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Ampelographic and Ampelometric Characterization of Berries and Seeds from Traditional Vineyards in Morocco

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Abstract: Morocco, like the other Mediterranean countries, is characterized by a great diversity of indigenous varieties of vines "*Vitis vinifera* ssp. *vinifera*", taking advantage of the climate and also of the heterogeneity of their landscapes Without forgetting, the know-how and agricultural practices adopted by traditional farmers who have contributed in one way or another to preserve the genetic diversity of these indigenous grape varieties. Within the framework of this study, we are seeking the identification and characterization of 36 indigenous grape varieties sampled in the north and south of Morocco. The samples studied were taken from traditional vineyards in these regions. For the ampelographic and ampelometric description, 26 characters were used according to a list of descriptors developed by the International Organization of Vine and Wine (OIV). Thus, the ampelographic and ampelometric approach were refined by a principal component analysis (PCA) which made it possible to group the grape varieties into five distinct groups according to their correlations to the variables linked to the bunch, the berry and the seed. The results obtained from these different approaches confirmed the presence of great inter-grape and intra-grape variability within the samples studied. This observation leads us to make more efforts to maintain this variability and to fight against genetic erosion and the threat of environmental changes.

Keywords: Vine; *Vitis vinifera* ssp. *vinifera*; traditional grape; ampelographic; ampélometric; OIV

1. Introduction

The history of vine cultivation is parallel to the history of civilization in the Mediterranean basin. Beside the oldest perennial and emblematic Mediterranean crops (the olive tree (*Olea europaea* L.), date palm (*Phoenix dactylifera* L.), and the fig tree (*Ficus carica* L.)), the domestication of the vine (*Vitis vinifera* L.) dated back at least 6,000 years [1-2-3]. Indeed, the first productions of grapes and wine were a source of income and added economic value [4]. In Morocco, like other countries in the Mediterranean basin, the winemaking tradition dates back to very ancient times; to the probable contributions of the Phoenicians and the Romans, has been added the Arab imprint which, since the Middle Ages, has encrusted the winemaking landscapes of the country [5-6]. Subsequently, the historical exchanges between the two Mediterranean shores, French colonialism and the important diversity of the terroir have for centuries led to the development and evolution of a large number of grape varieties, especially for the production of wine and the export [7-8-9]. Thus, Morocco is characterized by a great diversity of traditional grape varieties thanks to its climate and the heterogeneity of its landscapes but above all thanks to the local knowledge and the agricultural practices adopted by traditional farmers who have contributed in one way or another to preserve the

genetic diversity of these grape varieties [10-11-12]. However, in recent decades, the modernization of agriculture and the transformation of agricultural systems have placed genetic resources of plant origin in a worrying situation. In fact, modern vineyards made from European vines were gaining more space to the detriment of traditional grape varieties which have declined, or even disappeared from the usual cultivation areas. From this perspective, given that valuation is a first step towards conservation, the present study focuses on the characterization of 36 traditional grape varieties via ampelometric and ampelographic parameters.

2. Materials and Methods

2-1. Prospecting and sampling

The surveys were carried out at the scale of areas recognized by the persistence of traditional vineyards, using indigenous grape varieties. In this sense, at the scale of Morocco, the study was conducted at 14 sites belonging to two main zones: the Western Rif in the North and the High Atlas in the South (Figure 1). For this, the sampling was carried out in traditional vineyards, at the time of fruiting. Within each site, with the help of the farmers, we collected samples of named and recognized fruits for each grape variety. Thus, we made a sampling of 27 grape varieties in the North and 9 grape varieties in the High Atlas (Table 1).

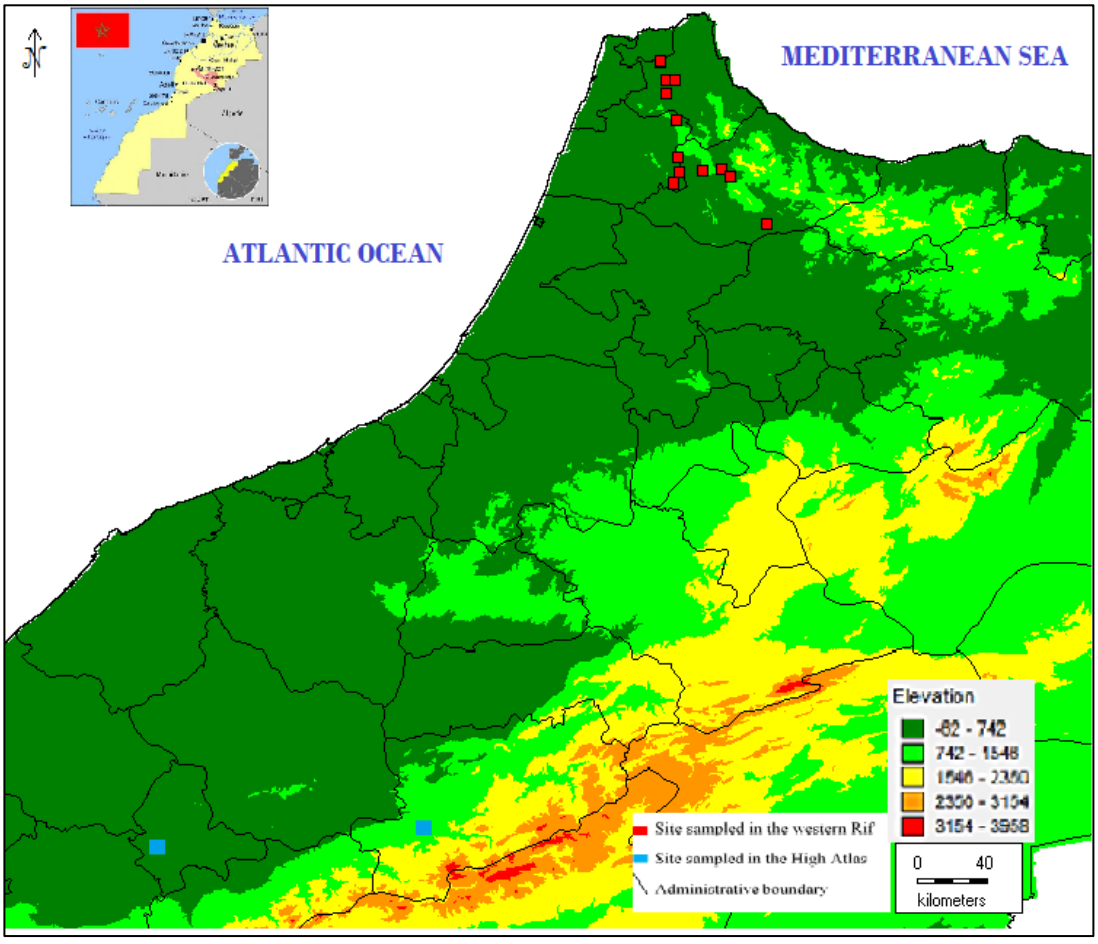

Figure 1. location of the sampled sites across Morocco

Table 1. List of grape varieties sampled in different sites

Region	Grape variety (code)

Western Rif	Ainab lebyed (ALB), Ainab leKhal (ALk), Albaydi (ALBY), Elfassi (ALF), Alkouz (ALKO), Babbour Hmara (BABH), Bezzoul Alaouda (BZA), Bezzoul Alaouda Byed (BZAB), Bezoul Alaouda Hmar (BZAH), Boukhanzir (BKH), Boukwaness (BKW), Chwikhi (CHW), Douak (DOU), Eddibani (EDD), Feqqass (FQS), Hmar Bouamar (HBA), Houmrani (HOU), Jenyani (JYN), Lechehab (LCH), Maticha (MTC), Sbyae Lebnat (SBLB), Taferyalet (TFR), Taferyalt Byed (TFRB), Taferyalet Lechehab (TFRL), Taferyalet sfar (TFRS), Taferyalet lekhal (TFRK), Valencia (VAL),
High Atlas	Abouhou (ABH), Bouchouka (BCHK), Guiyyar (GYR), Laadari (LAD), Tiglay n'Timilli (TGHL), Tiniwine (TNW), Aabbou (AAB), Feryali (FRY), Laadari Haouz (LADH).

2-2. Ampelographic and ampelometric parameters

According to the universal characteristics established by the OIV, the ampelographic and amperometric description of 36 indigenous Moroccan grape varieties was based on the use of 10 bunches of grapes/grape variety, 30 berries/each bunch of grapes and 100 seeds [13]. In this context, the study was carried out according to 26 ampelographic and ampelometric characteristics selected from the list of descriptors developed by the International Organization of Vine and Wine (OIV) (Table 2) [13]. Thus, for the description of the grape clusters, 8 OIV descriptors were adopted: 202, 203, 204, 206, 207, 208, 209 and 502. For the description of the berries, 15 OIV were used: 220, 221, 222, 223, 225, 226, 229, 231, 232, 235, 236, 238, 240, 503 and 505. While for the characterization of the seeds, we used 4 OIV: 241, 242, 243 and 244.

Table 2. List of OIV and corresponding characters

	OIV Codes N^{os} (Characteristics)
Bunches	**202** (length (peduncle excluded)); **203** (width); 204 (density); **206** (length of peduncle of primary bunch); **207** (lignification of peduncle); **208** (Shape); 209 number of wings of the primary bunch); **502** (single bunch weight)
Berries	**220** (Length); **221** (Width); 222 (Uniformity of size); **223** (Shape); **225** (color of skin); **226** (uniformity of skin color); **229** (hilum); **231** (intensity of flesh anthocyanin coloration); **232** (juiciness of flesh); **235** (firmness of flesh); **238** (length of pedicel); **240** (ease of detachment from pedicel); **503** (single berry weight); **505** (Sugar content of must)
Seeds	**241** (formation of seeds) ; **242** (length of seeds); **243** (weight of seeds) ; **244** (: transversal ridges on dorsal side of seeds)

2-3. Statistical analysis

Using the XLSTAT software, we performed an analysis of variance and correlation.

3. Results

3-1. Ampelographic parameters

3-1-1. Bunches of grapes

The ampelographic notations carried out on the bunches of grapes from the different grape varieties collected showed a fairly high level of variability. From the point of view of the length of the bunches of grapes (OIV 202), we have observed that the bunches of the different grape varieties have a length varying from short to very long. Thus, the grape clusters of the grape varieties AAB, BCHK and TFRS are very long, while the bunches of grapes of the grape varieties BABH, BZAH and SBLB are the short ones.

Concerning the width of the bunches of grapes (OIV 203), ampelographic analysis revealed a great diversity in width between the different grape varieties. Thus, the widest bunches of grapes belong to the BCHK and LAAH grape varieties, and the very narrow to narrow bunches of grapes

belong to the ALK grape variety. While the grape clusters of 12 varietals show a narrow to medium width. From the point of view of the density of the bunches of grapes (OIV 204), the bunches of grapes of the different grape varieties have a very heterogeneous compactness, ranging from very loose to very compact. Thus, the grape varieties BABH, BKW and MTC have very compact bunches of grapes, and the grape varieties BZAB, BKH, EDD and LCH have loose to very loose bunches of grapes. According to the character of the lignification of the peduncle (OIV 207), we note the presence of three categories; one presents the grape varieties with lignification which is limited to the base only and which are the most dominant (19 varieties) and the other are varieties which are characterized by lignification at the half of the peduncle (i.e. ABH, ALK, BCK, FQS, TFRS and TNW) then the third category, the lignification of which extends beyond half of the peduncle (11 grape varieties).

From the point of view of the shape of the bunches of grapes (OIV 208), and taking into account the shapes proposed in the list of descriptors, we found the existence of three shapes (cylindrical, conical and funnel-shaped) in the grape varieties studied with the predominance of the cylindrical shape, and of less importance the conical shape. Regarding the number of wings of the main bunche of grapes (OIV 209), our study revealed that more than half of the grape varieties have 1 to 2 wings while 14 grape varieties have no wings. However, in three grape varieties EDD, TFR and BCK the presence of 3 to 4 wings was noted.

3-1-2. Weight of Seeds

Based on our ampelographic analysis of berries of the different grape varieties, we noticed that there is great heterogeneity. In terms of bay length (OIV 220), it varies from short to long. Thus, the seeds of most grape varieties are of medium length. Regarding the width of the berry (OIV 221), we have demonstrated a quasi-balanced distribution between two categories (narrow and medium) with a predominance of the first. For the size of the berry (OIV 222), our study confirmed the non-uniformity of the majority of the grape varieties studied (31) whereas only 5 grape varieties ABH, BCK, JYN, ALF and GYR which were listed as having uniform berries. Thus, the ampelographic analysis of the shape of the berry (OIV 223) allowed us to confirm the dominance of the short elliptical shape, followed by the spherical shape.

In fact, the presence of the troncovoidal form was also demonstrated in 3 grape varieties BZAH, HBA and SBLB and flattened spherical in 3 grape varieties BKW, MTC and TFRS, however, the long elliptical shape was revealed in a single grape variety BCK. The grape varieties studied are distributed according to the color of their berries (OIV 225) into five clearly distinguished groups, each group is characterized by a clearly defined skin color and which are in order of importance of grape varieties: yellow green (17 grape varieties), blue black (9 grape varieties), pink (5 grape varieties), red (3 grape varieties) and dark red viol (2 grape varieties).

In relation to the uniformity of the color of the epidermis of berries in different grape varieties (OIV 226), we found that in 30 grape varieties the color is uniform while the color of the epidermis was not uniform in only 6 grape varieties BABH, EDD, ALF, FRY, HBA and TFR. From the hilum point of view (OIV 229), we noted that it is hardly apparent in 25 grape varieties while it is apparent in 11 grape varieties BKW, DOU, ALK, EDD, FQS, TFRK, FRY, GYR, LADH, TGHL and TNW. Concerning the intensity of flesh anthocyanin coloration (OIV 231), we found that it is very varied depending on the grape variety. Thus, it is zero in 3 grape varieties ALK, CHW and LCH and medium to very strong in most grape varieties. Likewise for the juiciness of flesh (OIV 232), it is moderately juicy in most grape varieties (25) and not very juicy in only one grape variety ABH. For the character and firmness of the pulp (OIV 235), it was noted that all the berries of the grape varieties studied are slightly firm, with the exception of the berries of a single grape variety which is very firm TGHL.

Likewise, from the standpoint of ease of separation of the pedicel (OIV 240), we found that the pedicels of all the grape varieties are difficult to separate, on the other hand it is easy only in three grape varieties AAB, GYR and LADH. Regarding the weight of the berries, we have noticed that most grape varieties have berries with a weight that varies from very low to low. While the berries with an average weight to grow are part of only 6 grape varieties ABH, BCHK, GYR, ALB, BZA and BZAB.

For the sugar content of the must (OIV 505), we noticed that 22 grape varieties have a high content, 11 grape varieties have an average content and the very high content was noted in 3 grape varieties VAL, ALK and TNW.

3-1-3. Seeds

According to the analysis of the ampelographic characters relating to the seeds of the different grape varieties, we observed that there are characters that do not discriminate between the different grape varieties, including the example of the formation of seeds (OIV 241) which was found to be complete in all the grape varieties, as well as the transverse groove on the gold-dirty side of the seeds (OIV 244) which is also absent in all of the seeds.

Thus, the difference between the seeds of the various grape varieties was noted in relation to the level of the length of the seeds (OIV 242) which varies from medium to long with a predominance of the average length of the seeds. In addition, the weight of seed (OIV 243) shows a variation between the different grape varieties. It varies from low to very high. Thus, the weight is medium to very high in most of the seeds, and it is only low in two grape varieties ALK and ALK.

3-2. Ampelometric parameters

3-2-1. Analysis of variance

The analysis of variance for the ampelometric characteristics measured shows a highly significant difference between the grape varieties studied ($P < 0.001$), and which is the result of a very significant intra and inter grape variety. This difference is more expressed with very high Fs, in particular for the characteristics relating to the weight of the bunch and the seed (Table 3).

Table 3. Results of the analysis of variance of ampelometric characteristics

OIV	202	203	206	502	220	221	238	503	241	243
Fisher's F	3,104	3,104	3,428	7,114	5,695	2,646	5,406	4,083	6,760	8,320
Pr >F	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

The highest bunches of grapes length (OIV 202) was observed in the LADH grape variety (326 cm) while the lowest average was observed in the BABH grape variety (130 cm). Regarding the width of the bunches of grapes, we noticed that the greatest width was observed in LADH (214 cm), while the lowest value is that of the ALK grape variety (86.25 cm). For the length of the peduncle, we found that it varies between 100 cm in the JYN grape variety and 30 cm in SBLB. In addition, the bunche of grape weight showed a strong differentiation in variance, which is much higher than the other parameters measured. In fact, it varies between 1186.5 g in LADH and 112.65 g in FER.

Regarding the berries, we revealed that the berry length varies between 27.75 mm at BCHK and 15 mm at HOU, where we also noted the smallest berry width (14 mm), while BZA is characterized by the widest width with an average of 21.25 mm. In addition, analyzes of variance revealed that the TFR grape variety has the longest pedicel with an average value of 10.973 mm while the TFRS variety had the shortest pedicel with an average of 6.25 mm. For the weight of the berry we marked a strong differentiation, in fact the highest weight is 6.36 g, which was noted at BZA, while the ALKO grape exhibited the lowest weight with an average of 1.03 g.

From a seed point of view, we have found that the seeds have a more or less homogeneous length in most grape varieties, of which we have noticed that the highest length was observed in LADH (7.858 mm), while the lowest length was noted in DOU (5.65 mm). Conversely to the length, the weight of the seeds showed a great variance between the grape varieties, of which the highest weight was noted at ABH with an average of 79.74 mg, while ALKO the lowest weight with an average of 30.01 mg.

3-2-2. Correlation matrix of variables

The analysis of the correlations between the measured parameters highlighted the presence of links between the various quantitative parameters (Table 4). Indeed, it appears that there is a positive and very significant correlation: Firstly; between the parameters of the bunch of grapes; in particular, the length of the cluster (OIV 202) with the width (OIV 203), and likewise the weight of the bunch of grapes (OIV 502) with the length (OIV 202) and the width of the bunch of grapes (OIV 203). On the other hand; between certain parameters of the berry, including the berry weight (OIV 503) which is strongly and positively correlated with the length (OIV 220) and the width of the berry (OIV 221). In addition, we found that there is a positive and highly significant correlation between the length (OIV 242) and the weight of the seeds (OIV 243). However, the length of the pedicel (OIV 238) and the sugar content of the must (OIV 505) did not show any correlation with any parameter.

Table 4. Correlation matrix of the variables analyzed

OIV	202	203	206	502	220	221	238	503	242	243	505
202	1	**0.795**	0.543	**0.783**	0.371	0.230	0.029	0.246	0.397	0.292	-0.055
203		1	0.533	**0.835**	0.481	0.374	0.003	0.436	0.419	0.250	-0.050
206			1	0.284	0.272	-0.042	0.078	0.265	0.260	0.221	-0.194
502				1	0.472	0.464	-0.138	0.447	0.503	0.371	-0.100
220					1	0.359	-0.057	**0.624**	0.404	0.388	-0.233
221						1	0.077	**0.714**	0.459	0.341	0.084
238							1	0.055	0.097	-0.049	0.258
503								1	0.574	0.579	-0.238
242									1	**0.847**	-0.224
243										1	-0.402
505											1

4. Discussion

From the ampelographic approach, it emerges that the majority of the parameters used demonstrate the existence of fairly significant inter-varietal and intra-varietal variability. In addition, and on the ampelometric level, the statistical approach, by the ANOVA test, revealed the most discriminating parameters, the results of which showed a strong differentiation of variance, for two characters; the weight of the bunch and seed.

According to the ampelometric and ampelographic results obtained, we can confirm the presence of a clear differentiation, not only within the same grape variety, but also between the grape varieties. This observation is justified by the example of grape varieties characterized by several characteristics at the same time, such as the case of the HBA variety, which is a perfect example of this variability, since its bunche is characterized by a short to medium length (202) of grape, narrow to medium width (203), loose to medium density (204) and a cylindrical and conical shape of bunche (208).

In fact, the comparison of the ampelographic and ampelometric characteristics of traditional Moroccan grape varieties with other Mediterranean grape varieties has confirmed the existence of a significant diversity but also a resemblance of some ampelographic characteristics, in particular the shape of the berry and the color of the epidermis. For the character of the shape of the berry, we note a dominance of the spherical and short elliptical shape among Moroccan grape varieties; the same results were obtained in varieties from Montenegro [14], Palestine [15], Slovenia [16] and in Spain [17]. With regard to the color of the epidermis, it has been observed that almost all Moroccan grape varieties are yellow-green and blue-black in color, a finding which is in line with the results of the work carried out on grape varieties from Spain [18]. However, and taking into account the fact that the morphological characteristics vary considerably depending on the region, ecology, care practices, location, it can be said that these results should also be validated using molecular biology techniques.

5. Conclusions

This work constitutes a first opportunity to better understand the Moroccan wine heritage, and their situation among the other Mediterranean countries. It is therefore a study to be completed by molecular characterization approaches. In fact, the importance of the characterization of a rare viticultural genetic resource can be explained by the answers that will be provided through the identification of grape varieties tolerant to changing climatic conditions (drought, warming resistant to pathogenic agents,…) and could promote sustainable viticulture.

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