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Simultaneous morphological measurements comparison and automated analysis of two Algerian grapevine collections

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ABSTRACT

This study aim's is to characterize cultivars registered in two collections in Algeria, 34 cultivars constituting the collection of M'zej Edchiche in Skikda, 26 accessions from the germplasm of Tighennif in Mascara, using 38 ampelographic descriptors of the OIV on adult leaf. Data analysis revealed highly significant parameters, like angles, petiole sinus and the lengths of the veins. A strong similarity is shown in both collections. The developed SoftAmpeLog is a system designed for the classification of grape varieties. The software has successfully identified the same groups and the strong links between the probable synonyms.

ملخص

تهدف هذه الدراسة إلى توصيف الأصناف المسجلة في مجمعين وراثيين في الجزائر ، 34 مدخلا تشكل مجمع مزاج إدشيش في ولاية سكيكدة ، 26 مدخلًا من المادة الوراثية من مجمع تغنيف في ولاية معسكر ، باستخدام 38 واصفًا حسب المنظمة الدولية للعنب " OIV "على الأوراق البالغة. كشفت التحاليل المنجزة عن معايير ذات دلالة معنوية عالية ، مثل الزوايا ، الجيوب المعلاقية للورقة و اطوال العروق الورقية .كما يظهر تشابه قوي بين بعض الأصناف في كلا المجموعتين. ان برنامج " SoftAmpeLog " المطور هو برنامج مصمم لتصنيف والتعرف على أصناف العنب. تمكن هذا الأخير بنجاح من التعرف على نفس المجموعات والروابط القوية الممكنة بين المترادفات المحتملة.

Introduction

Leaf morphology represents a beautiful and tangible example of the infinite phenotypic possibilities in nature (Chitwood et al., 2016), it is considered the most important clue *to identify* the *grape variety*. All observations should be made on a dozen leaves to eliminate small fluctuations and obtain average numbers in the evaluations (Galet, 1998), where phyllometry consists in making quantitative measurements on leaf , will bring an interesting element for characterization of the grape varieties (Galet, 1998 ; Tomažič and Korošec-Koruza, 2003). Without doubt, Goethe (1878) was the first who consider the study of leaves and their morphology for purposes of recognition and classification. This pathway was then developed and continued by Ravaz (1902) who stated the principles and defined the bases and codifications of ampelometry without trying to apply this method. By his

considerable work has also developed an original ampelometric method based on the establishment of the contour of an average leaf. The code OIV (international office of the vine and wine) is at the base of the morphological description of the varieties and the new ones of them. It allows a universal and international language for ampelographs (Kerridge and Antchiff ,1999).

This is now a tool that provides valuable support for variety recognition. In particular, and thanks to the aspect of learning in artificial intelligence techniques as in the case of artificial neural networks, this will provide valuable insights into whether a new variety introduced into a collection will it does not already exist under another name (Boursiquot et al.,1987).

According to Cid-alvarez et al. (1994), the use of numerical data from measurements achieved has proved very useful in differentiating autochthonous grapevine varieties from Galicia. This method seems to be valid for a defined area because of the considerable influence of climatic parameters on the vigor of the plant. However, another AmpeloCADs program was created by the group of Alssendrie et al. (1996), and is already tested by the analysis of hundreds of leaves. New parameters are added to the standard one in order to improve the system, reduce the error and increase their efficiency in the classification of grape varieties.

The application of the fractal dimension to describe the biologic objects has been reported by several scientists. This technique is based on the acquisition of digital images. Some numbers of studies have shown the utility of the method in the characterization of biological structures (*Mancuso, 1999, 2001, 2002; Mancuso et al., 2001;* Zmeškal *et al., 2001*). Other researchers like Oancea (2007) and Tărdea *et al. (2008)* have shown that natural objects have a finite range; this has also proven a precise fractal range for grapevine leaves. An artificial neural network has been applied in many fields of experimental science; physics, medicine, electronics and botany for grapevine identification. He managed to identify unknown varieties with certainty. The results obtained are interesting because they are in agreement with those obtained using molecular methods. In addition, the method can be further improved by increasing the number of ampelographic parameters (Coban, *2004*). Recently Soldavini *et al. (2007)* have achieved to some extent through their software program SuperAmpelo which is based on the biometrics or descriptor proposed by the OIV.

The first descriptive study on Algerian grapevine was beginning in 1894 through the work of Leroux, who studied local varieties especially those in the region of Blida (Viala and Vermorel, 1901-1910). Pulliat (1898) and Trabut (1899) in Viala and Vermorel (1901-1910) described local grape varieties for the first time. This study was developed to cover other varieties by Levadoux et al. (1971) who managed to put a reference on the Algerian vineyard in "Algerian ampelography", he gave us a general vision on the existing local grape varieties and their denomination based on the old studies carried out in this field. Dont forgot the stady of Laiadi et al. (2009, 2013) and Zinelabine et al. (2014) on Algerian grapevines.

Materials and methods

11 adult leaves inserted between nodes 8 to 12 of a fruiting vine shoot produced by one year old, wood of each variety were taken between fruit-set and veraison (Martinez et al., 1997, Martinez and Grenan, 1999 ; Martínez and Pérez, 2000 ; Santiago et al., 2005a ; Martinez et al., 2006) for two successive years : 34 varieties of the collection M'zej Edchiche at Skikda in 2009 and 26 grape varieties from the Tighennif collection of Mascara in 2010. Leaves were cleaned and then scanned with a model (HP Deskjet F2200 series) on both sides, making sure that each leaf is well flattened and represented with the petiole up according to Galet (1998). Ampelometric measurements proposed by Martínez and Grenan (1999) were carried out with a free analysis software program (UTHSCSA Image Tool (IT) version 3.00, compdent.uthscsa.edu/dig/download.html) by using a specific calibration. 19 quantitative ampelometric parameters according to OIV (2007) : OIV601, OIV602, OIV603, OIV604, OIV605, OIV606, OIV66-5 ,OIV607, OIV608, OIV609, OIV610, OIV611, OIV612, OIV613, OIV614, OIV615, OIV616, OIV617, OIV618. Nevertheless, 17 qualitative visual parameters are noted and codified according to the standards of the OIV (2007); OIV67, OIV68, OIV70, OIV71, OIV76, OIV79, OIV80, OIV81-1, OIV82, OIV83-1, OIV83-2, OIV84, OIV85, OIV86, OIV87, OIV93, OIV94. Quantitative variables were submitted to a principal component analysis (PCA) using SAS statistical software, version 9.2 (SAS Institute, Cary, NC) (Mission Biologica de Galicia), this model has been used for studies by several ampelographic authors such as Martínez de Toda and Sancha (1997) and Martínez et al. (2006); XL STAT (trial version) was applied for the construction of the dendrogram based on the degree of similarity. The study of similarity by choosing the Jaccard coefficient is designed for qualitative variables. The phylogenetic tree displayed by NTSYSpc software (Mission Biologica de Galicia) is carried out according to the UPGMA method. The unsupervised classification is an artificial intelligence. From a population and without the need for a supervisor, it is to extract classes or groups of individuals with common characteristics. The operation

consists of calculating the Euclidean distance between the grapevine varieties by extracting the absolute value of the differences of coordinates between two points in a cartesian coordinate system. To continue the method, it is then necessary to choose a "distance" between groups (or between an individual and a group). The W-Language is used to program the developed SoftAmpeLog software. It is included in the WinDev development tools. It is a procedural, multi-paradigm programming language with high-level functions that enables imperative programming and object-oriented programming.

Results and discussion

Using PCA, we were able to define the most significant parameters in the study of Martinez et al. (1997) as well as Santiago et al. (2005b). In our study, it allowed to keep about 75% (significance level) of the total information in both collections; Skikda (73.68%) and Mascara (75.30%). The latter is taken into account by the first three axes as explained in Table 1.

Table 1 : Distribution of PCA information in the first three axes in terms of the three components

	Axes	Own value	Difference	Proportion	accrued
Collection of Skikda	1	7.37206276	3.04350904	0.3880	0.3880
	2	4.32855373	2.02912131	0.2278	0.6158
	3	2.29943241	0.96889777	0.1210	0.7368
Collection of Mascara	1	7.55315306	3.05759154	0.3975	0.3975
	2	4.49556152	2.23739416	0.2366	0.6341
	3	2.25816736	0.90299292	0.1189	0.7530

However, using PCA, we selected respectively; the number of teeth, the angles, the opening of the petiole sinus and the veins as the best significant parameters in the study of the two collections (Table 2). This last one represents eigenvalues thus allows us to know the interesting variables and the better represented in each axis; from their correlations. Those with a correlation of 0.25 are considered very well represented variables. The predominant axis 1 represents 38.80% of the total information of Skikda collection, and 39.75% of the information of Mascara collection.

Table 2: Distribution of the significant variables of the PCA according to the first three axes.

	Collection of **Skikda**			Collection of **Mascara**		
	Prin1	**Prin2**	**Prin3**	**Prin1**	**Prin2**	**Prin3**
OIV 601	0,3363	-0,0079	0,1168	0,3347	0,0208	0,1718
OIV 602	0,3525	-0,0592	0,0977	0,3406	-0,0546	0,1828
OIV 603	0,3509	-0,0904	0,0700	0,3463	-0,0788	0,0387
OIV 604	0,3205	-0,0249	0,1461	0,3230	-0,0620	0,0483
OIV 605	0,2543	0,1100	0,0443	0,1796	-0,2143	0,2024
OIV 606	0,2903	0,1208	0,1547	0,2148	-0,2024	0,3097
OIV 66-5	0,1510	-0,1772	-0,2294	0,2395	0,0118	-0,2771
OIV607	-0,0465	0,3988	0,1525	0,0187	0,3717	0,1248
OIV608	-0,0708	0,4310	0,1335	-0,0365	0,4247	0,0922
OIV609	-0,0774	0,3533	-0,3178	0,0533	0,4071	-0,0743
OIV610	0,0226	0,3975	0,0421	0,0009	0,3686	-0,0038
OIV611	0,2587	-0,0578	0,1087	0,2737	0,0322	0,0370
OIV612	0,2178	0,0949	0,1152	0,2267	0,0875	-0,1625
OIV613	0,2124	0,1239	-0,4001	0,2418	0,2111	-0,3003

OIV614	0,2320	0,0328	-0,2597	0,2212	-0,0746	-0,1886
OIV615	0,2240	0,1927	-0,3700	0,2915	0,1495	-0,2851
OIV617	0,2869	0,1554	0,1583	0,2866	0,1771	0,2268
OIV618	-0,0734	0,4585	0,0639	-0,0811	0,4014	0,2177
OIV616	0,0156	0,0401	0,5564	-0,0059	0,0759	0,5970

These percentages are in the vicinity of that of Martinez et al. (2006), where axis 1 retained 37% of the total information. This axis is defined positively and mainly by the lengths of length of veins N3, N2, N1 and N4 (OIV603, OIV602, OIV601, OIV604), by the distance between the end of N2 and the end of the first secondary vein of N2. (OIV617) and the length of the vein N5 (OIV611). Martinez et al. (2006) also proved that the lengths of the vein are the best parameters of axis 1. Axis 2 contains 22.78% of Skikda collection information and 23.66% of Mascara, almost 13%, the double that found in the Martinez et al. (2006) study. Axis 2 is defined positively but this time by the angles (OIV608, OIV607, OIV610 and OIV609) as well as by the opening of petiolar sinus (OIV618). Martinez et al.(2006) found that the angles are well in the axis 2, it was able to confirm that the angle α (OIV607) and γ (OIV610) are the most discriminating parameters that confer the best grouping between the individuals (Martinez et al., 1997). Nevertheless, the study of Rotaru (2005) has highlighted the importance of angles (OIV607) and (OIV609) as well as the opening of petiolar sinus (OIV618). The remaining 12% are contained in the third axis which is positively defined by the number of teeth between the end of N2 (OIV616) and negatively by the lengths and widths of the teeth (OIV613, OIV615). However, other parameters are significant in one of the two collections. In the Skikda collection, it was the upper lateral sinuses (OIV605) and the lower one (OIV606), the length of the N4 tooth (OIV614). In Mascara, it was the distance between the petiolar point and the departure of the vein N5 (OIV066-5). These parameters require more repetitions to clarify their ambiguity. The distribution of grape varieties in PCA allows us to define only a few groups. In Skikda (Figure 1) Boghni and Muscat de Berkaine have more or less short veins but very wide angles with a closed petiole sinus, shallow lateral sinuses with long and wide teeth. Ghanez and Sultanine Fandouk, Tadelith and SbaaTolba are two couples that are very similar to the previous ones, they have the same characteristics but with more or less long veins. However, Aneb el Cadi and Aïn el Couma, Amellal and Baladi, Farana Blanc and Farana Noir shared average features of the veins, angles, teeth and opening of petiolar sinuses. Adadi is close to the previous varieties, it differs from them just by short veins. Nevertheless, Lekhzine, Adari of the Bibans, Bouni, Bouaber des Aures and Kabyle Aldebert all have restricted angles, very open petiole sinuses, medium-sized teeth, but they differ in veins.

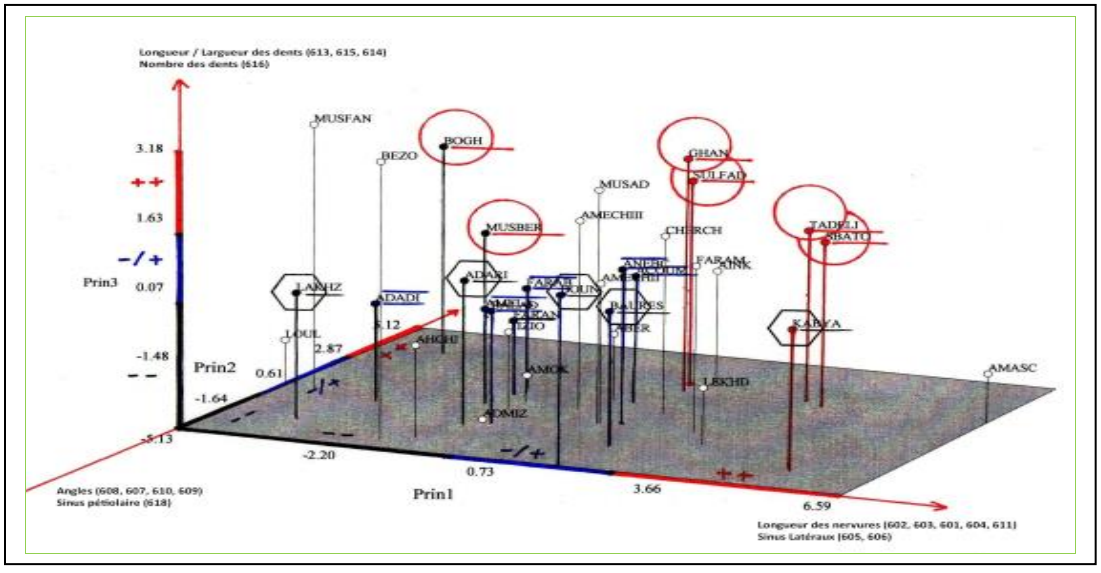

Figure 1. Distribution of grape varieties (collection of Skikda) according to the PCA projection into the plane defined by the three first principal coordinates (abbreviations in Table 1)

In Mascara, (Figure 2) three couples appear clearly by sharing the same characteristics. Valenci and Muscat el Adda are located in the area of very wide angles, petiolar sinus closed, and wide teeth with medium veins. Aneb el Cadi and Muscat Noir, Ghanez, Aïn el Kelb and Farana are different from the first couple only by more or less long veins. However, Bouni and Bouaber des Aures with Bezzoul el Khadem are more or less similar, they share small angles, very open petiole sinuses, medium teeth and veins that vary from the smallest to the largest ones. These cultivars do not differ much from Farana and Aïn el Couma, they are in the same sector and they share the same characters but with veins and medium teeth.

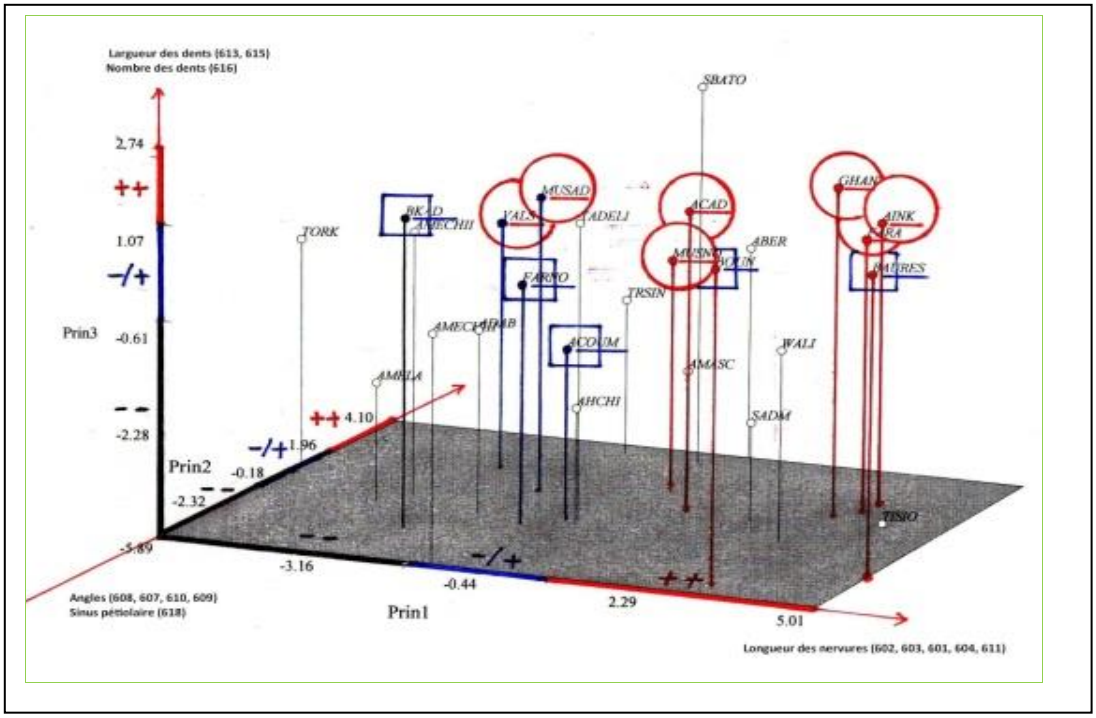

Figure 2. Distribution of grape varieties (collection of Mascara) according to the PCA projection into the plane defined by the three first principal coordinates (abbreviations in Table 1)

The grape varieties can be divided into 3 categories (Figure 3, 4) according to the variation of angles and the petiole sinus: subclass I, II and III. Each of these sub-clusters is divided into two subgroups according to the length of the veins. The representative leaves of each group confirm this grouping, and the coding of the OIV allows us to define the criteria of each group. Boghni (1) , Muscat of Berkaine (2), Ahmar of Mascara (3), Sbaa Tolba(4), Sultanine Fandouk(5), Ain el kelb(6) are located in Sector III, their leaves are characterized by very wide angles, closed petiole sinuses and medium veins. However, Bezzoull el Khadem (1), Adari des Bibans(2), Ahchichene(3), Lekhzine (4) are the grape varieties of sector II and they are characterized by small angles, very open petiolar sinuses and short veins. Nevertheless, Amokrane(1), Louali(2), Muscat elAdda (3), Farana Noir (4) are located in Sector I and their leaves are characterized by large angles, open petiolar sinuses and short veins. The synonyms identified during the molecular study (Laiadi et al., 2009) are juxtaposed with each other at the level of the dendrogram. These are Aberkane and Adadi, Ahchichene and Adari of the Bibans with Lekhzine, Amellal and Ahmed draa el Mizen, Amokrane and Louali, Kabyle Aldebert and Bouaber des Aures. Thus, the general dendrogram of the same molecular study allows us to confirm the relation between Cherchalli and Farana of Mascara, Aïnel Kelb and Ghanez (Figure 3). The comparison between the dendrogram of the general averages of both collections shows a certain degree of similarity in classification and confirms their approximation. The first group is the same from Skikda, with the exception of Aneb el Cadi who was ranked in the 1st group. Muscat el Adda and Ghanez are located in the second group instead of the first. Ahmar de Mascara is also located within this group instead of the 1st group. Adari Bibans, Ahchichene and Bouni, Bezzoul el Khadem are still close together but move in the 3rd group instead of the 2nd group (Figure 4).

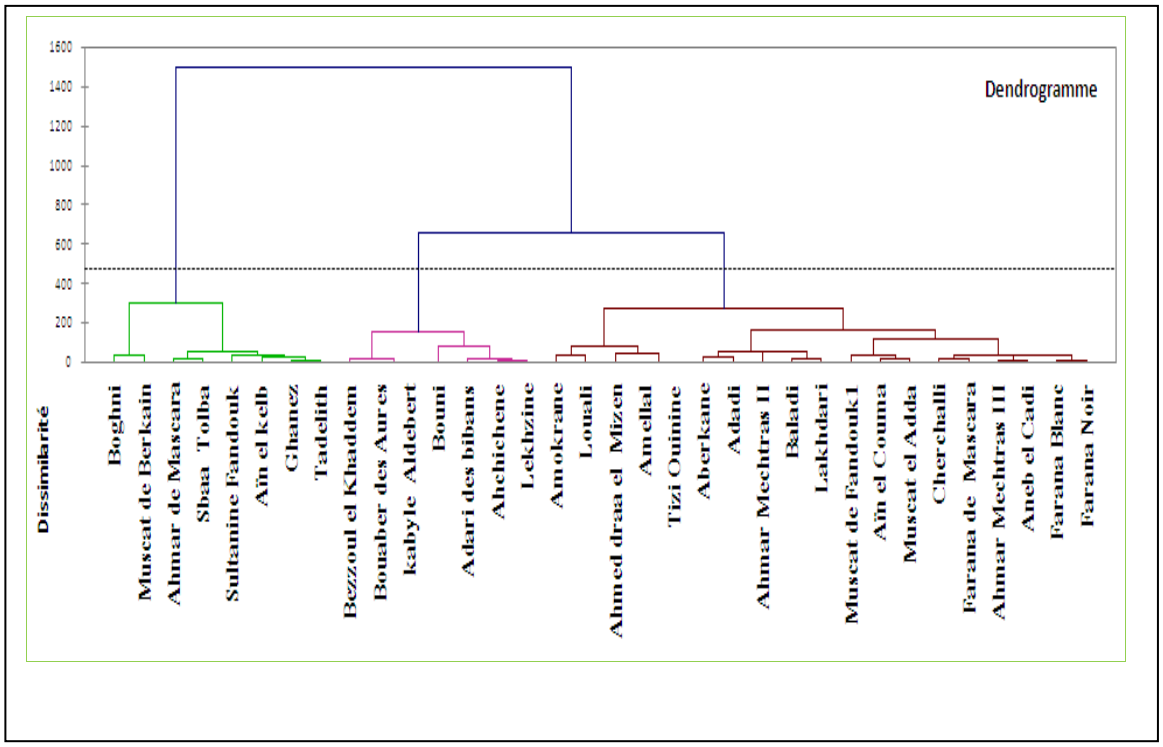

Figure 3: Dendrogram of dissimilarity between the grape varieties in the collection of Skikda based on the measured quantitative data not codified.

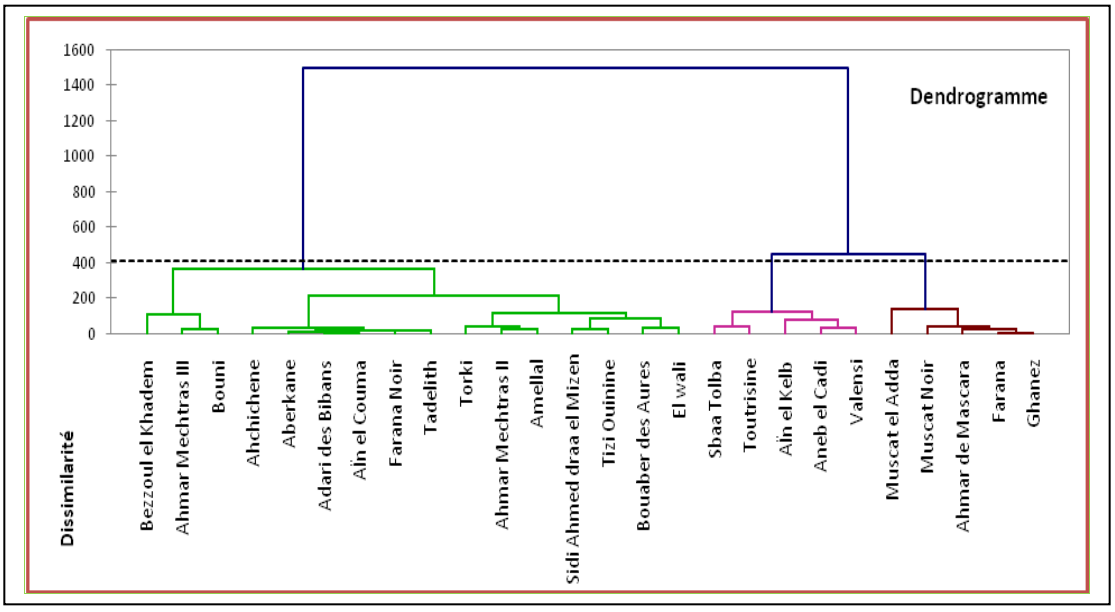

Figure 4: Dendrogram of dissimilarity between the varieties in the collection of Mascara based on the measured quantitative data not codified.

The developed SoftAmpeLog system is bifunctional (Figure 5); it is equipped with a database and an automated classification system. This system is very delicate; it consists in classifying the grape varieties according to their similarity, thanks to the realization of a succession of measurements of the distances between the different grape varieties.

The software system has 3 options. OIV codes are included with schematization of the measure. The database (Figure 6) serves as a descriptive catalog of autochtnounous grapevine varieties. It is based on the establishment of a reference input file in which 40 varieties are described with a set of characters (origin, collection ampelographic characters and phenological stages). Each variety is also provided with a leaf representative of all the ampelometric characters described. The procedure of the classification is delicate, it is enough all first to postpone on the table of phyllometric averages. It is possible to make a small comparison between the leaves of the varietals at the same time. The user must request the classification of grape varieties and the system calculates the distances between all individuals in pairs, in order to define the closest grape varieties in ascending order. The definition of groups is based on the selection of a level that ensures a strong similarity between the elements of each group. The result first displays the level, distance, number of groups and individuals included in each group.

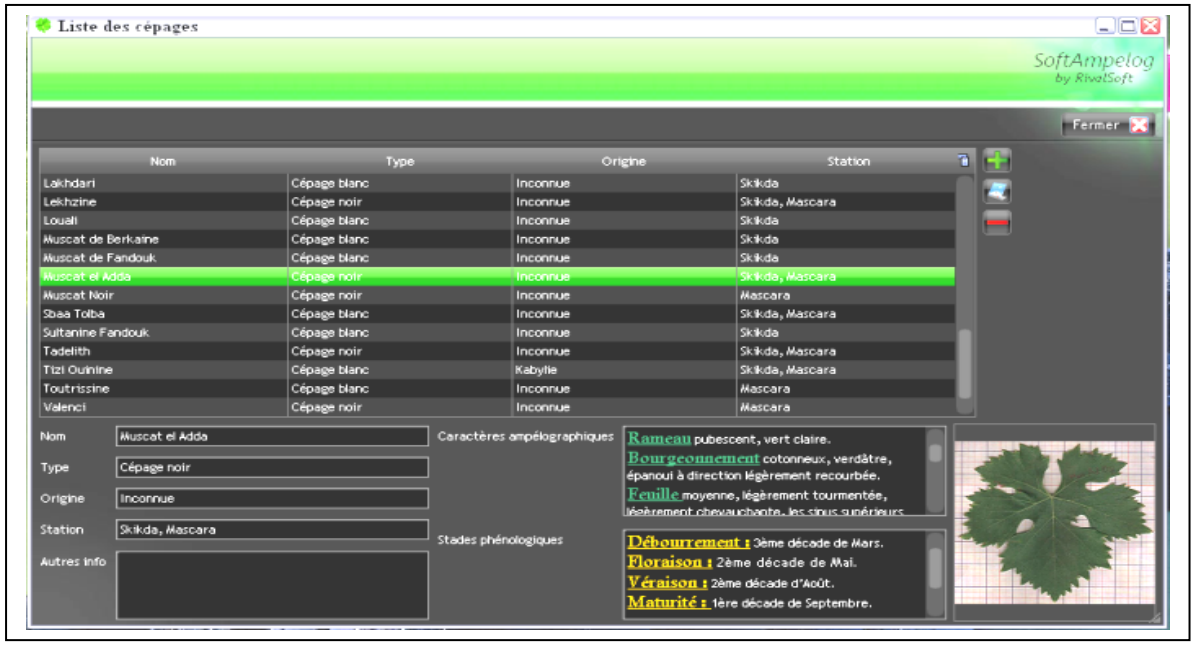

Figure 5. Classification system SoftAmpélog program.

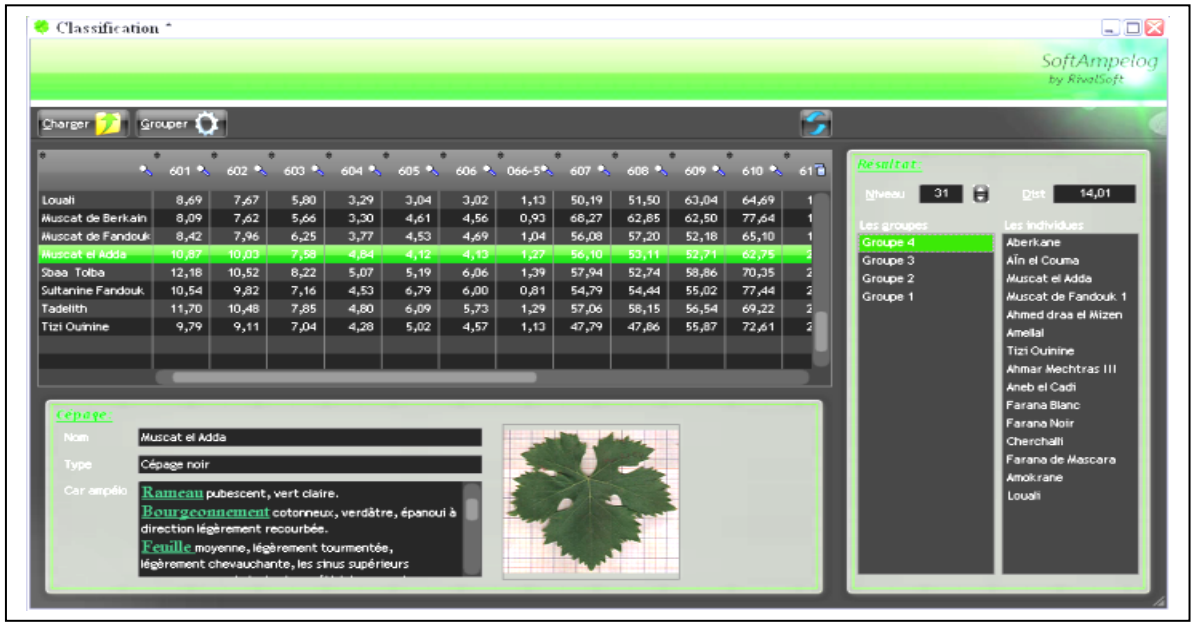

Figure 6. Database program SoftAmpélog of grape varieties.

Conclusion

The environment has a great influence on the vegetative expression of the grape varieties and the degree of influence differs according to the grape varieties as well as for the characters. The most correlated variables are the length of the veins. However, the most significant are the opening of the petiolar sinus, the angles the number of teeth. The grape varieties have been grouped into three distinct groups with the revelation of the criteria and the specificity of each of them. A strong similarity was illustrated between Aberkane and Adadi, Ahchichene and Adari des Bibans with Lekhzine, Amellal and Ahmed draa el Mizen, Amokrane and Louali, Kabyle Aldebert and Bouaber des Aures, Farana Blanc and Farana de Mascara, Cherchalli and Farana de Mascara, AïnKelb and Ghanez. The elaborated software serves as a descriptive catalog of the Algerian vineyard, and it offers a rather delicate automated pre-classification. Immediate and long-term perspectives can be considered to develop the software SoftAmpeLog developed and make it more complete and more operational.

References

Alssendrie, S., Vignozzi, N., and Vignini, A.M. 1996. AmpeloCADs (Ampelographic Computer-Aided Digitizing System): an integrated system to digitize file and process biometrical Data from *Vitis* spp. Leaves. American Journal of Enology and Viticulture, 47: 257-267.

Boursiquot, J.M., Faber, M.P., Blachier, O., and Truel, P. 1987. Utilisation par l'informatique et traitement statistique d'un fichier ampélographique. Agronomie, 7: 13-20.

Chitwood, D. H., Klein, L. L., Hanlon, R. O., Chacko S., Greg, M., Kitchen C., et al. 2016. Latent developmental and evolutionary shapes embedded within the grapevine leaf. New Phytologist, 210: 343–355.

Cid-alvarez, N., Boursiquot, J. M., Saa-otero, P., and Romani-Martinez, L. 1994. Différenciation des cépages autochtones du Nord-Ouest de l'Espagne (Galice) et élaboration d'une clé de détermination basée sur l'Ampélométrie. Journal International des Sciences de la Vigne et du Vin, 28 : 1-17.

Coban, H. 2004. Application of an artificial Neural Network (ANN) for the identification of grapevine (*Vitis vinifera* L.) genotypes Asian. *Journal* of *Plant* Sciences, 3: 340-343.

Galet, P. 1998. Précis d'ampélographie pratique. Imprimerie JF, Saint Jean de Vedas.

Goethe M. 1878. Handbuch der Ampelographie, Graz, Commission-Verlag von Leykam-Josefsthal.

Kerridge, G., and Antchiff, A. J. 1999. Wine grape varieties. Csiro publishing. 205.

Laiadi, Z., Bentchikou, M. M., Bravo, G., Cabello, F., and Martinez-Zapater, J.M. 2009. Molecular identification and genetic relationships of Algerian grapevine cultivars maintained at the germplasm collection of Skikda (Algeria). Vitis, 48: 25-32.

Laiadi, Z., Bencharif, S., Lakhrif, Z., Bentchikou, M. M., and Mohand-larbi, R. 2013. First ampelometric study of autochthonous grapevines in Algeria: Germplasm collection of Mascara. Vitis, 52(1): 21–27.

Levadoux, L., Benabderrabou, A., and Douaouri, B. 1971. Ampélographie Algérienne: cépages de table et de cuve cultivés en Algérie. Société Nationale d'Edition et de Diffusion, Alger.

Mancuso, S. 1999. Fractal geometry based image analysis of grapevine leaves using the box counting Algorithm. Vitis, 38: 97-100.

Mancuso, S. 2001. The fractal dimension of grapevine leaves as a tool for ampelographic research. Har FA E-Journal. 6-8.

Mancuso, S., Boselli, M., and *Masi, E. 2001. Distinction of "Sangiovese" clones and grapevine varieties using Elliptic Fourier Analysis (EFA), neural network and fractal analysis.* Advances in *Horticultural Science, 15: 61-65.*

Mancuso, S. 2002. Discrimination of grapevine Vitis vinifera L. Leaf shape by fractal spectrum. Vitis, 41: 37-142.

Martinez, M. C., Boursiquot, J. M., Grenan, S., and Boidron, R. 1997. Etude ampélométrique de feuilles adultes de somaclones du cv. Grenache N (*Vitis vinifera* L.). Canadian Journal of Botany, 75: 333-345.

Martinez, M. C., and Grenan, S. 1999. A graphic reconstruction method of an average leaf of vine. Agronomie, 19: 491-507.

Martínez, M. C., and Pérez, J. E. 2000. The forgotten vineyard of the Asturias Princedom (north of Spain) and ampelographic description of its grapevine cultivars (*Vitis vinifera* L.). American Journal of Enology and Viticulture, 51(4): 370-378.

Martinez, M. C., Santiago, J. L., Perez, J. E., and Boso S. 2006. The grapevine cultivar Mencia (*Vitis vinifera* L.): Similarities and differences with respect to other well-known internationals cultivars. Journal International des Sciences de la Vigne et du Vin, 40: 1-12.

Oancea, S. 2007. Fractal analysis as an useful method in ampelograph, Analele stiintifice ale universitatii"Al. I. Cuza." Iasi, Tomul III.

OIV (Office International de la Vigne et du Vin), 2007. List of descriptors for grapevine cultivars and species (*Vitis* L.).

Ravaz, L. 1902. Les vignes américaines. Porte-greffe et producteurs directs, Coulet et fils, Montpellier.

Reynier, A. 2003. Manuel de viticulture. Tech et Doc, Lavoisier, 549 p.

Rotaru, L. 2005. The Application of discriminate factorial analysis for establishing phenotypical homogenity of europeo-americanes rootstock, Lucrări Ştiinţifice USAMV Iaşi, seria Horticultură, 48: 287-292.

Santiago, J.L., Bosso, S., Martin, J.P., Ortiz, J.M., and Martinez, M.C. 2005a. Characterization and identification of grapevine cultivars (L.) from northwestern Spain using microsatellites marker and ampelometric methods. Vitis, 44 (2): 67-72.

Santiago, J.L., Boso, S., Martínez, M.C., Pinto-Carnide, O., and Ortiz, J.M. 2005b. Ampelographic Comparison of Grape Cultivars (*Vitis vinifera* L.) Grown in Northwestern Spain and Northern Portugal. American Journal of Enology and Viticulture , 56 (3): 287- 290.

Soldavini, C., Schneider, A., Stefanini, M., Dallaserra, M., and Policarpo M. 2007. Superampelo a software for ampelometric and ampelographic descriptions in Vitis. Acta horticulturae, 82(7): 253-257.

Tărdea, C., Oancea, S., and Roraru, L. 2008. Introduction of the fractal analysis in ampelography. Analele Ştiinţifice ale Universităţii.

Tomažič, I., and Korošec-Koruza Z. 2003. Validity of phyllometric parameters used to differentiate local *Vitis vinifera* L. cultivars. Genetic *Resources* and *Crop Evolution,* 50:773-778.

Viala, P., and Vermorel, V. 1901-1910. Ampélographie, tomes 1-7. Masson et Cie, Paris.

Zinelabidine, L.H.**,** Laiadi, Z**.**, Benmehaia, R., Gago, P., Boso, S., Santiago J.L. et al. 2014. Comparative ampelographic and genetic analysis of grapevine cultivars from Algeria and Morocco. Australian Journal of Grape and Wine Research. 20 (2): 324–333.

Zmeškal, O., Vels, Ỳ. M., Nežádal, M., and Buchnicek, M. 2001. Fractal analysis of image structures. Har FA. 3-5.