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Assessment of Phenotypic Variation of *Arum* Species in Jordan

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ABSTRACT

Twenty-one locations scattered over eight provinces in Jordan were surveyed to assess the ecogeographical distribution of wild *Arum* species. Twenty-six morphological traits were measured on the collected species and populations to study the phenotypic diversities among and within species. Based on mean and standard deviation values, the highest variations were recorded for plant height, plant span, corm weight, spathe length, spadix length, leaf length and leaf mid-vein characters. Canonical discriminant analysis showed that leaf waxiness, spadix colour, spathe colour, leaf length, leaf width, plant span and leaf mid-vein are the main descriptors that can be used to differentiate among *Arum* species. Based on Euclidean distance coefficient, morphological characters showed a significant separation between *Arum* species with a similarity of 90.28% between *A. palaestinum* and *A. dioscoridis*, 74.90% between *A. hygrophilum* and *A. dioscoridis* and 82.18% between *A. palaestinum* and *A. hygrophilum.* The overall similarity analysis showed that the coefficient of similarity 81.40% was recorded among species over locations and 74.17% for species and locations combination. The results showed that *Arum* populations belonging to the same species are grouped in the same clusters regardless of collection site. In addition to the conservation of collected accessions in an operational gene bank, it is recommended to promote also the *in situ* conservation of *Arum* species.

Keywords: *Arum* species, Phenotypic variation, Medicinal plants, *ex situ* conservation.

INTRODUCTION

Jordan's flora counts approximately 2,500 plant species comprising 1% of the recorded vascular plant species in the world (Al-Eisawi *et al.*, 1996). Species with medicinal values account for about 25% of the total flora of Jordan. Wild plant species with their massive genetic variation contributed to the development of agriculture, medicine and industry. Among this rich diversity, *Arum* species need to be domesticated and managed in their natural habitats in a proper way.

Arum genus groups wild herbaceous tuberous perennial species belonging to the *Araceae* family. In Jordan, *Arum* species grow naturally in mountains, in the upper Jordan valley and in many other regions of Jordan, and were reported in Ajlun, Irbid, Jarash, Al Balqa′, Wadi Shua'ib and Amman (Al-Eisawi, 1998; Feinbrun-Dothan, 1986). This genus is composed of 28 species, largely distributed in Europe, North Africa, Middle East and Central Asia (Boyce, 1993; Mayo *et al.*, 1997). Among the most studied species, *Arum maculatum*, *A. italicum*, *A. dioscoridis*, *A. palaestinum* and *A. idaeum* are qualified as "cryptic" species, while *Arum rupicola*, *A. hygrophilum* and *A. creticum* are known as "flag"

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species.

Al–Eisawi (1998), in his list of wild flora of Jordan recorded 3 species of *Arum*: *A. dioscoridis*, *A. hygrophilum* and *A. palaestinum*. *Arums* species (called spotted arum, green arum, water arum and Palestine arum) in Jordan are utilized as spices cooked like leafy crops and are believed in folk medicine to cure cancer, circulatory system, obesity, internal bacterial infection, diabetic symptoms and poisoning problems. Due to over-exploitation through uprooting and continuous removal of the plants and to natural habitat destruction, *Arum* populations are highly threatened calling for the protection and conservation of remaining diversity (Oran and Al-Eisawi, 1994).

The extent and structure of genetic variation of wild populations are essential not only for understanding the processes of evolution, but also for the development of appropriate and efficient strategies for collection and conservation of populations (Kiambi *et al.*, 2005). The genetic diversity or relatedness among populations is assessed using morphological, biochemical and molecular marker approaches. Marcos (1998) studied the modification of phenotypic and functional gender in three populations of the monoecious *Arum italicum* and reported that the probability of reproduction and the number of inflorescences increased with plant size, and that flowers number increased with both plant and inflorescence sizes. Twenty-four species of *Gerbera* were characterized morphologically, and it was found that flower diameter was the most variable character compared with other morphological characters (Chung *et al.,* 2001). Karam *et al.* (2006) found that environmental conditions affect the morphological characters of the black iris (*Iris nigricans* Dinsm.) population collected from Jordan. Phenotypic variation of eight populations belonging to two iris species (*Iris haynei* and *I. atrofusca*) was analyzed using 15 morphological traits related to the leaves, stems and flowers which allowed to differentiate among the two species (Arafeh *et al*., 2002).

This work is aimed to assess the ecogeographical distribution of wild *Arum* species in Jordan and to study the phenotypic variation of populations collected from Amman, Irbid, Jarash, Ajlun, Zarqa, Mafraq, Madaba and Al-Balqa.

MATERIALS AND METHODS

Survey and Selection of the Locations

Field collections of *Arum* populations were carried throughout January – April 2006. The collection sites were selected according to bibliographic information and herbarium samples of the National Center for Agricultural Research and Technology Transfer (NCARTT). Eight provinces were chosen to cover most of the geographical range of *Arum* populations. Each province was subdivided into locations for a total number of twenty-one locations (Figure 1 and Table 1). The selected locations within a province need to be distant of not less than 2 kilometers and should have a satisfactory number of *Arum* plants. Individuals within populations were chosen randomly and at wide space intervals to maximize the genetic diversity. The latitude, longitude and altitude of each location were determined using the Geographical Positioning System (GPS) using MAGELLAN (model NAV 5000 DX^{TM}, USA) and a Digital Barometer (model AIR – HB- IL, Atmospheric Instrumentation Research, Inc., USA). The long term average of rainfall (1997-2006) was provided by the Department of Meteorology.

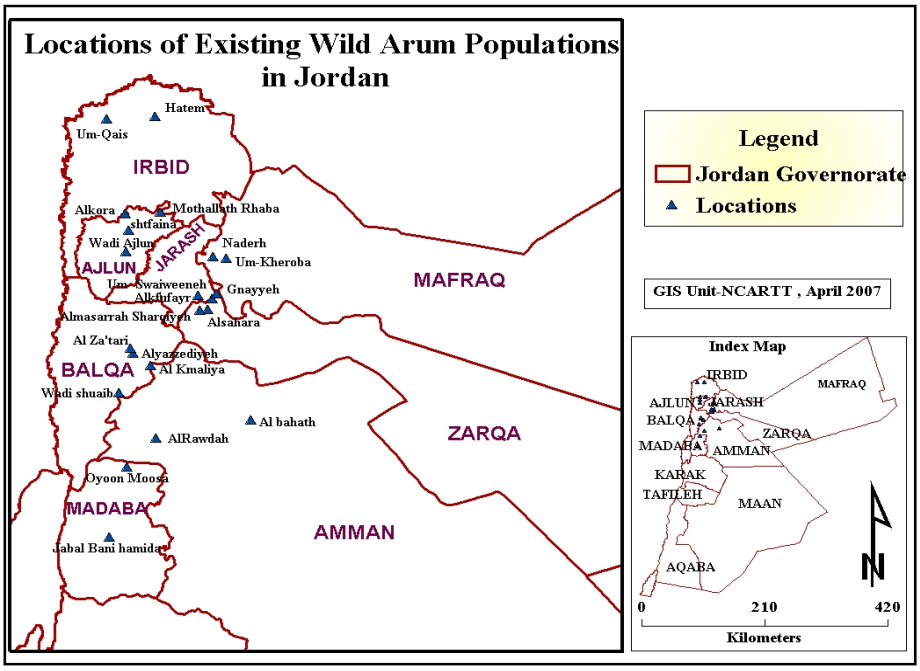

Figure (1): Jordan map showing the distribution of sampled *Arum* populations from twenty one locations in Jordan (GIS Unit – NCARE, April, 2007).

Table (1): Eco-geographical parameters and description of the twenty-one locations where *Arum* populations were sampled.

No.	Province	Rainfall (mm)	Location	Code	No. of samples	Longitude (E)	Latitude (N)	Altitude (M)
1	Irbid	463.52	Alkora	Alko	10	32°24′30	35°43′64	793
			Hatem	Hat	10	32°39′11	35°48′30	464
			Um-Qais	UMQ	10	32°38′50	35°40′29	350
2	Ajlun	614.66	Wadi Ajlun	Waj	10	32°18′49	35°43′57	631
			Eshtafaina	Shta	10	32°22′03	35°44′19	837
			Mothallath Rhaba	Mrha	10	32°24′47	35°49′34	1062
3	Jarash	315.0	Algnayyeh	Alg	10	32°11′13	35°58′22	469
			Um-Swaiweeneh	Umsw	10	32°11′54	35°58′21	382
			Al-Kufayr	Alku	10	32°12′22	35°56′01	540
4	Zarq'a	130.33	Al-sharah	Alsh	10	32°10`14	35°57′44	487
			Al-masarrah Al-Sharqiyeh	Alsa	10	32°10′03	35°56′26	567
5	Mafraq	146.54	Um-Kheroba	Umkh	10	32°17′55	36°00′38	729
			Naderh	Nad	10	32°18′12	35°58′27	778
6	Al- Balqa	513.89	Wadi Shua'ib	Wsh	10	31°57′34	35°43′04	379
			Al-Yazzediyeh	Alyaz	10	32°03′32	35°45′24	893
			Al-Za'tari	Alzat	10	32°04′18	35°44′58	992

No.	Province	Rainfall (mm)	Location	Code	No. of samples	Longitude (E)	Latitude (N)	Altitude (M)
7	Amman	433.17	Al Kmaliya	Alka	10	32°01′44	35°48′17	962
			Al Bahath	Alba	10	31°53′39	35°47′41	597
			Al Rawdah	ALR	10	31°50′49	35°49′18	860
8	Madaba	311.92	Oyoon-Moosa	Omus	10	31°46′23	35°44′34	593
			Jabal Bani Hamida	JBH	10	31°35′50	35°41′44	774

Source: Department of Meteorology, Jordan.

Morphological Characterization

The morphological characterization was done in the field for ten plants from each location using 26 characters related to the leaf, inflorescence and corm (Table 2) according to Taro (*Colocasia esculenta*) descriptors (IPGRI, 1999). The collected plants were identified according to flora Palaestina (Feinbrun–Dothan, 1986).Three species have been identified.

Table (2): Morphological characters analyzed in *Arum* populations from 21 locations in Jordan.

No	Characters	Code	Description
1	Plant Span (cm)	PS	Maximum horizontal distance reached by leaves
2	Plant Height (cm)	PH	Maximum vertical distance reached by leaves, relative to ground level
3	No. of Leaves / Plant	LNO	Observed on fully developed leaves
4	Leaf Length (cm)	LL	Measured on two fully developed leaves per plants
5	Leaf Width (cm)	LW	Measured on two fully developed leaves per plants
6	Leaf Mid Vein Length (cm)	LMVL	Measured on two fully developed leaves per plants
7	Leaf Base Shape	LBSH	With regard to the petiole attachment
8	Leaf Colour	LC	According to the scale (green, light green, dark green)
9	Leaf Blade Margin	LBM	Observed on fully expanded and mature leaves
10	Leaf Blade Margin Colour	LBMC	Observed on the upper side of blade
11	Leaf Lamina Appendages	LLA	Observed on fully open young leaves
12	Leaf Waxiness	LW	Observed on fully developed leaves
13	No. of Inflorescence / Leaf- axis	FLNO	Observed on fully mature flower
14	Spadix Length (cm)	SL	Measured on fully mature flower
15	Spadix Width (cm)	SW	Measured on fully mature flower
16	Spadix Colour	SC	Observed on fully mature flower
17	Spathe Length (cm)	SL	Measured on fully mature flower
18	Spathe Width (cm)	SW	Measured on fully mature flower
19	Spathe Shape	SSH	Observed on fully mature flower
20	Spathe Colour	SC	Observed on fully mature flower
21	Corm Mainfestation	CM	Observed on fully mature plants
22	Corm Length (cm)	CL	Measured on fully mature plants
23	Corm Diameter (cm)	CD	Measured on fully mature plants
24	Corm Weight (g)	CW	Measured on fully mature plants
25	Corm Shape	CSH	Observed on fully mature plants
26	Corm Branching	CB	Observed on fully mature plants

Data Analysis

Mean and standard deviation values of the morphological characters were determined using the statistical package for social studies software (SPSS 11.0.1 (SPSS Inc., 2001)). Discriminate multivariate analysis was performed to investigate the closeness of these populations based on their morphological characters. Canonical Discriminate Analysis (CDA) was performed using SPSS 11.0.1 (SPSS Inc., 2001). Based on Euclidean distance coefficient, dendrograms were constructed to evaluate levels of phenotypic variation among populations.

RESULTS AND DISCUSSION

The means and standard deviations of morphological characters studied are presented in Table 3. The highest values of mean and standard deviation were recorded for plant height, corm weight, plant span and, leaf length for the three species.

The canonical discriminant analysis using the standardized canonical discriminant function coefficients for all morphological characters showed that the first canonical function explained 89.7% of the variability and the second function accounted for 10.3% (Table 4). The first canonical function is strongly influenced by leaf waxiness, spadix color, spathe color, leaf mid-vein and leaf width (Table 5). All other morphological characters showed lower power for the distinction between the populations. The second canonical function coefficient was strongly influenced by spadix color, leaf waxiness, plant span, spathe color and leaf length.

Table (3): Mean and standard deviation values for all morphological characters measured in different populations of *Arum* species.

Morphological characters	Mean ± Standard Deviation			Overall Mean ± S.D.
	A. dioscordis	***A. hygrophium***	***A. palaestinum***	
1. Plant Span	25.9 ± 8.0	32.1 ±9.8	25.7 ±9.4	27.9±9.1
2. Plant Height	38.7 ± 9.6	41.7±11.0	37.3 ±11.2	39.2±10.6
3. No of Leaves/Plant	2.6 ± 1.1	3.2 ±0.87	2.6 ±0.9	2.8±0.95
4. Leaf Length	15.3 ± 4.7	16.1±3.7	13.8 ± 4.4	15.1±4.3
5. Leaf Width	8.6 ± 2.1	6.2 ± 1.1	7.2 ± 1.8	7.3±1.7
6. Leaf Mid-Vein	10 ± 2.8	11.2± 2.6	9.4 ± 2.6	10.2±2.7
7. Leaf Base Shape	1.0 ± 0.0	2.0 ± 0.0	1.0 ± 0.0	1.33±0.0
8. Leaf Color	4.0 ± 0.12	2.0 ± 0.18	3.2 ± 0.4	3.1±0.23
9. Leaf-Blade Margin	2.3 ± 0.47	2.0 ±0.0	2.2 ± 0.4	2.2±0.29
10. Leaf –Blade Margin Color	2 ± 0.0	1.0 ± 0.0	2.0 ± 0.0	1.7±0.0
11. Leaf Lamina Appendages	1 ± 0.0	1.0± 0.0	1.0 ± 0.0	1±0.0
12. Leaf Waxiness	7 ± 0.0	3.0 ± 0.0	5.2 ±0.6	5.1±0.2
13. No. of Inflor./Leaf Axis	1 ± 0.0	1.0±0.0	1.0±0.0	1±0.0
14. Spadix Length	11.1 ± 2.7	6.35 ±1.43	10.7 ±2.5	9.4±2.21
15. Spadix Width	1.9 ± 0.43	1.5 ±0.19	1.9 ±0.5	1.8±0.37
16. Spathe Length	16.4 ± 2.8	10.8 ±1.8	16.8 ± 3.4	14.7±2.7
17. Spathe Width	7.8 ± 2.35	4.5 ±2.8	7.6 ± 2.1	6.63±2.4
18. Spathe Shape	4.0 ± 0.0	1.0± 0.0	4.0 ± 0.0	3±0.0
19. Spadix Color	1 ± 0.0	1.97±0.18	1.0± 0.1	1.32±0.093
20. Spathe Color	1.0 ± 0.28	3.0 ±0.0	2.0± 0.2	2±0.16
21. Corm Mainfestation	1 ± 0.0	1.0 ± 0.0	1.0 ± 0.0	1±0.0
22. Corm Length	2.8 ±1.5	2.4 ±0.7	2.4 ±1.3	2.53±1.16
23. Corm Diameter	3.6 ±1.52	1.93 ±0.61	3.11 ±1. 2	2.9±1.11
24. Corm Weight	30.7 ±27	9.3 ±6.13	22.0 ±17.1	20.7±16.7
25. Corm Shape	3.0 ±1.53	3.22 ±1.50	2.7 ±1.5	2.97±1.51
26. Corm Branching	0.8 ± 0.43	0.613 ± 0.5	0.8 ± 0.4	0.74±0.44

These results indicate that leaf waxiness, spadix color, spathe color, leaf length, leaf width, plant span and leaf mid-vein are the main characters that can discriminate between *Arum* species. The two canonical functions accounted for 100% of the total variation.

Table (4): Eigen-values and percent of variability explained by each canonical discriminant function.

Function	Eigen-value	% of Variance	Cumulative %	Canonical Correlation
1	31.703	89.7	89.7	0.985
2	3.622	10.3	100.0	0.885

Table (5): Standardized canonical discriminant function coefficients for the analyzed morphological characters.

Morphological characters	Function	
	1	2
Plant Span	.058	-.416
Plant Height	-.012	.203
No. of Leaves/Plant	.104	.099
Leaf Length	-.042	.277
Leaf Width	-.410	-.032
Leaf Mid-Vein	.430	-.104
Leaf Color	.262	-.020
Leaf-Blade Margin	.035	-.114
Leaf Waxiness	-.756	.517
Spadix Length	-.012	-.064
Spadix Width	-.005	.068
Spathe Length	-.018	-.163
Spathe Width	-.085	-.156
Spadix Color	.610	.780
Spathe Color	.508	-.384
Corm Length	-.041	-.123
Corm Diameter	-.053	-.069
Corm Weight	.144	.097
Corm Shape	.129	.069
Corm Branching	-.049	.008

The graphical representation of the distribution of sampled *Arum* species in the space of the two discriminant functions is shown in Figure 2. The two canonical functions show a separation between the three *Arum* species *(A. dioscoridis, A. hygrophilum* and *A. palaestinum*). Function 1 discriminates *A. hygrophylium* from the other two species with a percent of 89.7%. Function 2 discriminates *A. palaestinum* from both species *A. dioscoridis* and *A. hygrophylium* with a percent of 10.3%. These results indicated that the morphological variation showed a good separation between the three *Arum* species.

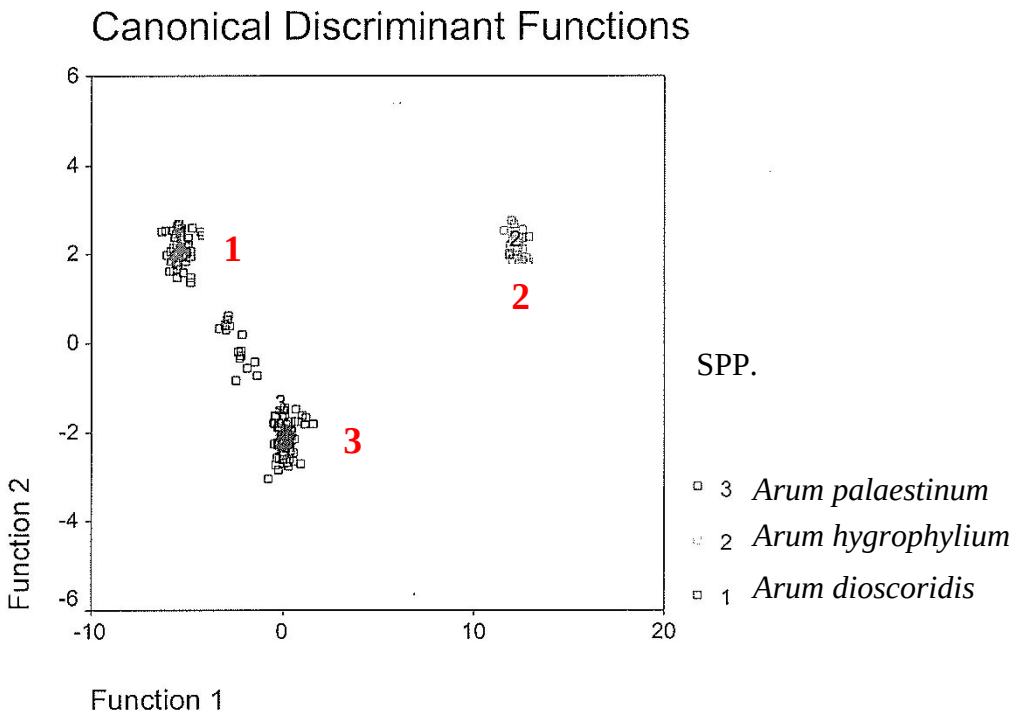

Figure (2): Canonical discriminant functions between the three *Arum* species (1: *A. dioscoridis*; 2: *A. hygrophylium*; 3: *A. palaestinum*) and the two main functions.

The hierarchical cluster (species over locations) based on morphological characters for *Arum* populations shown in Figure 3 revealed that *Arum* populations are separated in three different species: species 1 (*Arum dioscoridis*), species 2 (*Arum hygrophilum*) and species 3 (*Arum palaestinum*). The distance coefficients ranged from 9.72 between *A. palaestinum* and *A. dioscoridis*, to 25.10 between *A. hygrophilum* and *A. dioscoridis* (Table 6). The distance coefficient between *A. palaestinum* and *A. hygrophilum* was 17.82.

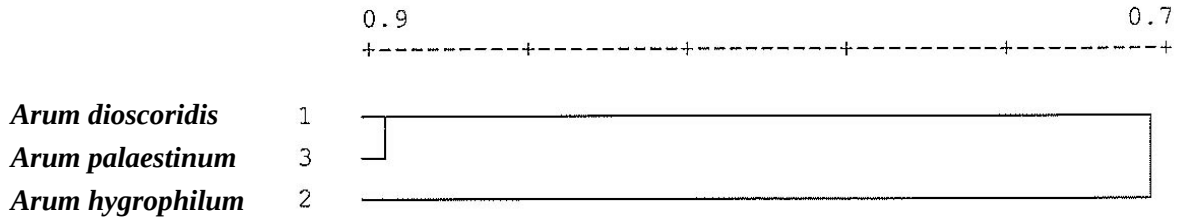

Figure (3): Dendrogram produced using Euclidean distance matrix (over species) using 26 morphological characters for clustering *Arum* species.

Table (6): Euclidean distance coefficient for 210 *Arum* populations (over species), using 26 morphological characters.

Species	*Arum dioscoridis*	*Arum hygrophilum*	*Arum palaestinum*
Arum dioscoridis	0.00		
Arum hygrophilum	25.10	0.00	
Arum palaestinum	9.72	17.82	0.00

The hierarchical cluster (location over species) based on morphological characters for *Arum* populations is shown in Figure 4. The distance coefficients ranged from 3.19 between Wadi Ajlun and Um-Qais having the same species *A. hygrophilum*, to 80.22 (between Oyoon Moosa and Alsaharah) locations which have *A. dioscoridis* and *A. palaestinum* species with an overall mean distance of 18.60.

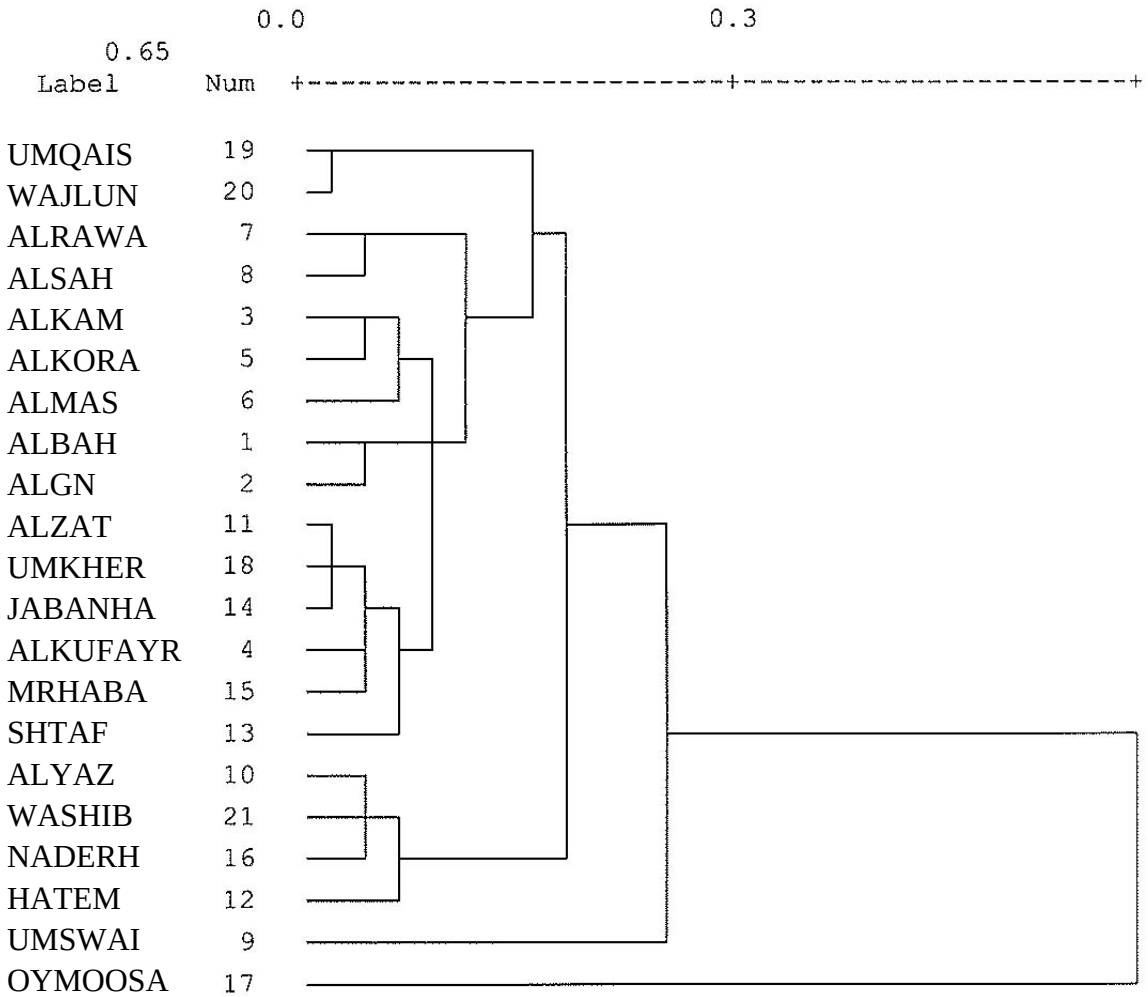

Figure (4): Dendrogram using Euclidean distance coefficient (over locations) using 26 morphological characters.

Based on Euclidean distance coefficient, a phonological dendrogram of 210 *Arum* samples resulted in four sub-clusters with the locations 17 (Oyoon Moosa) and 9 (Um-Swaiweeneh) forming single clusters (Figure 4). *Arum* populations (*A. dioscoridis* and *A. palaestinum*) collected from Oyoon Moosa location grow in the middle part of Jordan (Madaba) characterized by fertile soils. Most of the *Arum* plants in this location were grouped together forming a population with multi-large corm, high plants, long leaves and spathes and waxed leaves with darker green leaves and purple spathe and spadix. *Arum hygrophilum* populations collected from Um-Swaiweeneh location in northern part of Jordan (Jarash) characterized by humid conditions produce more vegetative growth and have high plant and plant span and long leaves, spathes. These results indicate that the differences between *Arum* species could be due to their genetic make up and to the growth conditions in their respective locations. It seems that *A. dioscoridis* is adapted in fallowed fields, forests, rocky places and mountains. *Arum palaestinum* grows in alluvial soils, rocky places and mountains while *A. hygrophilum* is adapted to more humid conditions, near water flows and under the shade of orchards (Feinbrun-Dothan, 1986). This indicates that *Arum* species have developed specific adaptations in response to different climatic, ecological and biotic (i.e., entomofauna) constraints (i.e., selective pressures) as suggested by Gibernau *et al.* (2004).

The four sub-clusters grouped the remaining locations. Sub-cluster 1 includes location 16 (Naderh) and location 12 (Hatem) with a genetic distance of 9.44, location 16 (Naderh) and location 21 (Wadi Shua'ib) with a genetic distance of 6.47 and location 10 (Alyazzediyeh) and location 21 (Wadi Shua'ib) with a genetic distance of 5.74. Sub-cluster 2 includes location 13 (Eshtafaina) and location 15 (Mothallath Rhaba) with a genetic distance of 8.11, location 15 (Mothallath Rhaba) and location 4 (Alkufayr) with a genetic distance of 11.55, location 14 (Jabal Bani Hamida) and location 18 (Um-Kheroba) with a genetic distance of 5.52 and location 18 (Um-Kheroba) and location 11 (Al Z'atari) with a genetic distance of 3.54. Sub-cluster 3 includes location 2 (Al Gnayyeh) and location 1 (Al Bahath) with a genetic distance of 6.77, location 8 (Al Sharah) and location 7 (Al Rawdah) with a genetic distance of 7.38, location 6 (Al Masarrah) and location 5 (Alkora) with a genetic distance of 8.42, and location 5 (Alkora) and location 3 (Al Kamaliya) with a genetic distance of 6.79. Sub- cluster 4 includes location 20 (Wadi Ajlun) and location 19 (Um-Qais) with a genetic distance of 3.19. These results indicate that the populations in the same sub-cluster may have similar adaptive characteristics or were of the same origin. These findings were in agreement with those of Jaradat (1992), who reported that the highest levels of variation among populations were found in material collected from different sites.

The hierarchical cluster (location and species combinations) based on morphological characters for *Arum* populations is shown in Figure 5. Distance coefficients ranged from 3.19 for location 20 (Wadi Ajlun) and (*Arum hygrophilum*) and location 19 (Um-Qais) and (*Arum hygrophilum*) to 108.42 for location 17 (Oyoon-mossa) and (*Arum dioscoridis*) and location 18 (Um-Kheroba) and (*Arum palaestinum*) with an overall mean of 25.83. Three clusters and eight sub-clusters were determined by the combinations of locations and species (Figure 5). The combination of location 17 (Oyoon-mossa) and (*Arum dioscoridis*) is included in a separate cluster with a genetic distance of 65.80. The first main-cluster included combinations of location 16 (Naderh) and (*Arum dioscoridis*), with a genetic distance 28.50 and the combination of location 17 (Oyoon-mossa) and *Arum palaestinum*. The second cluster included the combination of location 9 (Um-Swaiweeneh) and (*Arum hygrophilum*). Cluster 3 included eight sub-clusters. Sub-cluster 1 included the combination of location 15 (Mothallath Rhaba) and (*Arum dioscoridis*), location 5 (Alkora) and (*Arum palaestinum*) with genetic distances ranging from 5.16-7.18. Sub-cluster 2 included the combinations of location 11 (Al Za'tari) and (*Arum palaestinum*), location 4 (Al Kufayr) and (*Arum dioscoridis*), location 1 (Albahath)

and (*Arum dioscoridis*) and location 18 (Um-kheroba) and (*Arum palaestinum*), location 16 (Naderh) and (*Arum palestinum*), with genetic distances ranging from 5.12 to 8.17. Sub-cluster 3 included the combinations of location 13 (Eshtafaina) and (*Arum dioscoridis*), location 18 (Um-kheroba) and (*Arum dioscoridis*), location 15 (Mothallath Rhaba) and (*Arum palaestinum*), with a genetic distance range of 7.16-8.29. Sub-cluster 4 included the combinations of location 1 (Albahath) and (*Arum hygrophilum*), location 10 (Al Yazzediyeh) and (*Arum palaestinum*), location 2 (Algnayyeh) and (*Arum palaestinum*), location 21 (Wadi Shua'ib) and (*Arum dioscoridis*), location 10 (Al yazzediyeh) and (*Arum dioscoridis*), with a genetic distance range of 3.91-12.89. Sub-cluster 5 included the combinations of location 14 (Jabal Bani Hamida) and (*Arum dioscoridis*), location 12 (Hatem) and (*Arum palaestinum*), with a genetic distance of 7.61. Sub-cluster 6 included the combinations of location 8 (Alsharah) and (*Arum palaestinum*), location 13 (Eshtafaina) and (*Arum palaestinum*), location 8 (Alsharah) and (*Arum dioscoridis*), location 7 (Al Rawdah) and (*Arum palaestinum*), with a genetic distance ranging from 5.31 to 12.85. Sub-cluster 7 included the combinations of location 5 (Al Kora) and (*Arum dioscoridis*), location 14 (Jabal Bani Hamida) and (*Arum palaestinum*), location 3 (Al Kmaliya) and (*Arum dioscoridis*), location 6 (Almasarrah) and (*Arum dioscoridis*), location 1 (Albahath) and (*Arum palaestinum*), location 3 (Al kmaliya) and (*Arum palaestinum*), location 2 (Algnayyeh) and (*Arum dioscoridis*), with a genetic distance ranging from 5.31 to 10.72. Sub-cluster 8 included the combinations of location 20 (Wadi Ajlun) and (*Arum hygrophilum*), and location 19 (Um-Qais) and (*Arum hygrophilum*), with a genetic distance of 3.19.

Generally, the results showed that *Arum* populations belonging to the same species tend to cluster together regardless of the collection site. For instance, *A. hygrophilum* from location 20 (Wadi Ajlun) and *A. hygrophilum* from location 19 (Um-Qais) are included in the same cluster. Also *A. dioscoridis* from location 15 (Mothallath Rhaba) and location 11 (Al Za'tari) are grouped together and the populations of *Arum palaestinum* from location 18 (Um-kheroba) and location 16 (Naderh) are in the same cluster.

Arum species with common genomes tend to cluster together regardless of the collection site. This is the case of *A. dioscoridis* from location 18 (Um-Kheroba) and *A. palaestinum* from location 15 (Mothallath Rhaba). These results were in agreement of those reported by Migdadi et al. (2004).

These results indicated that morphological characters, although they can be affected by environmental conditions, showed a significant separation between *Arum* populations reflecting differences among localities and microclimatic conditions.

In conclusion, leaf waxiness, spadix colour, spathe colour, leaf length, leaf width, plant span and leaf mid-vein are the main characteristics to discriminate between *Arum* species, and these can be used as descriptors for the genus. These characteristics will be used to assess the diversity when designing strategies for *ex situ* and *in situ* conservation strategies.

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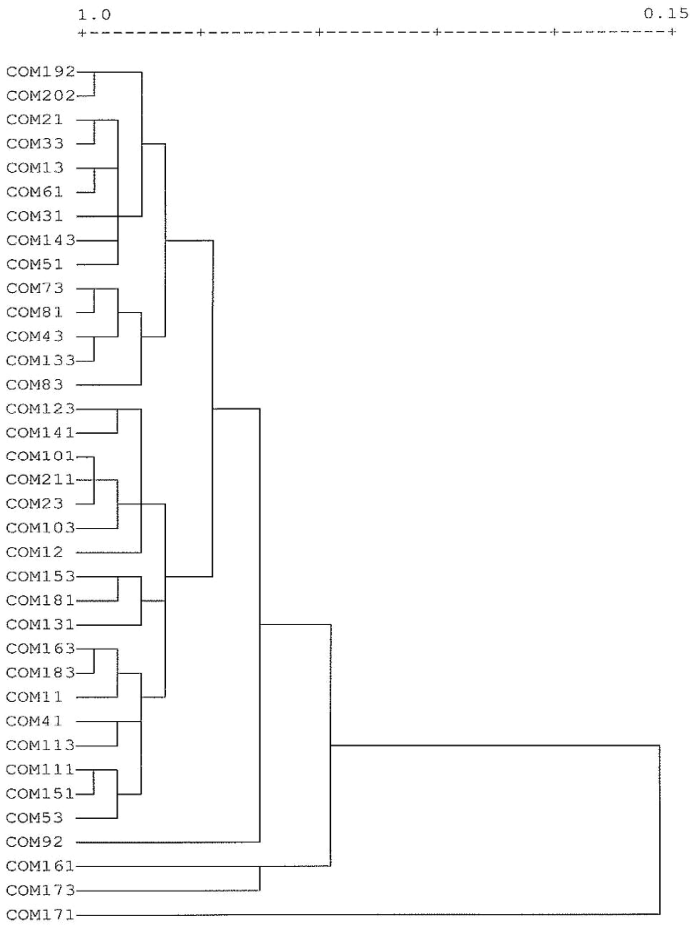

Figure (5): Dendrogram using Euclidean distance coefficient (combination of location and species) using 26 morphological characters.

COM 11: Location 1 and Species 1.

Locations:1- Albahath, 2- Algnayyeh, 3- Alkmaliya, 4- Alkufayr, 5- Alkora, 6- Almasarrah, 7- Alrawdah, 8-lsaharah, 9- Um-swaiweeneh, 10- Alyazzediyeh, 11- Alza'tari, 12- Hatem, 13- Shtafaina, 14- Jabal Bani Hamida , 15-Mothallath Rhab, 16- Naderh, 17- Oyoon-Moosa, 18- Um Kheroba, 19- Um-Qais, 20- Wadi Ajlun, 21- Wadi shua'ib.

Species :1- *A. dioscoridis.* 2- *A. hygrophilum.* 3- *A. palaestinum.*

REFERENCES

Al-Eisawi, D. M. H. 1998. Field-guide to wild flowers of Jordan and neighboring countries, ***Jordan Press Foundation " Al Rai"***, Amman, Jordan.

Al-Eisawi, D., A. El-Oqlah, S. Oran and J. Lahham. 1996. Plant biodiversity in Jordan. In: Jaradat AA. (editor). Plant genetic resources of Jordan. Proceedings of a national seminar, Amman, Jordan. 2-4 August 1994.

Arafeh, R. M. H., Y. Spair, A. Shimida, N. Iraki, O. Fragman and H. P. Comes. 2002. Patterns of genetic and phenotypic variation in *Iris haynei* and *I. atrofusca* (*Iris* sect. Onocyclus = the royal irises) along an ecogeographical gradient in Israel and the West Bank. ***Molecular Ecology,*** 11: 39-53.

Boyce, P. 1993. The genus *Arum*. London. ***The Royal Botanic Gardens,*** 197.

Chung, Y. M., H. A. Kim, K. Y. Kim, S. W. Park, Y. B. Yi, J. H. Lee and O. C. Kwon. 2001. Morphological characteristics and genetic variation of *Gerbera* (*Gerbera hybrida* Hort). ***J. Plant Biotechnology,*** 313: 145-149.

Fehr, W. R. 1987. Principles of cultivar development: theory and technique, vol. 1., Macmillan Publishing Company, New York.

Feinbrun-Dothan, N. 1986. Araceae. In M. Zohari and N. Feinbrun-Dothan (editors). Flora Palaestina. Part 4. Jerusalem, Palestine, 331-340.

Gibernau, M., D. Macquart and G. Przetak. 2004. Pollination in the genus *Arum*: a review. ***Aroideana***. 27: 148-166.

IPGRI. 1999. Descriptors for taro (*Colocasia Esculenta*). International Plant Genetic Resources Institute, Rome, Italy.

Jaradat, AA. 1992. Breeding potential of durum wheat landraces from Jordan. II Differential response to drought. Hereditas, 116: 305-309.

Karam, N., A. Al-Khasawneh, R. A. Shibli, H. M. Migdadi and M. Al-Ajlouni. 2006. Morphological variation in Black Iris (*Iris nigricans* Dinsm.) from Jordan. ***Plant Genetic Resources Newsletter,*** 147: 1-6.

Kiambi, D. K., H. J. Newbury, B. V. Ford-Lloyd and I. Dawson. 2005. Contrasting genetic diversity among *Oryza longistaminata* (A. Chev et Roehr) populations from different geographic origins using AFLP. ***African Journal of Biotechnology***, 4: 308-317.

Marcos, M. 1998. Modification of phenotypic and functional gender in the monoecious *Arum italicum* (*Araceae*). ***American Journal of Botany***, 85: 225-234.

Mayo, S. J., J. Bogner and P. C. Boyce. 1997. The Genera of *Araceae*. ***Royal Botanical Gardens***, 370.

Migdadi, H. M., A. M. Tell and S. Masoud. 2004. Genetic diversity in some *Aegilops* species in Jordan revealed using RAPD. ***Plant Genetic Resources Newsletter***, 139: 47-52.

Omar, G. I. 2006. Systematic study of the genus *Allium* (*Liliaceae*) in Jordan. Ph.D. thesis. University of Jordan, Amman, Jordan.

Oran, S. 1994. Genetic resources of medicinal plants in Jordan. In: Jaradat, A. A. (editor). Plant genetic resources of Jordan. Proceedings of a national seminar, Amman, Jordan. 2-4 August 1994.

Statistical Package for Social Studies (SPSS version 11.0.1 for windows) (SPSS Inc., 2001).

تقييم التباين المظهري لأنواع اللوف في الأردن

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ملخـص

أجري مسح ميداني لواحد وعشرين موقعاً في ثماني محافظات في الاردن لدراسة التوزيع الجغرافي وتقييم التباين المظهري لنبات اللوف في الاردن . تمت دراسة ست وعشرين صفة مظهرية لكل من الأوراق والساق والأزهار والكورمات.

أظهرت نتائج الدراسة المظهرية وجود بعض الصفات الأكثر تنوعاً لنبات اللوف، يمكن استخدامها في برامج التهجين مثل طول النبات والمسافة العمودية التي تصلها الأوراق ووزن الكورمات وطول الورقة وطول الإغريض وطول الشمراخ الزهري وطول منتصف الورقة. كما أظهرت نتائج الدراسة وجود بعض الصفات التي يمكن استخدامها للتمييز بين أنواع اللوف الثلاثة، وهي: درجة تشمع الورقة ولون الشمراخ الزهري ولون الإغريض وطول الورقة وعرض الورقة والمسافة العمودية التي تصلها الأوراق وطول منتصف الورقة.

باستخدام معامل (Euclidean) لإنشاء جداول التباين أظهرت النتائج القدرة على تمييز اللوف البري في الأردن إلى ثلاثة أنواع هي: اللوف الفلسطيني واللوف المبرقش واللوف المائي وبنسب تشابه تتراوح بين 90.28% بين اللوف الفلسطيني واللوف المبرقش، و74.90% بين اللوف المائي واللوف المبرقش، و82.18% بين اللوف المائي واللوف الفلسطيني. أما درجة التشابه بين المواقع فقد بلغت 81.40% و 74.17% بين الأنواع والمواقع على الترتيب. وتبين أن المدى الواسع لمعامل التباين يدل على وجود التباين الوراثي بين هذه الأنواع؛ إذ تبين أن العينات التي تنتمي إلى النوع الواحد قد تجمعت في مجموعة واحدة بغض النظر عن المواقع التي تم الجمع فيها، وقد كانت نسبة التشابه بين الأنواع في المجموعة نفسها أعلى من نسبة التشابه بين الأنواع في مجموعات أخرى.

إن نتائج هذا البحث ستكون لها أهمية في حفظ الأصول الوراثية لهذا النبات، وذلك عن طريق حمايته في مواقعه الطبيعية وخارج مواقعه الطبيعية بغية استغلاله واستخدامه في أغراض بحثية أخرى.

الكلمات الدالة: لنواع اللوف، التباين المظهري، النباتات الطبية، الحفظ خارج الموئل.

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