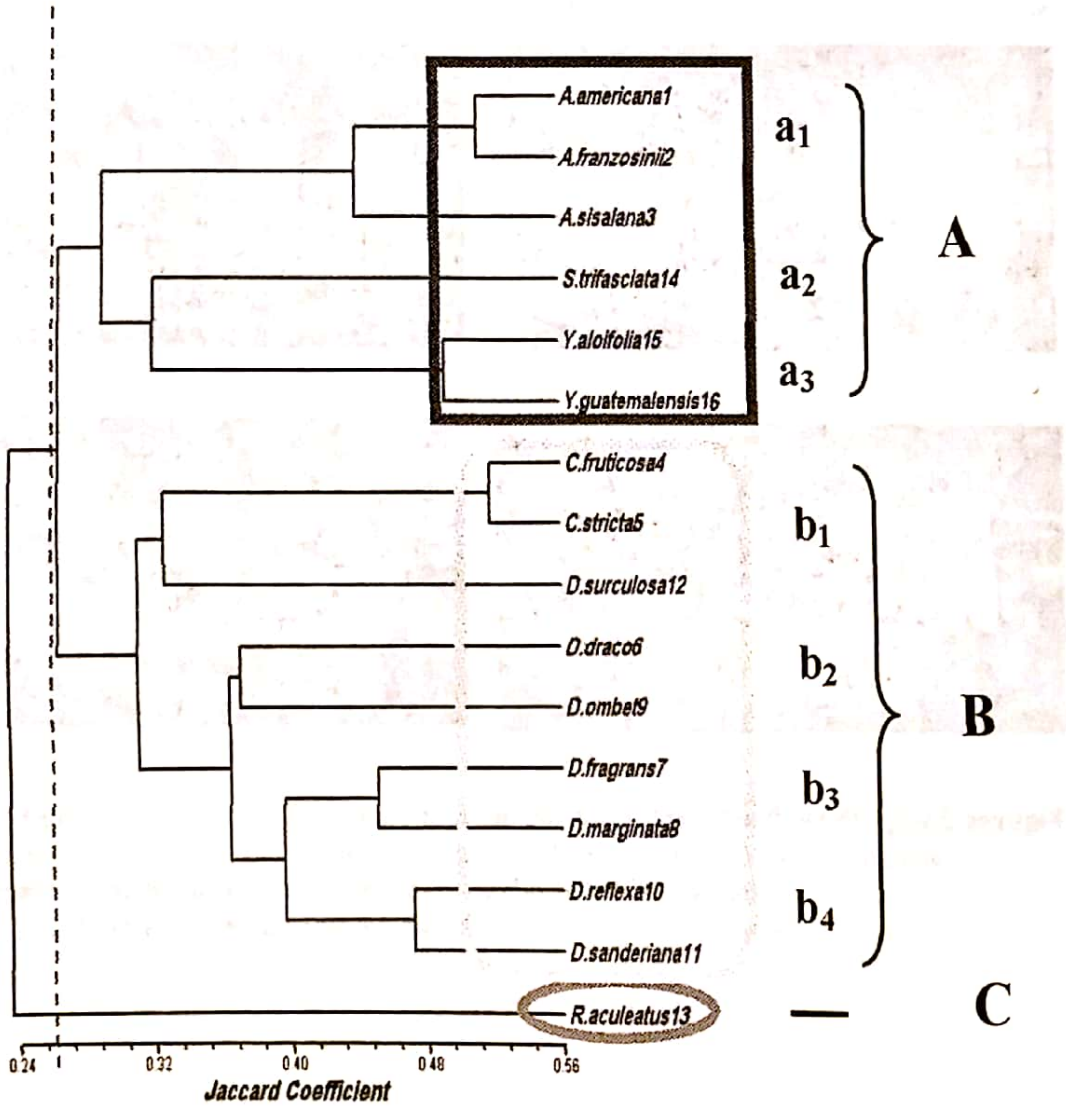


Figure 4. UPGMA - phenogram showing clustering of the studied taxa based on 350 character states.

The second cluster (B) is divided into four minor groups (b_1, b_2, b_3 & b_4). The first minor group b_1 comprised three species *Cordyline fruticosa* and *C. stricta* at the 0.52 level, and *Dracaena surculosa* is clustered with them at the 0.33 level. The second minor group b_2 comprised *Dracaena draco* and *D. ombet* at the level of 0.37. The third group b_3 comprised *Dracaena fragrans* and *D. marginata* at the level of 0.45. The fourth group b_4 comprised *Dracaena reflexa* and *D. sanderiana* at the level of 0.47, and clustered with b_3 at the level 0.39. The Third cluster (C) is distinguished as a separate phenetic line including only *Ruscus aculeatus* at the level of 0.24.

Sansevieria was classified in the Agavaceae by Cronquist (1981) alongside *Agave* and *Yucca* with other genera on the basis of their possession of a woody stem produced by a secondary thickening meristem. Rendle (1953) using morphological data divided Agavaceae into two subfamilies: Agavoideae including *Agave* and Dracaenoideae including *Yucca* and *Sansevieria*. Dahlgren *et al.* (1985 & 1989) using a phylogenetic analysis of morphological data moved the genus *Sansevieria* into the family Dracaenaceae which was established earlier by Salisbury (1866) who divided the Agavaceae into two subfamilies Agavoideae and Yuccoideae instead of Dracaenoideae in Rendle's (1953) classification. These data were adopted by APGII (2003) and Takhtajan (2009) except that APG II (2003) placed *Sansevieria* in the family Ruscaceae, whereas Takhtajan (2009) retained it in Dracaenaceae.

In the present study, the representative taxa of *Agave*, *Yucca* and *Sansevieria* are clustered together in the major group A which corresponding to the family Agavaceae. They are morphologically characterized by rosette leaves arrangement, petiole absent, inflorescence panicle, flower bisexual, six lobes of perianth tube and six stamens. Anatomically, they are characterized by the ill-defined epidermis, collenchyma present, leaf vascular bundle embedded in conjunctive tissue and amphistomatic leaf. Molecular data revealed that they are shared band number 12 in the produced ISSR profile by using the primer HBA44 with molecular size (Mr) of 339.97 base pair.

Table 2. A comparison between groups of the studied taxa and their corresponding tribes in the most common systems of classification

Proposed classification			Bessey (1915), Hallier (1923), Pulle (1938) and Englar & Diels (1936)	Hutchinson (1973), Heywood (1978) and Cronquists (1981)	Dahlgren *et al.* (1989)	APG II, 2003	Takhtajan (2009)	APG III, 2009
Group	Subgroup	Taxa						
A	a_1	*Agave americana*	Liliaceae	Agavaceae	Agavaceae			Asparagaceae
		A. franzosinii						
		A. sisalana						
	a_2	*Sansevieria trifasciata*			Ruscaceae			
	a_3	*Yucca aloifolia*			Agavaceae			
		Y. guatemalensis						
B	b_1	*Cordyline fruticosa*			Dracaenaceae	Laxmanniaceae	Asteliaceae	
		C. stricta						
		Dracaena surculosa				Ruscaceae	Dracaenaceae	
	b_2	*D. draco*						
		D. ombet						
	b_3	*D. fragrans*						
		D. marginata						
	b_4	*D. reflexa*						
		D. sanderiana						
C	-	*Ruscus aculeatus*		Ruscaceae				

The first minor group (a_1) comprised *Agave americana*, *A. franzosinii* and *A. sisalana* were morphologically clustered due to the broad leaf, inflorescence lateral, anther introse, ovary inferior, subsessile setting, three locules, three ovules and style elongated. Anatomically, they are clustered together due to the absence of schlerenchyma fibers, presence of stone cells, absence of extraxylary fibers, stomata anomocytic and sunken, epidermal cells of wide anticlinal walls, raised periclinal walls and smooth wax. Molecular data reveled that they shared bands of numbers 12 in the produced ISSR profile by using the primer HBA44 at Mr of 339.965 bp, 4, 6 & 9 in the produced ISSR profile by using the primer HB11 at Mr of 874.379, 687.034 & 381.661 bp respectively.

The second minor group (a_2) including *Sansevieria trifasciata* var. *laurentii* which distinguished as a separate phenetic line, molecular data reveled that it shared bands number 1, 3 & 5 in the produced ISSR profile by using the primer HBA44 at Mr of 1853.93, 991.08 & 812.98 bp respectively, band no. 8 in the produced ISSR profile by using the primer HB10 at Mr of 604.94 bp, bands no. 2, 4 & 10 in the produced ISSR profile by using the primer HB14 at Mr of 1518.16, 1175.91 & 372.41 bp respectively; bands no. 1, 2 & 5 in the produced ISSR profile by using the primer HB12 at Mr 923.88, 788.39 & 532.36 bp respectively. Isozymes data revealed that it shared bands number 2 & 3 in Ao enzyme profiles, band number 6 in α-est enzyme profile.

The third minor group (a_3) including *Yucca aloifolia* & *Y. guatemalensis* was established morphologically due to: flower sessile, anther introse, three ovules, fruit capsule. Anatomically, they characterized by the recta-hexagonal cell of stem epidermal cells, crystals absent, sculpture lineate, anticlinal walls depressed, periclinal walls raised. Molecular data revealed that they share bands number 4, 9 & 10 in HB11 at Mr of 874.38, 381.661 bp respectively, bands number 3 & 10 in HB12 at Mr of 704.75 & 173.457 bp respectively, presence of bands number 4 & 9 in HB14 at Mr of 1363.02, 614.89 bp respectively, band number 9 in HB15 at Mr of 208.28 bp. Thus, the present data confirmed those of Cronquist (1981) and Rendle (1953) regarding the placement of *Agave* and *Yucca* in two different subfamilies of the Agavaceae.

Dracaena and *Cordyline* were either placed together in the same family, regardless the family name, or separated in two different families. Bessey (1915), Melchior (1964), Goldberg (1986) and Thorne (1992) placed the two genera in Liliaceae *sensu lato*. Rendle (1953), Hutchinson (1973), Heywood (1978) and Cronquist (1981) placed both genera in Agavaceae. Dahlgren *et al.* (1985 & 1989) placed the two genera in Dracaenaceae. On the other hand, APGII (2003) separated *Dracaena* and *Cordyline* in the Ruscaceae and Laxmanniaceae respectively, whereas Takhtajan (2009) separated them in Dracaenaceae and Asteliaceae respectively.

In present study, *Cordyline* is clustered with the studied species of *Dracaena* in the same major group B; which corresponding to the family Dracaenaceae as defined by Dahlgren *et al.* (1985 &1989). This group is morphologically characterized by entire leaf, inflorescence terminal, panicle, bisexual, flower actinomorphic, gamotepalous, six stamen, ovary superior, three locules, capitates stigma, fruit small i.e. < 1.5 cm. Anatomically, the group B is characterized by absence stone cells, cuticle thin, stomata level, anticlinal walls depressed.

Molecular data reveled that, group B is characterized by the absence of bands number 1 & 4 in the produced ISSR profile by using the primer HBA44 at Mr of 1853.93 & 891.47 bp respectively; bands number 2 & 7 in the produced ISSR profile by using the primer HB10 at Mr of 1209.64 & 795.34 bp respectively, presence of band number 6 in the produced ISSR profile by using the primer HB11 at Mr. of 687.03 bp, absence of band number 1 in HB12 at Mr of 923.88 bp, absence of bands number 1, 3 & 13 in the produced ISSR profile by using the primer HB14 at Mr of 1685.24, 1363.023 & 362.50 bp respectively, presence of band number 11 in the produced ISSR profile by using the primer HB14 at Mr of 439.173 bp, presence of band number 6 in HB15 at Mr of 429.74 bp.

Isozymes data revealed that group B is characterized by presence of band number 1 in α-est enzyme profile. These data confirms the placing of *Cordyline* with *Dracaena* in the same family i.e. Dracaenaceae as reported by Rendle (1953), Chupov & Kutiavina (1978 & 1981) and summarized by Dahlgren *et al.* (1985 & 1989).

Klimko & Wiland-Szymańska (2008) reported divergence of both *Dracaena ombet* and *D. surculosa* from the rest of the genus *Dracaena* based on the highest variability in the leaf texture and cuticle features between the adaxial and abaxial surfaces. In the present study, *D. surculosa* is distinguished from the remaining studied species of *Dracaena* and

grouped with those of *Cordyline* due to the following morphological characters: stem branched, leaf lax, taering/ strap, bright to dark green, inflorescence lateral, perianth greenish to purple, anther extrose, ovary subsessile, one ovule and fruit orange. Anatomically, *Dracaena surculosa* is characterized by stem epidermal cells tangentially arranged, crystals present, square to pentagonal in side view, lineate sculpture, droplet waxes, cuticular flange absent. Molecular data revealed that it is characterized by the presence of bands number 5 & 9 in the produced ISSR profile by using the primer HBA44 at Mr of 991.08 & 529.91 bp respectively, band number 23 in HB10 at Mr of 204.43 bp, band number 3 in HB12 at Mr of 704.75 bp, bands number 12 & 14 in HB14 at Mr of 405.17 & 315.625 bp respectively, band number 9 in HB15 at Mr of 208.28. Isozymes data revealed that it is characterized by the presence of band number 10 in Ad enzyme and band 5 in Ao enzyme. These data are compatible with findings of Klimko & Wiland-Szymańska (2008) regarding the divergence of *Dracaena surculosa* away from other *Dracaena* species. Moreover, such data reveals a potentiality of placing *D. surculosa* with *Cordyline* in a separate subfamily Dracaenaceae, although it needs further studies on larger number of samples.

Klimko & Wiland-Szymańska (2008) reported a close relationship between *Dracaena draco* and *D. ombet* based on SEM criteria of the leaf surface. They pointed out that both species have some characteristics of xerophytes especially the slightly succulent leaves and presence of the cuticular flange around stomata. In the present study, *D. draco* and *D. ombet* are clustered together in the same minor group (b_2) due to sharing the following morphological characters: leaf slender, entire, sessile, inflorescence panicle, flower actinomorphic, gamotepalous, six stamens, filament inserted at perianth top, filiform, anther extrose, ovary superior, three locules, stigma capitate, fruit berry.

Anatomically *D. draco* and *D. ombet* shared the following characters: epidermal cells ill-defined, cortical cells suberizied, absence of stone cells, absence of crystals, leaf epidermal cells include crystals, cuticle thin, raised anticlinal walls, granular periclinal walls, stomata at the same level, surrounded by a thick cuticular flange, square or rectangular in outline. Molecular data revealed that, *D. draco* and *D. ombet* are characterized by presence of band number 10 in the produced ISSR profile by using the primer HB10 at Mr of 624.74 bp, band number 6 in Hb11 at Mr of 687.034 bp, band 8 in HB12 at Mr 290.39 bp, band 8 in HB14 at Mr 709.92 bp.

Isozymes data revealed that, *Dracaena draco* and *D. ombet* are characterized by the presence of band number 3 in β-est, band 4 in Acph. The present data confirms the close relationships between *D. draco* and *D. ombet* as proposed by White (1983) and Klimko & Wiland-Szymańska (2008) *D. draco* and *D. ombet* could be placed in a separate subgenus (i.e. *Ombet*) in Dracaenaceae.

Bos (1998) and Klimko & Wiland-Szymańska (2008) reported a closer relationship of *D. marginata* to *D. draco* and *D. ombet* than *D. fragrans* based on morphological and anatomical criteria. In the present study *D. fragrans* and *D. marginata* are grouped together in the same minor group (b_3) due to sharing the following morphological characters: stem single, leaf rosette, inflorescence branched, flower sessile and white, filament inserted at top of perianth, ovary superior, one ovule, style filiform; fruit round. They are anatomically shared the following characters: cork cells well represented, canals absent, vascular bundle absent, lignified conjunctive tissue present, epidermis penta-hexagonal shaped, square/ pentagonal in side view, stomata at the same level, oval shaped, cuticular flanges present. Molecular data revealed that, *D. fragrans* and *D. marginata* are characterized by presence of bands number 8 & 10 in the produced ISSR profile by using the primer HBA44 at Mr of 604.94 & 468.57 bp respectively: band number 8 in HB10 at Mr of 737.55 bp, bands number 2, 4, 8, 9 & 10 in Hb11 at Mr of 1112.99, 874.38, 504.68, 381.66 & 320.70 bp respectively; bands number 3, 5, 6 & 9 in HB12 at Mr of 704.75, 532.36, 431.67 & 173.46 bp respectively; bands number 6, 8 & 9 in HB14 at Mr of 935.724, 709.919 & 614.894 bp respectively, bands number number 3 and 9 in HB15 at Mr of 708.907 & 208.284 bp respectively. Thus, the present data disagree with those of Bos (1998) and Klimko & Wiland-Szymańska (2008) and reveals a closer relationship between *D. marginata* and *D. fragrans* than to both *D. draco* and *D. ombet*. These two species could be distinguished at least in the same subfamily.

Dracaena reflexa and *D. sanderiana* exhibit a close relationship and could be placed in the same subfamily. They are grouped together in the same minor group (b_4) due to sharing the following morphological characters: leaf acute, entire, petiolate, inflorescence panicle, flowers long, subsessile, filament inserted at the top of perianth , filiform, ovary superior, sessile, with one ovule, and elongated style. They are anatomically shared the following characters: stomata at the same level, oval, lineate, cuticular flanges absent. Molecular data revealed that, they are characterized by presence of band number 12 in the produced ISSR profile by using the primer HBA44 at Mr of

339.97 bp, band number 15 in Hb10 at Mr of 410.75 bp, band number 4 in HB11 at Mr of 874.38 bp. Isozyme data revealed that, both species have the band number 1 in Adh enzyme.

APGIII (2009) placed the genus *Ruscus* and the other studied genera (*Agave*, *Yucca*, *Cordyline*, *Sansevieria* and *Dracaena*) in the family Asparagaceae, whereas Shipunov (2009) and Takhtajan (2009) placed this genus apart of such genera in the family Ruscaceae. In present study, the representative species of the genus *Ruscus* is used as outgroup and is distinguished as separate phenetic line (i.e. group C). This is morphologically due to: leaf elliptic, pale green, flower unisexual, sessile/ subsessile , filament green tinged, stigma papillate, fruit brown, oval. Anatomically, it is characterized by thin cell wall stem, cuticle thin, cork absent, conjunctive tissue absent, leaf surface sulcate. Molecular data revealed that it is characterized by presence of bands number 2 & 5 in the produced ISSR profile by using the primer HBA44 at Mr of 1853.93 & 812.975 respectively. Isozyme data revealed that *Ruscus aculeatus* has the band number 2 in α-est enzyme. These data disagree with those of APGIII (2009) and could support the distinction of the genus *Ruscus* in a separate family (Ruscaceae) as proposed by Shipunov (2009) and Takhtajan (2009).

Carlquist & Schneider (2007) reported the close relationship between *Sansevieria* and *Dracaena* based on some root anatomical characters, the present data disagree with those regarding the close relationship between *Sansevieria* and *Dracaena*. Rather, it reveals the possibility of separation of *Sansevieria* from Dracaenaceae as defined by Dahlgren *et al.* (1989) or from Ruscaceae as defined by APGIII (2003) and retaining it with *Yucca* in the subfamily Yuccoideae.

The distinction of *Dracaena* and *Sansevieria* has previously been reported by Kauff *et al.* (2000) and Rudall *et al.* (2000). They reported that *Dracaena* and *Sansevieria* are very alike, but secondary thickening growth does not occur in roots of *Sansevieria* and the two genera can be distinguished by their exotesta despite its inclusion within *Dracaena* by Bos (1998). Furthermore, Rudall *et al.* (2000) stated that "despite their similarity in overall morphology *Sansevieria* and *Dracaena* should be treated as distinct entities based on palynology, ontogenetic and molecular data" and this gives further support to the present conclusion.

Concluding remarks

The present data confirmed each of the following: a) Placing of *Agave* and *Yucca* in two different subfamilies of Agavaceae i.e. Agavoideae and Yuccoideae as proposed by Cronquist (1981), Rendle (1953) and Torres-Morán *et al.* (2008). b) Placing of *Cordyline* with *Dracaena* in the same family i.e. Dracaenaceae as reported by Rendle (1953), Chupov & Kutiavina (1978 & 1981) and summarized by Dahlgren *et al.* (1985& 1989). c) The close relationship between *D. draco* and *D. ombet* that proposed by Klimko & Wiland-Szymańska (2008) and placing them in a separate subgenus (i.e. Ombet) of Dracaenaceae as defined by White (1983).

The present data disagreed each of the following: a- The close relationship between *Sansevieria* and *Dracaena* that proposed by Carlquist & Schneider (2007). b- Rather, it revealed the possibility of separation of *Sansevieria* from Dracaenaceae as defined by Dahlgren *et al.* (1989) or from Ruscaceae as defined by APG (2003) and retaining it with *Yucca* in the subfamily Yuccoideae of the Agavaceae. c- The closer relationship of *Dracaena marginata* to both *D. draco* and *D. ombet* than to *D. fragrans* as proposed by Bos (1998) and Klimko & Wiland-Szymańska (2008). Rather, it revealed a closer relationship between *D. marginata* and *D. fragrans* than to both *D. draco* and *D. ombet*. d- Merging of the genus *Ruscus* with the other studied taxa in the same family as proposed by APG (2009) and could support the distinction of the genus *Ruscus* in a separate family (Ruscaceae) as proposed by Shipunov (2009) and Takhtajan (2009).

The present data was compatible with those of Klimko & Wiland-Szymańska (2008) regarding the divergence of *Dracaena surculosa* from the rest species of *Dracaena* and revealed a potentiality of placing *D. surculosa* and *Cordyline* in a separate subfamily in the Dracaenaceae, although it needs further studies on larger number samples.

Appendix 1: All the 350 character states and their data matrix used in the phenetic analysis of the present study; 1 = Present; 0 = Absent.

No.	Characters \ OTU's		0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6
		I- Macro morphology	
i: Whole Plant			
01	Habit	Shrub	0 0 0 1 0 0 0 0 0 0 0 1 1 1 0 0 0
02		Sub-shrub/ shrub	0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
03		Shrub/ tree	1 1 0 0 1 0 1 1 0 1 0 0 0 0 1 1
04		Rhizome	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
05		Tree	0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0
ii: Stem			
06	Branching	Single	1 1 1 0 0 0 1 1 0 0 1 0 0 0 0 0
07		Single/ branched	0 0 0 0 1 1 0 0 0 0 0 0 0 0 1 1
08		Branched	0 0 0 0 0 1 0 0 1 1 0 1 1 0 0 0
09		Reduced	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
iii: Leaves			
10	Arrangment	Lax	0 0 0 0 0 1 0 0 0 0 1 1 1 0 0 0
11		Rosette	1 1 1 1 1 0 1 1 1 1 0 0 0 1 1 1
12	Width	Broad	1 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0
13		Slender	0 0 0 1 1 1 0 1 1 1 1 1 1 1 1 1
14	Shape	Linear/lanceolate	0 1 1 0 0 0 1 0 0 0 0 0 0 0 1 1
15		Lanceolate	0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0
16		Linear	0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
17		Lanceolate/ elliptic	0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
18		Tapering/ strap	0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
19		Elliptic	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
20		Strap/ lanceolate	1 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0
21	Apex	Acuminate	1 0 0 1 1 0 0 0 0 0 0 1 0 0 0 0
22		Acute	0 1 1 0 0 1 0 1 1 0 0 0 1 1 1 1
23		Acute-subulate mucro	0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
24		Acute/ acuminate	0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0
25	Colour	Gray green with yellow	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
26		Blue gray	0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
27		Dark green with purplish	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
28		Green tinged purpish	0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
29		Grayish green	0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
30		Green broad yellow	0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
31		Glossy green	0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
32		Dark green	0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1
33		Olive green	0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
34		Glossy green with silver	0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
35		Bright to dark green	0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
36		Pale green	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
37		Grayish green	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
38	Margins	Undulate	0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0
39		Entire	0 0 0 1 1 1 0 1 1 1 1 1 1 0 1 1 0
40		Serrate	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
iv: Petiole			

41	Presence	Absent/ present	1 1 1 0 0 1 1 1 1 0 0 0 0 1 1 1
v: Inflorescence			
42	Length	Absent	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
43		15-40 cm Short	0 0 0 1 1 0 0 0 0 1 1 1 0 0 0 0
44		50-80 cm Meddle	0 0 1 0 0 0 1 1 1 0 0 0 0 1 1 1
45		90-110 cm Long	1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0
46	Position	Lateral	1 1 1 0 0 0 0 0 0 0 0 1 0 0 0 0
47		Terminal	0 0 0 1 1 1 1 1 1 1 1 1 0 0 1 1 1
48	Type	Panicle	1 1 1 1 1 1 0 1 1 1 1 1 1 1 1 1
49		Raceme	0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
50	Branching	Branched	1 1 1 1 1 1 1 1 1 0 0 1 1 0 0 1 1
51		Branched- unbranched	0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0
52		Unbranched	0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0
vi: Flower			
53	Length	0.7-10 cm Small	1 0 1 1 1 0 0 0 0 0 0 0 1 0 1 1
54		30-50 cm Medium	0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0
55		60-70 cm Long	0 1 0 0 0 1 1 0 1 1 1 0 0 1 0 0
56	Sex	Bisexual	1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1
57		Unisexual	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
58	Setting	Subsessile	1 1 1 1 1 1 0 0 1 1 1 1 0 1 0 0
59		Sessile	0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1
60		Sessile/ subsessile	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
61	Symmetry	Dimorphic	1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
62		Actinomorphic	0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1
63	Colour	Pale yellow	1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
64		Green to yellowish	0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
65		Yellowish	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
66		Red purple	0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
67		Creamy white	0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
68		White	0 0 0 0 0 0 1 1 1 0 1 0 0 0 0 0
69		Cream green	0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
70		Greenish to purple	0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
71		Green or tinged	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
72		Greenish- white	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
a: Perianth			
73	Cohesion	Polytepalous	1 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
74		Gamotepalous	0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
75	Tube	0.2-0.8 cm small	0 0 0 0 0 1 0 0 1 1 0 0 0 0 0 0
76		0.9-1.2 cm middle	0 0 0 1 1 0 1 1 0 0 1 1 0 0 0 0
77		1.8-2.2 cm large	0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
78	Lobes	6	1 1 1 0 0 0 0 0 1 1 0 1 1 1 1 1
79		3	0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0
b: Stamen			
80	Number	6	1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1
81		3	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
82	Insertion	At the top of throat	0 1 0 0 0 1 1 1 1 1 1 1 0 1 0 0 0
83		Above the throat	0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
84		In the throat	0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0
85		On the throat	0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
86	Filament	Filiform	1 1 0 1 0 0 1 0 1 1 1 1 1 1 0 0
87		Linear	0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
88		Flattened	0 0 0 0 1 1 0 1 0 0 0 0 0 0 1 1

89	Anther	Introse	1 1 1 1 0 0 0 0 0 0 0 0 0 0 1 1
90		Extrose	0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0
c: Ovary			
91	Position	Inferior	1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
92		Superior	0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1
93	Length	0.9-2 cm short	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
94		2-3.5 cm medium	0 0 1 1 1 1 1 1 1 1 1 1 1 0 1 0
95		4- 5 cm long	1 1 0 0 0 0 0 0 0 0 0 0 0 1 0 0
96	Setting	Subsessile	1 1 1 0 0 1 0 0 1 0 0 1 0 1 0 1
97		Sessile	0 0 0 1 1 0 1 1 0 1 1 0 1 0 1 0
98	Locules	3	1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 0 1
99		1	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
100		6	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
101	Ovules	3	1 1 1 0 0 0 0 0 0 0 0 0 0 0 1 1
102		2	0 0 0 1 1 0 0 0 0 0 0 0 1 0 0 0
103		1	0 0 0 0 0 1 1 1 0 1 1 1 0 0 0 0
104		1-2	0 0 0 0 0 0 0 0 1 0 0 0 0 1 0 0
d: Style			
105	Shape	Elongated	1 1 1 0 0 0 0 0 0 1 1 0 1 0 0 1
106		Slender	0 0 0 1 1 1 0 0 0 0 0 0 0 1 1 0
107		Filiform	0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0
e: Stigma			
108	Shape	Capitate	1 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
109		Clavate	0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
110		Papillate	0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
111		Simple	0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
vii: Fruit			
112	Type	Fleshy	1 1 0 1 0 0 0 1 0 0 0 0 1 0 0 0
113		Capsule	0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1
114		Berry	0 0 0 0 1 1 1 0 1 1 1 1 0 1 0 0
115	Colour	Red	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
116		Bright orange	0 1 0 0 0 0 1 0 0 0 0 0 0 1 0 0
117		Orange	0 0 1 0 0 0 0 1 0 1 0 1 0 0 0 0
118		Yellow red	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
119		Purple black	0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
120		Orange red	0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
121		Brown	0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0
122		Purple	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
123		White yellowish	0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 1
124	Shape	Obovoid	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
125		linear	0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
126		Cylindrical	0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0
127		Linear-oblong	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
128		Globose	0 0 0 0 0 0 0 0 0 1 1 1 0 1 0 0
129		Oval	0 0 0 0 0 0 0 0 0 1 1 1 0 1 0 0
130		Round	0 0 0 0 1 1 1 1 0 0 0 0 0 0 0 0
131		Oblong -ellpsoid	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
132		Oblong-ovoid	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
133	Length	5-20 cm small	1 1 0 1 1 1 1 1 1 1 1 1 1 1 0 0
134		25-40 cm medium	0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 0
135		70-90 cm large	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1

II- Micro morphology

i. Stem Epidermal Cells			
136		Ruptured /Homogenous	0 0 0 1 1 0 1 1 0 1 1 1 1 0 0 0
137		Barrel	0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0
138		Radially elongated	0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
139		Papillose	0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0
140		Radial	0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0
141		Tangentially	0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
142	Cell wall	Ill-defined	1 1 1 0 0 1 0 0 1 0 0 0 0 1 1 1
143		Thick	0 0 0 1 0 0 1 0 0 1 1 1 0 0 0 0
144		Thin	0 0 0 0 0 0 0 1 0 0 0 0 1 0 0 0
145	Cuticle	Thick	0 0 0 1 0 0 1 0 0 1 1 1 0 0 0 0
146		Thin	0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0
A: Protective tissue			
147	Schlerenchyma	Absent/ Present	1 1 1 0 1 1 0 1 1 0 1 1 1 1 0 1
148	Cortical cell	Absent	0 0 0 1 1 0 1 1 0 1 0 1 1 1 0 0
149		Non-suberized	1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
150		Suberized	0 0 1 0 0 1 0 0 1 0 0 0 0 0 1 1
151	Stone cells	Absent /Present	0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1
152	Storied cork	Present/Absent	1 1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 1
153	Collenchyma	Absent/Present	1 1 1 1 1 1 0 1 1 1 0 1 1 1 1 1
B:Cortex			
154	Canals	Absent /Present	0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1
155	Vascular bundle	Absent /Present	1 1 1 0 1 0 0 0 1 1 0 0 0 1 1 1
156	Crystals	Absent /Present	1 0 1 1 1 1 0 1 1 1 1 0 0 0 1 0
C: Anomalous 2^{ry} growth			
157	Conjunctive tissue	Absent	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0
158		Thin	1 1 1 0 0 0 0 0 1 0 1 0 0 1 1 1
159		Lignified	0 0 0 1 1 1 1 1 0 1 0 1 0 0 0 0
160	Width of ring	Very narrow	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
161		±Narrow	1 1 1 0 1 0 1 1 0 0 0 1 0 0 1 1
162		±Wide	0 0 0 1 0 1 0 0 1 1 1 0 0 0 0 0
ii. Lamina Epidermis			
a: Surface view			
163	Shape	Penta-hexagonal	1 1 1 1 1 1 1 1 0 1 1 1 0 1 0 0
164		Recta-pentagonal	0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 1
165	Thickness	Thin	0 0 0 0 1 1 0 1 0 1 0 0 0 0 1 0
166		Thick	1 1 1 1 0 0 1 0 1 0 0 1 0 1 0 1
167	Crystals	Absent/ Present	1 0 1 1 0 1 1 1 1 0 1 0 0 1 1 1
b: Side view			
168	Shape	Papillose	1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
169		Barrel	0 1 0 0 0 1 0 0 1 0 0 0 0 0 1 1
170		Square	0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0
171		Cupic	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
172		±Tangentially elongated	0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
173		Square - pentagonal	0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0
174		Radialy elongated	0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0
175	Cuticle	Thin	0 0 0 1 1 1 1 1 1 1 1 1 0 1 1 0
176		Thick	1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 1
iii. Leaf			
a- Mesophyll			
177	Composition	Chlo&Par	1 1 1 0 1 1 1 0 1 1 1 0 0 1 1 0
178		Parenchyma	0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 1

179		Chlorenchyma	0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
180	Crystals	Absent/ Present	1 1 0 0 0 0 0 1 0 1 1 0 0 1 0 0
181	E. xyellary fibers	Absent/Present	0 0 0 0 1 0 0 1 1 1 1 0 0 0 1 0
b- Vasculature			
182	Central portion rows	1-2 rows	1 0 0 0 0 1 0 1 0 0 0 1 0 1 1 0
183		2- 3 rows	0 0 0 1 1 0 0 0 0 1 1 1 1 0 0 1
184		3 -4 rows	0 0 1 0 0 0 0 0 1 0 0 0 0 0 0 0
185		4 – 5 rows	0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
186		5 -6 rows	0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
187	Lateral portion	Attach& embedded	0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0
188		Embedded	1 1 1 0 0 1 1 1 1 1 1 0 1 1 1 1
c- Stomata			
189	Location	Ab & ad	1 1 1 0 0 1 1 1 0 0 1 1 0 1 1 1
190		Ab	0 0 0 1 1 0 0 0 1 1 0 0 0 0 0 0
191	Type	Anomocytic	1 1 1 1 1 0 1 0 1 0 0 0 0 1 1 1
192		Iris	0 0 0 0 0 1 0 1 0 1 1 1 0 0 0 0
193		canna	0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
194	Guard cells Position	Sunken	1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
195		Same level	0 0 0 1 1 1 1 1 1 1 1 1 1 0 1 1 1
196	Guard cells Shape	Globose	1 1 1 0 1 1 0 0 0 0 0 0 0 0 0 0
197		Oval	0 0 0 1 0 0 1 1 1 1 1 1 0 1 1 1
iv. SEM of Leaf Epidermal cells			
A. Sculpture			
198	Shape	Colliculate	0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
199		Lineate	0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 1 1
200		Sulcate	0 0 0 0 1 0 0 0 0 0 0 0 1 0 0 0
201		Reticulate	0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
202		Rugose	1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0
203		Ruminate	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
204		Tuberculate	0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
B. Anticlinal walls			
205	Range	Narrow	0 0 0 1 1 1 1 0 0 1 1 1 0 1 1 1
206		Wide	1 1 1 0 0 0 0 1 1 0 0 0 1 0 0 0
207	Level	Level	0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
208		Raised	0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0
209		Depressed	1 0 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1
210	Texture	Granular	0 1 0 0 0 0 0 1 1 1 1 0 0 0 0 1
211		Smooth	1 0 1 1 1 1 1 0 0 0 1 0 1 1 1 0
C. Periclinal walls			
212	Level	Depressed	0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0
213		Raised	1 1 1 0 1 1 1 1 1 1 1 1 1 1 0 1 1
214	Texture	Granular	0 0 1 0 1 1 1 1 1 1 1 0 0 0 0 0 1
215		Smooth	1 1 0 1 0 0 0 0 0 0 1 1 1 1 1 0
216	Secondary sculpture	Absent	1 1 1 1 0 1 0 0 1 0 1 1 1 1 1 1
217		Colliculate	0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0
218		Granulate	0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0
D. Wax			
219	Type	Droplets	0 0 0 0 0 0 0 0 1 0 1 1 1 1 0 0
220		Granules	0 0 0 0 1 1 0 1 0 1 0 0 0 0 0 0
221		Smooth	1 1 1 1 0 0 1 0 0 0 0 0 0 0 1 1
E. Cuticular flange			
222	Occurrence	Absent/Present	1 1 1 1 1 1 1 1 1 0 0 0 0 0 1 1

III- Micro molecules			
PCR-ISSR			
	Primer	Band no.	
223	H844A	1	1000000000000100
224		2	0000001010001010
225		3	0001110100000100
226		4	0000000000000001
227		5	0000000000011100
228		6	0100001000010101
229		7	0000010000000000
230		8	1001101101000100
231		9	0110000011011010
232		10	1001111110011010 1
233		11	0000000000000000
234		12	1110000011111111
235		13	0000001000000000
236		14	0000000000000000
237		15	0000000001000010
238		16	0000000000000000
239		17	0011100100000000
240		18	1000010000000000
241	HB10	1	0000000000100000
242		2	0000000000000100
243		3	0000000100000000
244		4	0000001010000100
245		5	0100000000100000
246		6	0000000010001001
247		7	0010000000000010
248		8	0000001100100001
249		9	0111100000000010
250		10	1000001010001100
251		11	0001100101000000
252		12	0010000000100101
253		13	0000001110001010
254		14	1001100000001000
255		15	0100000101100000
256		16	0010011000000100
257		17	0000001010000000
258		18	0100000101001100
259		19	0000001000000000
260		20	0000010010100010
261		21	0000000100000001
262		22	0001100000000000
263		23	1000000000010000
264	HB11	1	0000000010000001
265		2	0001101110111101
266		3	0100001000001001
267		4	1111110111111011
268		5	0011101011001001
269		6	1111111111111111
270		7	1100000010000000
271		8	0100001100101111

272		9	1 1 0 1 1 1 1 1 1 0 1 0 1 0 1 1
273		10	0 0 0 0 0 1 1 1 0 0 1 0 1 1 1 0
274		11	0 0 0 1 1 0 0 1 0 0 0 0 0 0 0 0
275	HB12	1	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
276		2	0 0 1 1 1 0 1 0 0 0 0 0 0 1 0 0
277		3	0 1 1 0 0 0 1 1 0 0 1 1 1 0 1 1
278		4	1 0 0 1 1 0 0 0 0 1 1 0 1 1 1 0
279		5	1 0 1 0 0 0 1 1 1 1 0 0 0 0 1 0 0
280		6	0 1 1 1 1 0 1 1 1 1 1 1 0 1 1 1 1
281		7	1 1 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0
282		8	0 1 0 0 0 1 0 1 1 1 1 0 0 0 0 0 0
283		9	0 0 0 0 0 1 1 1 0 1 0 0 0 0 0 0
284		10	1 0 0 1 1 0 0 0 1 0 0 1 0 0 1 1
285		11	0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
286	HB14	1	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
287		2	0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0
288		3	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1
289		4	0 0 0 0 0 0 1 0 1 0 0 0 0 1 0 0
290		5	0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1
291		6	0 0 1 0 0 0 1 1 0 1 1 0 0 1 0 1
292		7	0 0 0 0 0 0 1 0 0 0 0 0 1 1 1 1
293		8	1 1 0 1 1 1 1 1 1 1 1 1 0 1 1 0 1
294		9	1 0 1 0 0 1 1 1 0 0 1 0 0 0 1 1
295		10	0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 1 1
296		11	1 1 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0
297		12	0 0 1 0 0 0 0 0 0 0 0 0 1 0 0 0 0
298		13	0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
299		14	0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
300	HB15	1	0 0 0 1 1 0 1 0 1 0 1 0 0 0 0 0
301		2	0 0 0 0 0 1 0 0 0 0 1 0 0 0 0 0
302		3	0 1 0 1 1 0 1 1 1 0 1 0 1 1 0 1
303		4	0 0 0 0 0 0 0 1 1 0 1 0 0 1 0 1
304		5	0 1 0 1 1 0 1 0 0 0 0 0 0 1 0 0
305		6	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
306		7	1 1 1 0 0 1 1 1 1 1 1 1 0 1 1 0 1
307		8	0 0 1 0 0 0 0 1 0 1 1 0 1 1 0 1
308		9	1 1 1 0 0 1 1 1 0 1 1 1 1 1 0 1 1
	IV- Macro molecules		
Isozymes			
	Enzyme	Band no.	
309	Ao.	1	0 0 0 0 0 1 0 1 1 1 1 0 0 0 0 0
310		2	0 0 0 0 1 0 0 0 0 0 0 1 0 1 0 0
311		3	0 0 0 1 0 0 0 0 0 0 0 0 0 1 0 0
312		4	0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0
313	Adh.	1	0 0 1 0 0 1 0 1 0 1 1 1 0 0 0 0
314		2	0 0 0 0 1 0 0 0 0 0 0 0 0 0 1 0
315		3	0 1 1 1 0 1 0 0 0 0 0 0 0 0 0 0
316		4	0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
317	α-est	1	0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0
318		2	0 0 0 1 0 0 0 0 0 0 0 0 1 0 1 0
319		3	0 1 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0
320		4	0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 1

321		5	0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0
322		6	0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0
323		7	0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0
324		8	0 0 0 1 0 0 0 0 1 0 0 0 0 0 0 0
325		9	0 0 0 0 0 1 1 0 0 1 0 0 0 0 0 0
326		10	0 0 0 1 0 0 0 0 0 0 0 1 0 0 0 0
327		11	0 0 0 1 1 0 0 0 0 0 0 0 0 0 0 0
328		12	0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0
329		13	0 0 0 0 1 0 0 0 0 1 0 0 0 0 0 0
330		14	0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
331		15	0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
332	β-est.	1	0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
333		2	0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
334		3	0 0 0 0 0 1 1 1 1 1 1 0 0 1 1 1
335		4	0 0 1 0 0 1 0 0 0 0 0 1 0 0 0 0
336		5	1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0
337		6	0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1
338		7	0 0 0 1 1 0 0 0 0 0 0 1 0 0 1 0
339		8	0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0
340		9	0 0 0 1 1 0 0 0 1 0 0 1 0 0 0 0
341		10	0 0 0 0 0 0 0 1 0 0 0 1 0 0 0 0
342		11	0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
343		12	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
344		13	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
345		14	0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0
346		15	0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0
347	Acph.	1	0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0
348		2	0 0 0 0 0 1 0 1 1 1 1 0 0 0 0 0
349		3	0 0 0 0 0 1 0 0 0 1 0 1 0 0 0 0
350		4	0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0

01: *Agave americana*, 02: *A. franzosinii*, 03: *A. sisalana*, 04: *Cordyline fruticosa*, 05: *Cordyline stricta*, 06: *Dracaena draco*, 07: *D. fragrans*, 08: *D. marginata*, 09: *D. ombet*, 10: *D. reflexa*, 11: *D. sanderiana*, 12: *D. surculosa*,13: *Ruscus aculeatus*, *14: Sansevieria trifasciata* var *laurentii*, 15: *Yucca aloifolia* , 16: *Y. guatemalensis*.

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