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# PHENOTYPIC CHARACTERIZATION OF SOME LETTUCE CULTIVARS (*LACTUCA SATIVA* L.) CULTIVATED IN ALGERIA

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## Abstract

**Description of the subject:** Principal Component Analysis (PCA) and Morphological Similarity Coefficient were used for the objective to determine the ability of the 29 morphological descriptors in distinguishing lettuce cultivars.

**Objective:** The characterization of five lettuce cultivars was performed based on a study of 29 morphological descriptors proposed by the International Union for the Protection of New Varieties of Plant (UPOV).

**Methods:** Twenty-three descriptors quantitative, and six pseudo qualitative were analyzed in the present study.

**Results.** PCA showed that 13 descriptors out of 29 were admitted as the most important descriptors. Morphological similarity coefficient suggested that the five lettuce cultivars belonged to three clusters.

**Conclusion:** The results of the current study indicated that the use of morphological descriptors, along with morphological similarity analysis and PCA, proved to be effective for discriminating lettuce cultivars.

**Keywords:** Lettuce (*Lactuca sativa* L.); morphological characterization; UPOV; phenotypic diversity.

# CARACTÉRISATION PHÉNOTYPIQUE DE QUELQUES CULTIVARS DE LAITUE (*LACTUCA SATIVA* L.) CULTIVÉS EN ALGÉRIE

## Résumé

**Description du sujet :** L'Analyse en Composantes Principales (ACP) et le Coefficient de Similarité Morphologique ont été utilisées pour déterminer l'aptitude de descripteurs morphologiques à distinguer les cultivars de laitues.

**Objectifs** : La caractérisation de 5 cultivars de laitue a été effectuée en se basant sur l'étude de 29 descripteurs morphologiques proposée par l'Union internationale pour la protection des nouvelles variétés de plantes (UPOV).

**Méthodes :** Vingt-trois descripteurs-quantitatifs et six pseudo-qualitatifs ont été analysés dans la présente étude.

**Résultats :** L'ACP a montré que 13 descripteurs sur 29 identifiés comme les plus discriminants. Le Coefficient de Similarité Morphologique a suggéré que les cinq cultivars de laitue appartiennent à trois groupes.

**Conclusion :** L'utilisation des descripteurs morphologiques ainsi que l'analyse de la similarité et l'ACP, se sont révélés efficaces pour discriminer les cultivars de laitues.

**Mots clés :** Laitue (*Lactuca sativa* L.) ; caractérisation morphologique ; UPOV ; diversité phénotypique

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## INTRODUCTION

Lettuce (*Lactuca sativa* L.) is the most important crop in the group of leafy vegetables [1]. The crop includes seven main groups of cultivars (butterhead, cos, crisphead, cutting, Latin, oilseed, and stalk lettuce) with high morphological diversity and several genotypic diversity with different genomes resulting from natural selection, a complex domestication process and polyphyletic origin [2, 3]. This crop cultivated in several countries worldwide [1, 4]. It is particularly important as a commercial crop in North and Central America, Asia, and Europe. Spain, China, U.S., India, Japan and Italy are among the world's major producers [3, 4]. This plant is one of the oldest known edible vegetable and has gained importance mainly because of its biological activities including antioxidant, antimicrobial and neuroprotective [5, 6, and 7]. This vegetable rich in mineral nutrient like vitamins, calcium, iron, flavonoids, fiber, potassium, and phosphorus [8]. It is a precious dietary source of vitamin K, E and C as well as carotenoids. In General, the description of morphological and agronomic of wild lettuce accessions is incomplete. Also, the status of several species related to the cultivated lettuce is not detailed and studies with molecular markers do not support discrimination among *L. serriola-like* species [9, 10], which makes it arduous to properly document and register different species under the basis of a reliable classification procedure. Several authors have evaluated phenotypic diversity in several plants [11, 12, and 13]. In lettuce, morphological investigations have been carried out in Slovenian and Swedish [14], Austrian and Italian [15], Brazilian [16], Philippians [17] and Iranian genetic resources [18]. Phenotypic evaluation and morphological characterization of available germplasm is an obligatory first step to help breeding efforts and remain the only legitimate marker type acknowledged by the International Union for protection of new varieties of plants (UPOV) [19]. To date, lettuce species cultivated and commercialized in Algeria have not yet been specifically described. In addition, the phenotypic and genetic diversity of lettuce has not been well assessed previously.

The absence of such studies in Algeria motivated us to study the morphological polymorphism of these cultivars and to determine the most discriminatory descriptors that allow separating this genetic richness.

In the present study, we aim to evaluate and assess the phenotypic diversity in five lettuce cultivars with potential agro-economical values for human consumption, using 29 traits collected from seed plant and leaf following the International Union for the Protection of New Varieties of Plants [19]. The morphological differences among and within the cultivars have been evaluated to determine the descriptor that contributes most to the phenotypic variation of the cultivars using Principal Component Analysis (PCA) and phenotypic diversity based on morphological similarity coefficient.

## MATERIAL AND METHODS

### *1. Plant materials*

This study used five commercial cultivars of lettuce (*L. sativa* cv. Batavia rubia, *L. sativa* cv. local cultivar Anabia, *L. sativa* cv. Parris Island, *L. sativa* cv. red leaf, *L. sativa* cv. Trocadero). These were largely cultivated in Algeria. The source of cultivars included in the study is the local market. The present experiment was conducted in an experimental station, M'sila (Algeria). The geographic coordinates of the Station are latitude 35º74´N, longitude 04º55´E, altitude 512 m with an average annual temperature of 20.0°C and an average annual rainfall of 142.2 mm.

### *2. Germination*

These lettuce seeds were placed in trays of 50 alveoli filled with substrate loam. The trays were watered to field capacity (every two days) with a watering can up to three or 4 leaves.

### *3. Transplanting and experimental design*

The experiment was arranged according to a completely randomized design with five cultivars and twenty replications. Seedlings with three to four definitive leaves of each cultivar were transplanted on rows of 300 m length with row spacing's 120 cm and plant spacing's 30 cm. The Seedlings were regularly irrigated to field capacity (every two days) with a watering can. The manual control of weeds happened through hoeing. The chemical and physical characterizations of the soil are presented in Table 1.

### *4. Morphological descriptors*

Cultivars analysis per cultivars was applied to assess morphological diversity, 10 individuals were marked, and from each individual 10 leaves were examined for their differences according to the 29 major morphological characters selected from the UPOV list for lettuce (*L. sativa*).

Twenty-three descriptors were quantitative, and six were pseudo–qualitative. All of the characters are assessed with a score ranging from 1 to 29 (Fig. 1, Table 2). Measurements and evaluations were realized by the same two persons to avert errors due to individual variations.

***5. Statistical analysis***

The data for 29 morphological descriptors selected from the UPOV list [19] were separately analyzed. Twenty-nine morphological descriptors selected from the UPOV list was analyzed by multivariate analyses and clustering using XLSTAT software (Addinsoft, www.xlstat.com). Principal Component Analysis (PCA) was subsequently performed to individuate the grouping of descriptors and cultivars, then to determine the axes and the descriptors significantly contributing to the variation. In this procedure, the similarity matrix was used to generate eigenvalues and scores for the cultivars. The first three axes, which accounted for the highest variation, were then used to plot two-dimensional scatter plots. Clustering analysis of morphological similarity was conduct and a phylogenetic dendrogram was plotted by using unweighted pair-group method with arithmetic mean (UPGMA) [20], and squared Euclidean distances as a measure of similarity [21].

Table 1: Physical and chemical characteristics of the soil.

| Soil analysis | Results | Soil analysis | Results |
|---|---|---|---|
| pH (Potential of hydrogen) | 8.23 | Total limestone % | 11.79 |
| Electrical conductivity (EC) ms/cm | 0.40 | Organic matter % | 3.27 |
| Moisture % | 4.14% | Texture | sandy-clay |

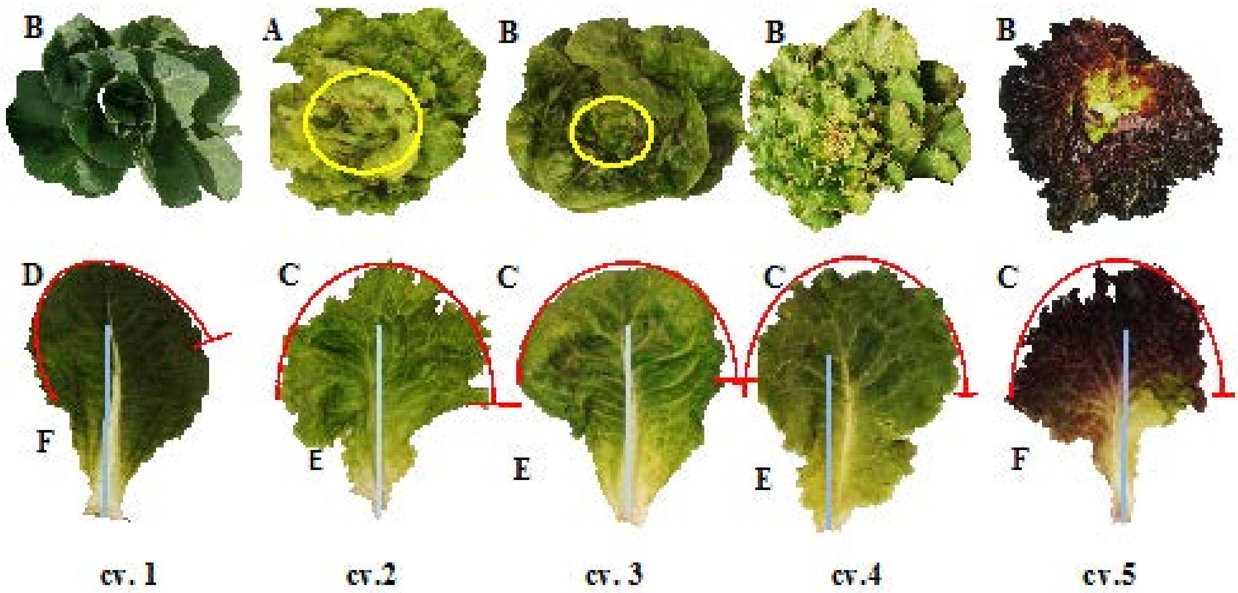



Figure 1: Morphological traits in the Algerian lettuce cultivars investigated in this study

cv.1: Parris Island; cv.2: Batavia rubia; cv.3: local cultivar Anabia; cv.4: Trocadero; cv.5: red-leaf. (A and B): Plant: a degree of overlapping of the upper part of leaves (A) strong; (B) absent or weak. (C and D (: Only cultivars with Leaf: number of divisions: absent or very few: Leaf: the shape of apex: (C) rounded; (D) obtuse. (E and F): Only cultivars with Leaf: number of divisions: absent or very few: Leaf: longitudinal section: (E) convex; (F) flat.

Table 2: Quantitative and pseudo–qualitative traits proposed from the « International Union for the Protection of New Varieties of Plants » for lettuce (*L. sativa*) (UPOV) [19] for evaluated five lettuce cultivars.

| Abbr. | Traits | Description | Note | | | | |
|---|---|---|---|---|---|---|---|
| | | | B | T | R | L | A |
| SC | Seed: color | 1 : white ; 2 : yellow; 4 : black | 1 | 4 | 1 | 2 | 4 |
| PD | Plant: diameter | 3 :small; 5 : medium; 7 : large | 5 | 5 | 7 | 3 | 5 |
| PDL | Plant: degree of overlapping of upper part of leaves | 1 : absent or weak ; 3 : strong | 3 | 1 | 1 | 1 | 1 |
| ONL NL | Only varieties with Plant: degree of overlapping of upper part of leaves: absent or weak: Plant: number of leaves | 3 : few ; 7 : many | / | 3 | 7 | 3 | 7 |
| LA | Leaf: attitude | 1 : erect; 3 : semi-erect | 3 | 3 | 3 | 1 | 3 |
| LND | Leaf: number of divisions | 1 : absent or very few | 1 | 1 | 1 | 1 | 1 |
| OLS | Only varieties with Leaf: number of divisions: absent or very few: Leaf: shape | 4 : narrow oblate; 6 : broad elliptic; 7 : medium elliptic; 10 : broad obtrullate; 11 : obovate; | 10 | 4 | 7 | 11 | 6 |
| OLA | Only varieties with Leaf: number of divisions: absent or very few: Leaf: shape of apex | 2 : obtuse; 3 : rounded | 3 | 3 | 2 | 3 | 3 |
| LLS | Only varieties with Leaf: number of divisions: absent or very few: Leaf: longitudinal section | 3 : flat;5 : convex | 5 | 5 | 3 | 3 | 5 |
| LAC | Leaf: anthocyanin coloration | 1 : absent or very weak; 9 : very strong | 1 | 1 | 1 | 9 | 1 |
| LHC | Leaf: hue of anthocyanin coloration | 1 :reddish ; 2 : purplish | / | 2 | / | 1 | / |
| LAA | Leaf: area covered by anthocyanin coloration | 1 : very small; 7 : large | / | 1 | / | 7 | / |
| LC | Leaf: color | 1 : green; 2 : yellowish green; 3 : greyish green | 2 | 3 | 1 | / | 1 |
| LIGC | Leaf: intensity of green color | 1 : very light; 5 : medium; 7 : dark; 9 : very dark | 1 | 5 | 9 | / | 7 |
| LGS | Leaf: glossiness of upper side | 3 : weak; 5 : medium | 5 | 3 | 3 | 5 | 3 |
| LT | Leaf: thickness | 2 : hin;3 : medium;4 : thick | 2 | 3 | 4 | 2 | 3 |
| LB | Leaf: blistering | 1 : absent or very weak ; 3 : weak; 5 : medium; 9 : very strong | 9 | 5 | 1 | 9 | 3 |
| LSB | Leaf: size of blisters | 3: small ; 5 : medium ; 7 : large | 7 | 5 | 3 | 3 | 3 |
| LUM | Leaf: undulation of margin | 1: absent or very weak ; 3 : weak;5 : medium;7 : strong;9 : very strong | 7 | 5 | 3 | 9 | 1 |
| LTIM | Leaf: type of incisions of margin | 2 : regularly dentate; 3 : irregularly dentate, 5 : tridentate | 3 | 2 | / | 5 | 2 |
| LDPI | Leaf: depth of incisions of margin | 3 : shallow; 5 : medium; 9 : very deep | 5 | 3 | / | 9 | 3 |
| LDSI | Only varieties with Leaf: type of incisions of margin: irregularly dentate, bi- or tridentate: Leaf: depth of secondary incisions of margin | 3 : shallow ; 5 : medium | 3 | / | / | 5 | / |
| LDM | Leaf: density of incisions of margin | 2 : sparse; 7 : dense; 9 : very dense | 7 | 7 | 2 | 9 | / |
| HS | Only varieties with Plant: degree of overlapping of upper part of leaves: medium or strong: Head: size | 5 : medium | 5 | / | / | / | / |
| HSLS | Only varieties with Plant: degree of overlapping of upper part of leaves: medium or strong: Head: shape in longitudinal section | 3 : circular | 3 | / | / | / | / |
| HD | Only varieties with Plant: degree of overlapping of upper part of leaves: medium or strong: Head: density | 5 : medium | 5 | / | / | / | / |
| THM | Only varieties with Plant: degree of overlapping of upper part of leaves: medium or strong: Time of harvest maturity | 3 : early | 3 | / | / | / | / |
| TBB | Time of beginning of bolting | 3 : early; 5 : medium; 7 : late | 7 | 3 | 7 | 5 | 7 |
| AS | Axillary sprouting | 1 : absent or weak | 1 | 1 | 1 | 1 | 1 |

B : cv. Batavia rubia ; T : cv. Trocadero; R: cv. Parris Island; A: cv. Anabia; L: cv. red leaf

## RESULTS

### *1. Morphological comparisons within five cultivars by Principal Component Analysis*

The principal component analysis (PCA) was performed to determine the main distinguishing characteristics of the variability. The first two components derived from PCA, which accounted for 59% of the total variation, were plotted (Fig. 2). The major variables in the PC1, which showed 48.53% of the total variation, were: Leaf intensity of the green color (wasn't observed of cv. red leaf, very light of cv. Batavia rubia, medium of cv. Trocadero, dark of cv. local cultivar Anabia, very dark of cv. Parris Island); Leaf thickness (hin of cv. Batavia rubia and cv. red leaf medium of cv. Trocadero and cv. local cultivar Anabia; thick of cv. Parris Island); Leaf blistering (absent or very weak of cv. Parris Island; weak of cv. local cultivar Anabia; medium of cv. Trocadero; very strong of cv. Batavia rubia and cv. red leaf); Leaf glossiness of upper side (weak of cv. Trocadero, cv. Parris Island and cv. local cultivar Anabia; medium of cv. Batavia rubia and cv. red leaf); Leaf depth of incisions of margin (wasn't observed of Parris Island, shallow of Trocadero and local cultivar Anabia; medium of Batavia rubia; very deep of cv. red leaf); Leaf depth of secondary incisions of margin (wasn't observed of cv. Trocadero, cv. Parris Island and cv. local cultivar Anabia, shallow of Batavia rubia; medium of cv. red leaf); Leaf undulation of margin (absent or very weak of cv. local cultivar Anabia; weak of cv. Parris Island; medium of cv. trocadero; strong of Batavia rubia; very strong of red leaf);

The first three axes derived from PCA accounted for a total of 93.39 % morphological variability, which had an eigenvalue higher than one (Table 3).

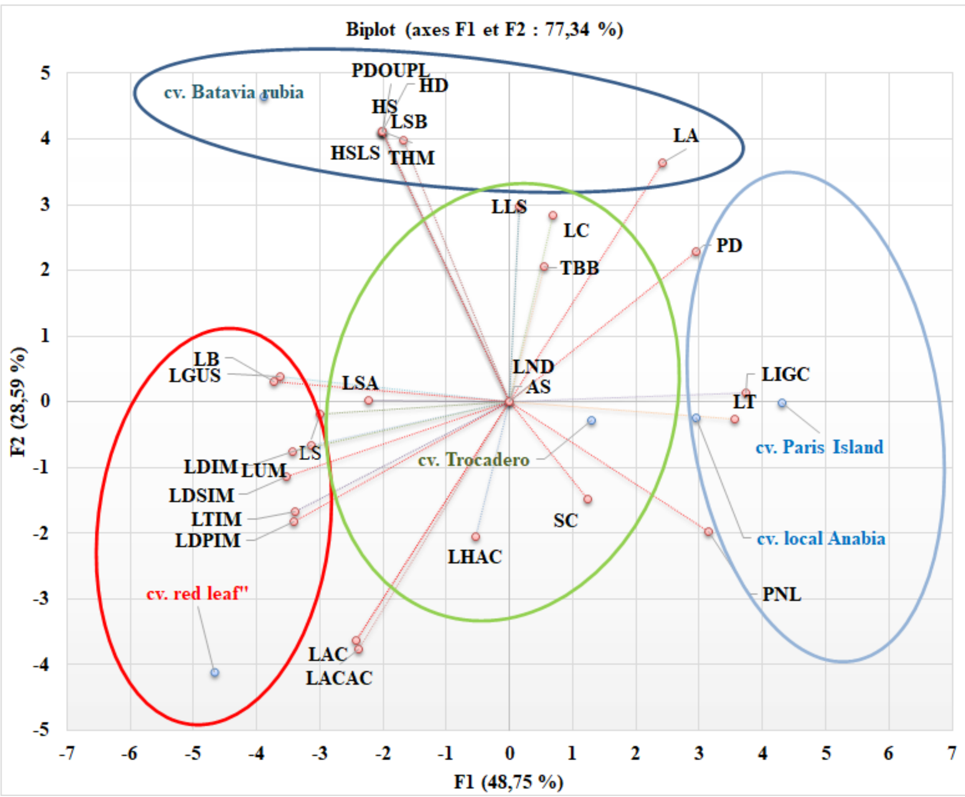



Figure 2: Grouping of five lettuce cultivars according to 29 descriptors determined by biplot analysis. Different symbol shapes denote cluster groups, and colors distinguish cultivars and descriptors within clusters.

Table 3: Characters found most variable based on the first four principal components, derived from morphological characters adapted from the UPOV codes.

| Character | F1 | F2 | F3 | F4 |
|---|---|---|---|---|
| Seed: color | 0,09 | -0,10 | 0,37 | 0,34 |
| Plant: diameter | 0,21 | 0,16 | -0,12 | -0,23 |
| Plant: degree of overlapping of upper part of leaves | -0,14 | 0,30 | -0,05 | 0,007 |
| Only varieties with Plant: degree of overlapping of upper part of leaves: absent or weak: Plant: number of leaves | 0,23 | -0,14 | -0,14 | 0,17 |
| Leaf: attitude | 0,17 | 0,26 | 0,09 | 0,01 |
| Leaf: number of divisions | 0,00 | 0,00 | 0,00 | 0,00 |
| Only varieties with Leaf: number of divisions: absent or very few: Leaf: shape | -0,21 | -0,01 | -0,29 | 0,02 |
| Only varieties with Leaf: number of divisions: absent or very few: Leaf: shape of apex | -0,16 | 0,00 | 0,29 | 0,38 |
| Only varieties with Leaf: number of divisions: absent or very few: Leaf: longitudinal section | 0,01 | 0,21 | 0,32 | 0,32 |
| Leaf: anthocyanin coloration | -0,17 | -0,26 | -0,09 | -0,01 |
| Leaf: hue of anthocyanin coloration | -0,04 | -0,15 | 0,38 | -0,29 |
| Leaf: area covered by anthocyanin coloration | -0,17 | -0,27 | -0,03 | -0,05 |
| Leaf: color | 0,05 | 0,20 | 0,35 | -0,22 |
| Leaf: intensity of green color | 0,27 | 0,01 | -0,05 | -0,01 |
| Leaf: glossiness of upper side | -0,26 | 0,02 | -0,12 | -0,004 |
| Leaf: thickness | 0,26 | -0,01 | -0,07 | -0,20 |
| Leaf: blistering | -0,27 | 0,02 | 0,06 | 0,01 |
| Leaf: size of blisters | -0,12 | 0,29 | 0,15 | -0,13 |
| Leaf: undulation of margin | -0,25 | -0,05 | 0,00 | -0,28 |
| Leaf: type of incisions of margin | -0,24 | -0,12 | 0,06 | 0,18 |
| Leaf: depth of incisions of margin | -0,25 | -0,13 | 0,02 | 0,14 |
| Only varieties with Leaf: type of incisions of margin: irregularly dentate, bi- or tridentate: Leaf: depth of secondary incisions of margin | -0,25 | -0,08 | -0,12 | -0,008 |
| Leaf: density of incisions of margin | -0,23 | -0,04 | 0,13 | -0,33 |
| Only varieties with Plant: degree of overlapping of upper part of leaves: medium or strong: Head: size | -0,14 | 0,30 | -0,05 | 0,007 |
| Only varieties with Plant: degree of overlapping of upper part of leaves: medium or strong: Head: shape in longitudinal section | -0,14 | 0,30 | -0,05 | 0,007 |
| Only varieties with Plant: degree of overlapping of upper part of leaves: medium or strong: Head: density | -0,14 | 0,30 | -0,05 | 0,007 |
| Only varieties with Plant: degree of overlapping of upper part of leaves: medium or strong: Time of harvest maturity | -0,14 | 0,30 | -0,05 | 0,007 |
| Time of beginning of bolting | 0,04 | 0,15 | -0,38 | 0,29 |
| Axillary sprouting | 0,00 | 0,00 | 0,00 | 0,00 |

Leaf density of incisions of margin
(wasn't observed of cv local cultivar Anabia, sparse of cv. Parris Island; dense of cv. Batavia rubia and cv. Trocadero; very dense of cv. red leaf) (Tables 2 and 3, Fig. 1 and 2).

In the PC2, which explained 28.59% of the total variation. Degree of overlapping of upper part of leaves (absent or weak of cv. Trocadero, cv. red leaf, cv. Parris Island and cv. local cultivar Anabia, strong of cv. Batavia rubia); head size (wasn't observed of cv. Trocadero, cv. local cultivar Anabia, cv. Parris Island and cv. red leaf, medium of cv. Batavia rubia); head shape in longitudinal section (wasn't observed of cv. Trocadero, cv. Parris Island, cv. local Anabiaand cv. red leaf, circular of cv. Batavia rubia); head density (wasn't observed at of cv. Trocadero, cv. Parris Island, cv. local cultivar Anabia and cv. red leaf, medium of cv. Batavia rubia) and time of harvest maturity (wasn't observed of cv. Trocadero, cv. Parris Island, cv. local cultivar Anabia and cv. red leaf, early of cv. Batavia rubia) were the predominant traits to PC2 (Tables 2 and 3).

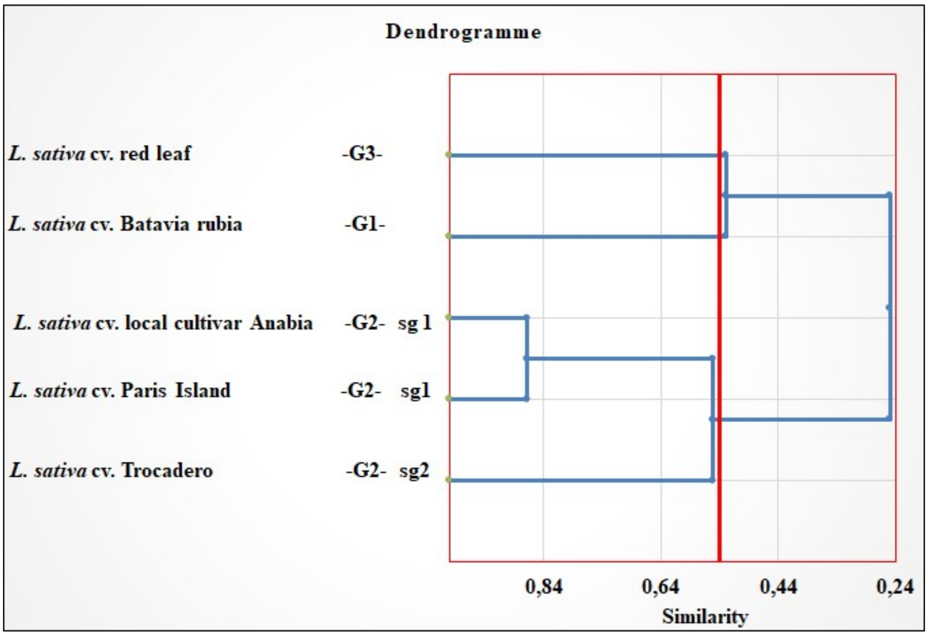
PC3 explained 16.05 % of the total variance. Seed color (white of Batavia rubia and Parris Island, yellow of red leaf, black of cv. Trocadero and cv. local cultivar Anabia); leaf hue of anthocyanin coloration (wasn't observed at of cv. Batavia rubia, cv. Parris Island, cv. local cultivar Anabia, reddish of cv. red leaf; purplish of cv.Trocadero);

leaf color (wasn't observed at of cv. red leaf, green of cv. Parris Island and cv. local cultivar Anabia, yellowish green of cv. Batavia rubia; greyish green of cv. Trocadero); time of beginning of bolting (early of cv. Trocadero; medium of cv. red leaf; late of cv. Batavia rubia, cv. Parris Island and cv. local cultivar Anabia); leaf shape of apex (obtuse of cv. Parris Island, rounded of cv. Trocadero, cv. red leaf, cv. Batavia rubia, and cv. local cultivar Anabia) and leaf longitudinal section (flat of cv. Parris Island and cv. red leaf; convex of cv. Batavia rubia, cv. Trocadero and cv. local cultivar Anabia) were the dominant variables to PC3 (Tables 2 and 3). Thirteen (44.82 %) out of 29 descriptors studied were they had dissimilar scores and therefore are suitable to distinguish between cultivars within this specie (*L. sativa*) (Fig. 2, Tables 2 and 3). These descriptors were: Plant number of leaves (many) and leaf intensity of green color (very dark, dark), the two descriptors were unique to the cultivars Parris Island and local cultivar Anabia respectively; Leaf type of incisions of margin (tridentate); leaf depth of incisions of margin (very deep) and leaf depth of secondary incisions of margin (medium), the three descriptors were unique to the cultivar red leaf; Leaf hue of anthocyanin coloration (purplish) and color (greyish green), the two descriptors were unique to the cultivar Trocadero; Plant degree of overlapping of upper part of leaves (strong), leaf size of blisters (large); head size (medium), head shape in longitudinal section (circular); head density (medium) and time of harvest maturity (early), the six descriptors were unique to the cultivar Batavia rubia.

### *2. Phenotypic diversity based on Morphological Similarity Coefficient*

The UPGMA clustering analyzes indicated that the *L. sativa* cultivars belonged to different groups and had a significant morphological distance with the morphological similarity coefficient ranged from 0.88 between cultivars local cultivar Anabia and Parris Island to 0.52 between cv. red leaf and cv. Batavia rubia (Fig. 3). The largest Morphological Similarity Coefficient observed between cv. local cultivar Anabia and cv. Parris Island suggesting that there is a relationship between them. However, results of UPGMA dendrogram showed that Trocadero cultivar did not separate in a distinct group and grouped in the common group with cv. Parris Island and cv. local cultivar Anabia. The dendrogram generated from morphological distances yielded three groups at 0.24 Morphological Similarity Coefficients (Fig. 3). Group 1 comprised "Batavia rubia" only (Morphological Similarity Coefficient = 0.52 with Group 3). Group 2 comprised 2 subgroups, and Subgroup 1 consisted of cv. Parris Island and local cultivar Anabia (Morphological Similarity Coefficient = 0.88); whereas Subgroup 2 included cv. Trocadero at Morphological Similarity Coefficient = 0.56 with Subgroup 1cv. red leaf cultivar is clustered in a single, separate cluster (Group 3).

Figure 3: Dendrogram of morphological similarities between five lettuce cultivars cultivated in Algeria obtained through morphological descriptors proposed from the UPOV [19].



## DISCUSSION

The characterization of plant, leaf, and depth and seed morphology by the descriptors proposed by UPOV [19] detected wide diversity (72% polymorphism) among the cultivars studied which is prerequisite for maximizing genetic gain in a more efficient way. The set of the UPOV descriptors used here allowed, for the first time, the characterization of the morphological variability in five lettuce cultivars. The number of the descriptors was high if compared to previous studies in lettuce with 12 descriptors: leaf length, width, thickness, number, dry matter percentage, leaf position, color, shape, and position of leaf tip, plant head fresh weight, head compactness, and presence or absence of anthocyanin, were measured in Mousavi *et al*. [18], 17 descriptors: bolting, head formation, leaf texture, anthocyanin, pest and disease, plant height, plant diameter, fresh marketable weight (FMW), and non-marketable (FNMW) total fresh weight (TFW), dry marketable weight (DMW) and non-marketable (DNMW), total dry weight, chlorophyll a, chlorophyll b, chlorophyll a/b ratio in Cardoso *et al*. [16] and 4 descriptors in Franquera *et al*. [17]. According to the results obtained, thirteen (44.82 %) out of 29 descriptors studied have shown an effective discriminating capacity and can be used to cluster the cultivars and may be used to distinguish these cultivars from other 'lettuce' cultivars (Table 2). Three pseudo qualitative descriptors (leaf hue of anthocyanin coloration, leaf color, leaf type of incisions of margin) and ten quantitative descriptors (plant number of leaves, leaf intensity of green color, leaf depth of incisions of margin, leaf depth of secondary incisions of margin, plant degree of overlapping of upper part of leaves, leaf size of blisters, head size, head shape in longitudinal section head density and time of harvest maturity) have been identified as differential characters in Batavia rubia, Trocadero, red leaf, local cultivar Anabia and Parris Island (Table 3). In comparison with other results, four variables were found to be significant to discriminate eight cultivars of lettuce (*Lactuca sativa* L.) head weight, head diameter, leaf, and seed color were considered as the most discriminative traits [22].

Four variables were selected as significant to discriminate 34 Slovenian and 12 Swedish populations of *Lactuca serriola* L.: length and width of achene body, length of pappus bristles, and pappus area were the most discriminating of the UPOV guidelines traits [14]. Moreover, commercial weight and susceptibility to B. lactucae were selected as the two major traits to discriminate between 16 landraces and 16 modern varieties of lettuce [23]. It has been reported that morphological variation between populations can be linked to environmental and genetic variables [14]. Additionally, Waycott *et al.*[24], Mou [25]; and Zhang *et al.*[26], reported the elements of the syndrome of domestication in lettuce and many parameters are of primary interest for human utilization and have had a clear effect on domestication.

The use of phenotypic descriptors including plant, leaf, head and seed characters yielded a high number of morphotypes and permitted the discrimination of all of the studied cultivars.

In previous studies, the discrimination level was found to be as high as those reported by other studies using molecular markers for lettuce [24, 27, 4, 18, and 28]. Multivariate methods based on phenotypic characters are continuously providing valuable information allowing the breeder to improve the cultivars selected from specific geographical regions.

Previously, the multivariate statistics have been applied in lettuce aiming at the commercial and the morphological characteristics [29, 30, 31, and 32], the ecological characteristics [33], and the horticultural and the nutritional [34], and the productive [35]. In our study, multivariate data analysis has shown that the highest amount of difference was attained using leaf traits (Table 3). These were previously shown as the most discriminant traits for the characterization of the species [29 and 35].

## CONCLUSION

Phenotypic descriptors were identified as inexpensive and powerful tools for the classification and characterization of some lettuce cultivars. Phenotypic evaluation is needed to provide the users with valuable data on relationship among descriptors, structure of collections and the individual accessions.

In the present study, we managed to provide insights on the structuring of the diversity and the level of polymorphism in five lettuce cultivars using 29 UPOV morphological descriptors.

These results may contribute to the best conservation and management of the genetic diversity in lettuce cultivars in Algeria, and this would be a benefit for future breeding programs.

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