

Original Research Paper

Evaluation of the genetic diversity of *Inula viscosa* (Vahl) Mast. in northwestern Algeria

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Abstract

As part of the study of plant genetic resources, we were interested in a medicinal and aromatic plant *Inula viscosa*. Following the absence of characterization of this species in Algeria, we saw it useful to start with the morphometric study of the population of *Inula viscosa* in western Algeria. A workforce of 175 plants distributed at the level of seven regions is the subject of this investigation. 15 quantitative traits and 12 qualitative traits were selected for this study. The region has a significant effect on all characters. The principal component analysis (PCA) and the Ascending Hierarchical Classification (AHC) allowed us to distinguish four groups of populations; a factorial analysis of the multiple correspondences (AMC) highlighted differences in the qualitative parameters. The AHC was made from an input matrix composed of 12 qualitative characters allowing us to identify 5 groups of characters. Finally, the relative index of genetic diversity (H') gives average and almost identical values for the seven localities, which is probably the reflection of significant genetic diversity. The estimated H' of 175 plants showed a moderate phenotypic variability for different traits with a mean of 0.287.

Key words *Inula viscosa*, genetic diversity, morphometric characterization, western Algeria

المخلص

كجزء من دراسة الموارد الوراثية النباتية، كنا مهتمين بالنباتات الطبية والعطرية كمثال: إينولا دبكة، (إينولا فيسكوزا) وذلك نظرا لعدم وجود دراسة توصيف لهذا النوع في غرب الجزائر، رأينا أنه من المفيد البدء بالدراسة الشكلية لـ 175 عينة موزعة على مستوى سبع مناطق باستعمال 15 صفة كمية و 12 صفة نوعية لهذه الدراسة. أثبتت التحاليل أن لمنطقة التواجد تأثير كبير على جميع الصفات المدروسة. كذلك سمح لنا تحليل المكون الرئيسي والتصنيف الهرمي التصاعدي بالتمييز بين أربع مجموعات من عينات النباتات، كما سلط تحليل عاملي للمراسلات المتعددة الضوء على الاختلافات في المميزات النوعية، أخيرا، أعطى المؤشر النسبي للتنوع الجيني قيمة متوسطة ومتطابقة تقريبا للمواقع السبع، والتي ربما تكون انعكاسا للتنوع الجيني الكبير. أظهر تقدير المؤشر النسبي للتنوع الجيني تقلبا ظاهريا معتدلا لصفات مختلفة بمتوسط 0.287.

الكلمات المفتاحية: إينولا دبكة، التوصيف المتري، التنوع الوراثي، التباين الظاهري، غرب الجزائر

Introduction

From the perspective of valuing plant resources, we expected local aromatic and medicinal plants (*Inula viscosa*) in Algeria.

According to Fauron et al 1983, the name Inule came from the Greek "Iné", which means "I purge", an allusion to a therapeutic property of the plant (Fauron et al., 1983). Moreover, viscosa means "viscous" (Fournier, 1947). *Inula viscosa* is also called "*Dittrichia viscosa* (L.) Greuter" synonymy of "*Capularia viscosa*", since it has glandular hairs on the ovary, which differs from other species of the genus *Inula* (Ciccarelli et al., 2007).

This species is present throughout the Mediterranean basin (Oka et al., 2006; Parolin et al., 2014). Its natural range includes North Africa (Parolin et al., 2014). It is common in all Maghreb countries: Tunisia and Morocco and widely distributed in northern Algeria and throughout the Mediterranean rim to the heart of the Sahara. As well as on the coasts of Southern Europe (Spain, Greece, Italy, Bulgaria), the Middle East (Jordan, Syria, Egypt, and Turkey) (Ulubelen & Goun, 1986; Parolin et al., 2014; Sevindik et al., 2022).

Inula viscosa known in Algeria as **Magramen** or **Mersitt** (Zeguerrou et al., 2013). It is a less demanding plant whose distribution area is in the Mediterranean region and it is widespread in northern Algeria. It is found in places not conducive to vegetation: roadsides, rubble, abandoned land, fallow, and scrubland. It adapts in areas freshly disturbed by work or fire, grows on both; clay and sandy soils, and likes dry, calcareous soils (Cacarelli et al., 2007).

Inula viscosa (L.) was used in traditional medicine, because of its therapeutic properties, including anti-inflammatory, anthelmintic, lung disorders, antipyretic, antiseptic, and antiphlogistic activities. In addition to treating gastroduodenal disorders, crude extracts prepared from different parts of *Inula viscosa* exhibit antifungal, antioxidant, antiulcerogenic, and anthelmintic properties and prevent zygote implantation. In previous studies, we reported the potent antiproliferative and antimicrobial activities of an *Inula viscosa* methanol extract (Wamidhet al., 2012); Chemical analysis showed that *Inula viscosa* contains many biologically active compounds, including flavonoids and terpenoids. Fourteen known and four new compounds were isolated from Jordanian *Inula viscosa*. *In vitro*, antiproliferative and antimicrobial screening of plant products can provide valuable preliminary data for the potential use of these products to treat cancer and/or microbial infections (Wamidhet al., 2012).

Due to the lack of study concerning this species in Algeria, we saw it useful to start with the morphometric study of populations in western Algeria. The aim of this study consists of the morphometric characterization of the aerial part of this medicinal plant.

Material and methods

Study stations

Our study stations are localized in the northwest of Algeria (2020), where *Inula Viscosa* is exclusively confined to the semi-arid bioclimatic stage with warm, mild, and even cool variants that can develop at a maximum altitude of 1400 m (table 1) (figure 1).

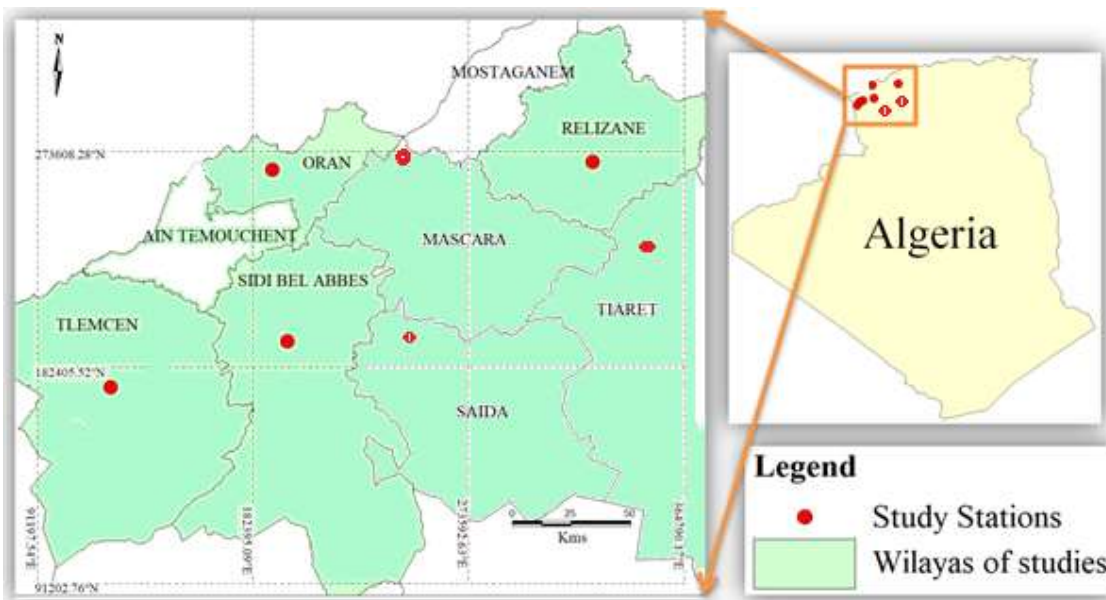


Figure 1. Geographical representation of study areas (1cm/ 20km)

Table 1. Geographical location of populations of *Inula viscosa*

Wilaya	Station	Latitude (N)	Longitude (E+, W-)	Climate	Altitude (m)
Tlemcen	Nedroma	35.02808	-1.76695	Semi-arid superior to temperate winter	613
	Tirni	34.79240	-1.35420	Dry semi-arid	846
	Mersa Ben Mehidi	35.02411	-2.16876	Cold semi-arid	829
Sidi Bel Abbes (SBA)	Mostapha Ben Brahim	35.15789	-0.36173	Semi-arid dry and cold	835
	Sidi Ali Benyoub	34.9456	-0.71943	Semi-arid dry and cold	693
	Ain El Berd	35.3657	-0.51283	Semi-arid dry and cold	490
Saida	Ain Hadjar	34.7587	-0.14436	Semi-arid dry and cold	1014
	Hammam Rebi	34.9666	-0.16667	Semi-arid dry and cold	868
	Ouled Khaled	34.8766	0.15282	semi-arid dry and cold	743
Oran	Ain Turk	35.74544	-0.77295	Semi-arid dry and cold	125
	Es- Senia	35.65407	-0.60558	Semi-arid dry and cold	90
	Bitioua	35.8167	-0.28333	Semi-arid dry and hot	41
Tiaret	Souguar	35.1976	1.49109	semi-arid to cool winter	1133
	Tamda	32.4408	-8.37083	semi-arid to cool winter	319
	Ghertoufa	35.38883	1.298184	semi-arid to cool winter	1094
Relizane	Douhra	35.70583	0.776111	semi-arid to cool winter	310
	Zmala	35.9353	0.8667	semi-arid to cool winter	118
	Yellal	35.7224	0.3533	semi-arid to cool winter	252
Mascara	Mouhamadiya	35,590378	0,104206	Semi arid	28
	Bouhnifyia	35,291959	-0,069807	Semi arid	225
	Tighinif	35,42051	0.32799	Semi arid	569

Plant material

The plant material used during this study is the aerial part of the *Inula viscosa*: leaves and stems were collected in seven locations, and each location is divided into study stations: Tlemcen (Nedroma / Djeballa, Marsa ben M'hidi, and Tirni / Mafrouch), Sidi Bel Abbes (Mostapha ben Brahim, Sidi Ali Benyoub, and Ain berd), Saida (Ain Hadjar, Hammam rebi, and Ouled Khaled), Relizane (Duhra, Zemmala, and Yellel), Mascara (Mouhamadia, Bouhnifia, and Tighenif), Tiaret (Sougueur, Tamda, and Ghertoufa), and Oran (Ain Turk, ES-senia and Betioua) (Table 1).

Data collection

A survey was carried out for the collection of plant material in the seven regions of western Algeria in order to estimate the genetic diversity of these populations.

The morphological characterization of plants was generally based on the description of UPOV "international union for the protection of varieties plants". One hundred seventy-five plants taken randomly were studied for 15 quantitative parameters and 12 qualitative parameters, the study was performed on adult individuals who are approximately the same age (Table 2).

In the field, a 150 cm and a 5m × 19mm Dexter tape measure was used to measure the height of the plant, plant width, and petiole length. In addition, we have used the "Mesurim_pro" software to measure quantitative traits relative to the small size of the leaves of this species.

Statistical analysis

Morphological data for quantitative traits were analyzed by one-way analysis of variance (ANOVA) test using SPSS software (Graduate Pack for Windows, version 20) and R statistical software. The comparison between means was set at a significance level of $\alpha = 0.05$.

Table 2. Quantitative and qualitative parameters of *Inula viscosa*

Quantitative traits	Qualitative traits
Height of the plant (H P)	Habit
Plant width (PW)	Plant habit PHb: Trained, Spread
Number of branches (N B)	Stem hairiness Sh: Absent, Average, Falling back.
Number of leaves per branch (Nlb)	Leaf
Number of rods (Nr)	Edge incision (EI) Very small or absent, Small , Medium, Large
Number of branches per rod (NBr)	Leaf Type (LT): Simple, Compound
Length of small leaves (LsL)	Leaf color (LC): Clear, Dark
length of medium leaf (LmL)	Secondary color distribution (SCd): Marginal. Everywhere, Absence
Length of large leaves (LlL)	Leaf edge curl (LECl): Absent/Low/Strong.
Width of small leaves (WsL)	Leaf Hairiness (LH): Absent, Medium, Dense.
Width of medium leaf (WmL)	Leaf t roughness (LR): Very small or absent , Small, Medium, Large
Width of large leaves (WlL)	Position of the widest part of leaf (PwL): very low, moderately downwards, in the middle
Small leaf surface (S Ls)	Blade
Medium leaf surface (MLs)	Shape of lower leaf blade (SLLb): Acute, Obtuse, Rounded, Truncated, Cordiform
Large leaf surface (LLs)	Apex shape blade (ASb): Acuminate, Acute, Obtuse, and Rounded.

To examine variations between different sets of quantitative and qualitative parameters (Table 2), a range of multivariate tools were used, including principal component analysis (PCA), which uses covariances and correlations to identify relationships between quantitative variables, and multiple correspondence analysis (MCA) to analyze the relationship between qualitative variables. Hierarchical Ascendant Classification (HAC) or cluster analysis was used to calculate the mean data of populations using the FactoMineR package (version R- 4.0.2). And finally, the Shannon and Weaver Index was based only on qualitative traits.

Results

Morphometric analysis

Descriptive Analysis

For the estimation of the variability associated with each character, of the different samples, we calculated the frequencies relating to the morphological characters (biometric characteristics), which are the minimum and the maximum, the averages, the standard errors, the standard deviations, and the statistical variance (Table 3). The total population studied presents on average

- ✓ A height plant (HP) of (65.067 ± 12.717) cm.
- ✓ Small, medium, and large leaf lengths of (3.934 ± 1.084) , (5.429 ± 1.657) and (8.584 ± 2.893) cm.
- ✓ A width of small, medium and large leaves of (0.979 ± 0.355) , (1.329 ± 0.555) and (2.211 ± 1.097) cm.
- ✓ Small, medium and large leaf surface of (5.489 ± 0.919) , (9.618 ± 1.849) and (16.066 ± 4.334) cm².
- ✓ Branch number of (17.434 ± 10.467) .
- ✓ Number of leaves per branch of (464.560 ± 354.622) .
- ✓ Number of rods of (12.726 ± 7.252) .
- ✓ Number of branches per rod of (17.503 ± 5.465) .
- ✓ A width plant of (114.094 ± 43.401) .

Analysis of Variance (ANOVA 1)

1st we compare according to regions

After processing the statistical data by ANOVA 1, we obtained a ***P*-value < 0.05** for all the quantitative traits. There is also a significant difference in these traits between regions (these traits are influenced by environmental factors) (Table 4)

Table 3. Descriptive analysis of morphometric measurements of *Inula viscosa*

Quantitative Traits	Mean	Standard deviation	Standard error	Variance	Min	Max
Number of branches (NB)	17.434	10.4670	.7912	109.557	3.0	42.0
Number of leaves per branch (NLb)	464.560	125757.006	354.62	125757.01	82	1144
Number of rods (Nr)	12.726	7.2528	0.5483	52.6	2	30
Number of branches per rod (NBr)	17.5	29.87	0.413	29.87	11	25
Height of the plant (H P)	65.06	12.71	0.961	161.744	29	87
Length of small leaves (LsL)	3.93	1.084	0.082	1.177	1.31	6.58
Length of medium leaf (LmL)	5.429	1.665	0.125	2.747	0.34	9.05
Length of large leaves (LlL)	8.58	2.89	0.218	8.37	4.5	13.94
Width of small leaves (WsL)	0.979	0.355	0.026	0.126	0.24	1.94
width of medium leaf (WmL)	1.329	0.55	0.041	0.309	0.26	2.82
Width of large leaves (WlL)	2.21	1.09	0.082	1.204	0.6	4.43
Plant width (Pw)	114.09	43.40	3.28	1883.73	26	220
Small leaf surface (SLs)	5.48	0.919	0.69	0.846	2.6	7.39
Medium leaf surface (MLs)	9.618	1.84	0.139	3.422	1.62	13.8
Large leaf surface (LLs)	16.06	4.33	0.327	18.78	10.25	25.87

Table 4. Analysis of variance (ANOVA 1) for the quantitative effects of the regions of *Inula viscosa*

Trait	Region	N	Mean	Dviation	Sig
Number of branches (N B)	Tlemcen	41	11 ,902	8,2698	0
	SBA	18	13,722	9 ,8088	0
	Saida	31	23 ,903	8,6192	0
	Relizane	22	16,682	9,6874	0
	Mascara	23	25,174	10,9737	0
	Tiaret	20	15,25	8,6686	0
	Oran	20	16,2	10,5111	0
	total	175	17,434	10,467	0
Number of rods (Nr)	Tlemcen	41	295,78	231,9373	0
	SBA	18	378,611	358,1628	0
	Saida	31	698,194	383,9061	0
	Relizane	22	490,5	342,9873	0
	Mascara	23	693,565	378,0342	0
	Tiaret	20	13,3	5,2825	0
	Oran	20	8,55	5,3849	0
	Total	175	12,726	7,2528	0
Number of branches per rod (NBr)	Tlemcen	41	13,976	2,8939	0
	SBA	18	22,833	3,2222	0
	Saida	31	21,097	6,2629	0
	Relizane	22	20,227	3,3371	0
	Mascara	23	17,391	5,1322	0
	Tiaret	20	15,25	5,7754	0
	Oran	20	13,75	2,2213	0
	total	175	17,503	5,4655	0
Height of the plant (H P)	Tlemcen	41	58,8244	13,58058	0
	SBA	18	57,0256	11,16403	0
	Saida	31	65,0977	13,1362	0
	Relizane	22	75,2982	3,93085	0
	Mascara	23	70,0235	11,39605	0
	Tiaret	20	75,609	3,3236	0
	Oran	20	57,5645	7,61202	0

	Total	175	65,0678	12,71785	0
Length of small leaves (LsL)	Tlemcen	41	4,8878	0,97799	0
	SBA	18	3,5844	0,18098	0
	Saida	31	3,631	0,20024	0
	Relizane	22	3,4509	0,18672	0
	Mascara	23	3,9778	0,45364	0
	Tiaret	20	2,077	0,64988	0
	Oran	20	5,1015	0,63637	0
	Total	175	3,9341	1,08477	0
length of medium leaf (LmL)	Tlemcen	41	7.0393	1,27957	0
	SBA	18	4.4822	1,1791	0
	Saida	31	4.721	0,60449	0
	Relizane	22	4.7382	0,46147	0
	Mascara	23	5.7304	0,88871	0
	Tiaret	20	2.9065	1,01689	0
	Oran	20	7.0175	0,65457	0
	Total	175	5.4295	1,65749	0
Length of large leaves (LlL)	Tlemcen	41	10.0417	1,76265	0
	SBA	18	8.19	3,43755	0
	Saida	31	7,9368	3,13485	0
	Relizane	22	10,9355	3,74373	0
	Mascara	23	7,3683	1,02194	0
	Tiaret	20	5,273	1,03149	0
	Oran	20	9,0815	1,92347	0
	Total	175	8,5846	2,89316	0
Width of small leaves (WsL)	Tlemcen	41	1,1337	0,284	0
	SBA	18	0,9489	0,09517	0
	Saida	31	0,9719	0,10144	0
	Relizane	22	0,8877	0,09102	0
	Mascara	23	0,7261	0,22397	0
	Tiaret	20	0,958	0,79844	0
	Oran	20	1,1145	0,31203	0
	Total	175	0,9793	0,35524	0
Width of medium leaf (WmL)	Tlemcen	41	1,8663	0,42267	0
	SBA	18	1,0961	0,2302	0
	Saida	31	1,1026	0,20294	0
	Relizane	22	1,2655	0,24448	0
	Mascara	23	1,1696	0,28447	0
	Tiaret	20	0,48	0,26905	0
	Oran	20	1,891	0,46966	0
	Total	175	1,3291	0,55551	0
Width of large leaves (WlL)	Tlemcen	41	2,6851	0,67378	0
	SBA	18	2,2806	1,25815	0
	Saida	31	2,1832	1,18289	0
	Relizane	22	3,2014	1,33059	0
	Mascara	23	1,5991	0,24541	0
	Tiaret	20	0,8255	0,3196	0
	Oran	20	2,2205	0,46057	0
	Total	175	2,2111	1,0971	0
Plant width (PW)	Tlemcen	41	82,5046	38,54312	0
	SBA	18	107,7422	29,26876	0
	Saida	31	130,0465	48,63315	0
	Relizane	22	145,2223	24,36732	0

	Mascara	23	127,6957	37,16472	0
	Tiaret	20	147,165	23,6032	0
	Oran	20	76,889	15,77465	0
	Total	175	114,0941	43,40199	0
Small leaf surface (S Ls)	Tlemcen	41	5,6473	1,01226	0
	SBA	18	5,5767	0,27726	0
	Saida	31	5,6381	0,29253	0
	Relizane	22	5,4186	0,24641	0
	Mascara	23	5,76	0,6056	0
	Tiaret	20	4,076	1,06939	0
	Oran	20	6,039	0,91959	0
	Total	175	5,4897	1,77946	0
Medium leaf surface (MLs)	Tlemcen	41	10,5251	0,76817	0
	SBA	18	9,2644	0,77112	0
	Saida	31	9,2984	1,76965	0
	Relizane	22	9,0632	1,13456	0
	Mascara	23	10,3557	1,2833	0
	Tiaret	20	6,8345	1,72969	0
	Oran	20	11,1235	1,84994	0
	Total	175	9,6187	1,77946	0
Large leaf surface (LLs)	Tlemcen	41	18,0412	3,56279	0
	SBA	18	15,6594	4,71896	0
	Saida	31	15,4345	4, 52447	0
	Relizane	22	19,4018	5,21377	0
	Mascara	23	14,1043	1,2019	0
	Tiaret	20	11,222	1,30496	0
	Oran	20	16,792	2,76111	0
	Total	175	16,066	4,33425	0

The variations (mean \pm standard deviation) of the parameters studied in the Tlemcen region show a low variability for the number of branches (11.902 ± 8.269) and a high value for the length of the medium leaf (7.039 ± 1.279) and the width of the small leaf (1.133 ± 0.284). The Mascara region, unlike Tlemcen, has high variability in the number of branches (25.174 ± 10.973) and a low in the width of the small leaf (0.726 ± 0.223).

For the Sidi Bel Abbes's (SBA) region, we note that there is a great variability for the number of branches per stem (22.833 ± 3.222) and a modest one for the height of the plant (57.025 ± 11.164).

The Saida region contains large instability for stem number (16.645 ± 7.7354) and leaf number per branch (21.097 ± 6.2629).

Relizane specifically emits a great variability for the large leaf of the plant studied; we note the length (10.935 ± 3.743); width (3.201 ± 1.330); surface (19.401 ± 5.213).

We notice in the Tiaret zone a great instability concerning the width of the plant (147.165 ± 23.603) and its height (75.609 ± 3.323), and a deficiency in the surface of the three types of the small leaf (4.076 ± 1.065); medium (6.834 ± 1.283) and large (11.222 ± 1.304).

Finally, in the region of Oran, in which a strong variability was seen concerning the surface of the two, types of leaf the small and the medium (6.039 ± 1.069); (11.123 ± 1.729). Thus, the length of the small leaf was 5.101 ± 0.636 , and the width of the medium leaf was 1.891 ± 0.469 .

For the characters of plant width (76.889 ± 15.774), number of branches per rod (13.750 ± 2.221), number of rods (8.550 ± 5.384), and number of leaves per branch (245.050 ± 170.862).

2nd, we compare according to each station/region)

The *P*-value is inferior to 0.05 for the characters studied, which indicates a significant difference for these characters between the stations (these characters are influenced by the environment) (Table 5).

Table 5. Analysis of variance (ANOVA 1) for the quantitative effects of station / regions of *Inula viscosa*

Trait	Station	N	Mean	Deviation	Sig
Number of branches (NB)	Nedroma/djbala	12	9,000	2,1320	0
	Tirni/mefrouch	8	9,500	2,2039	0
	Marsa ben m'hidi/msirda	21	14,476	10,8748	0
	Mostapha ben brahim	4	29,500	2,0817	0
	Sidi ali benyoub	6	10,667	7,6333	0
	Ain berd	8	8,125	2,0310	0
	Ain hadjar	8	10,750	1,4880	0
	Hammam rebi	11	27,636	5,4272	0
	Ouled khaled	12	29,250	1,8647	0
	Duhra	6	10,000	2,1909	0
	Zemmala	9	10,556	1,7401	0
	Yellel	7	30,286	1,8898	0
	Mouhamadia	7	10,000	2,2361	0
	Bouhnifia	5	29,600	1,8166	0
	Tighenif	11	32,818	5,0362	0
	Sougueur	5	29,600	1,8166	0
	Tamda	6	10,333	1,8619	0
	Ghertoufa	9	10,556	1,7401	0
	Ain turk	8	27,625	6,8020	0
	Es-senia	5	8,000	0,7071	0
	Betiou	7	9,000	2,2361	0
	total	175	17434	10,4670	0
Number of branches per rod (NBr)	Nedroma/djbala	12	11,083	2887	0
	Tirni/mefrouch	8	18,000	0,0000	0
	Marsa ben m'hidi/msirda el fouaga	21	14,095	2,2783	0
	Mostapha ben brahim	4	25,000	0,0000	0
	Sidi ali benyoub	6	18,500	1,2247	0
	Ain berd	8	25,000	0,0000	0
	Ain hadjar	8	11,625	1,7678	0
	Hammam rebi	11	23,727	4,2212	0
	Ouled khaled	12	25,000	0,0000	0
	Duhra	6	18,000	0,0000	0
	Zemmala	9	18,000	0,0000	0
	Yellel	7	25,000	0,0000	0
	Mouhamadia	7	11,000	0,0000	0
	Bouhnifia	5	25,000	0,0000	0
	Tighenif	11	18,000	0,0000	0
	Sougueur	5	25,000	0,0000	0
	Tamda	6	12,000	0,0000	0
	Ghertoufa	9	12,000	0,0000	0
	Ain turk	8	16,375	05175	0
	Es-senia	5	12,000	0,0000	0
	betioua	7	12,000	0,0000	0
	Total	175	17,503	5,4655	0
	Nedroma/djbala	12	136,000	7,9658	0
	Tirni/mefrouch	8	243,500	41,2553	0

Number of leaves per branch (NLb)	Marsa ben m'hidi/msirda el fouaga	21	407,000	278,4956	0
	Mostapha ben brahim	4	951,500	92,2334	0
	Sidi ali benyoub	6	286,667	285,2064	0
	Ain berd	8	161,125	30,7173	0
	Ain hadjar	8	116,125	22,4845	0
	Hammam rebi	11	861,818	256,8804	0
	Ouled khaled	12	936,250	81,5298	0
	Duhra	6	265,333	50,4804	0
	Zemmala	9	264,556	54,2451	0
	Yellel	7	974,000	75,3879	0
	Mouhamadia	7	137,286	10,4517	0
	Bouhnifia	5	950,200	76,9558	0
	Tighenif	11	930,909	21,4124	0
	Sougueur	5	957,800	75,4533	0
	Tamda	6	272,333	60,8101	0
	Ghertoufa	9	293,889	69,9954	0
	Ain turk	8	408,125	168,7504	0
	Es-senia	5	137,600	3,3615	0
	betioua	7	135,429	10,8912	0
	Total	175	464,560	354,6223	0
Number of rods (Nr)	Nedroma/djbala	12	4,750	2,2208	0
	Tirni/mefrouch	8	10,875	1,2464	0
	Marsa ben m'hidi/msirda el fouaga	21	10,857	5,6858	0
	Mostapha ben brahim	4	24,500	5,2599	0
	Sidi ali benyoub	6	11,833	5,1929	0
	Ain berd	8	5,375	5,6850	0
	Ain hadjar	8	5,250	1,0351	0
	Hammam rebi	11	19,636	5,1239	0
	Ouled khaled	12	21,500	3,0896	0
	Duhra	6	10,667	1,0328	0
	Zemmala	9	10,222	1,4814	0
	Yellel	7	24,571	4,9952	0
	Mouhamadia	7	5,286	1,2536	0
	Bouhnifia	5	21,600	3,6469	0
	Tighenif	11	19,727	1,4206	0
	Sougueur	5	21,600	3,6469	0
	Tamda	6	10,500	1,2247	0
	Ghertoufa	9	10,556	1,1304	0
	Ain turk	8	13,250	5,5227	0
	Es-senia	5	3,800	1,0954	0
	betioua	7	6,571	1,6183	0
	Total	175	12,726	7,2528	0
Height of the plant (H P)	Nedroma/djbala	12	55,6667	3,78282	0
	Tirni/mefrouch	8	76,3500	3,25415	0
	Marsa ben m'hidi/msirda el fouaga	21	53,9524	14,26614	0
	Mostapha ben brahim	4	72,6000	2,224499	0
	Sidi ali benyoub	6	51,3500	11,28074	0
	Ain berd	8	53,4950	5,40063	0
	Ain hadjar	8	45,2763	4,18727	0
	Hammam rebi	11	70,7018	8,61903	0
	Ouled khaled	12	73,1750	1,89934	0
	Duhra	6	73,1750	3,96452	0
	Zemmala	9	78,5700	2,80827	0

Length of small leaves (LsL)	Yellel	7	75,8933	2,08943	0
	Mouhamadia	7	54,7586	3,91182	0
	Bouhnifia	5	72,6000	1,88547	0
	Tighenif	11	78 ,5664	5,32919	0
	Sougueur	5	72,6800	2,01668	0
	Tamda	6	76,2067	2 ,89611	0
	Ghertoufa	9	76,8378	3,41040	0
	Ain turk	8	59,0625	10,99934	0
	Es-senia	5	58,1220	3,57609	0
	betioua	7	55,4543	5,03625	0
	Total	175	65,0678	12,71785	0
	Nedroma/djbala	12	4,7042	,16844	0
	Tirni/mefrouch	8	3 ,3425	,08908	0
	Marsa ben m'hidi/msirda el fouaga	21	5,5814	,64340	0
	Mostapha ben brahim	4	3,7325	,12203	0
	Sidi ali benyoub	6	3,3667	,02944	0
Length of medium leaf (LmL)	Ain berd	8	3 ,6738	,10127	0
	Ain hadjar	8	3 ,3600	,02777	0
	Hammam rebi	11	3,7091	,16525	0
	Ouled khaled	12	3,7400	,10753	0
	Duhra	6	3,3233	,09709	0
	Zemmala	9	3,3444	,01014	0
	Yellel	7	3,6971	,10012	0
	Mouhamadia	7	4,6329	,07610	0
	Bouhnifia	5	3,7120	,11628	0
	Tighenif	11	3,6818	,10861	0
	Sougueur	5	2,9900	,44469	0
	Tamda	6	1,7600	,35654	0
	Ghertoufa	9	1,7811	,36040	0
	Ain turk	8	5,7580	,55097	0
	Es-senia	5	4,7580	,25411	0
	betioua	7	4,6312	,08112	0
	Total	175	3,9341	1,08477	0
Length of medium leaf (LmL)	Nedroma/djbala	12	6,8500	,11078	0
	Tirni/mefrouch	8	5,0013	,48022	0
	Marsa ben m'hidi/msirda el fouaga	21	7,9238	,82627	0
	Mostapha ben brahim	4	4,3600	,14353	0
	Sidi ali benyoub	6	5,4017	,46473	0
	Ain berd	8	3,8538	1,42433	0
	Ain hadjar	8	5,6013	,27527	0
	Hammam rebi	11	4,4845	,41159	0
	Ouled khaled	12	4,3508	,13474	0
	Duhra	6	5,0433	,52454	0
	Zemmala	9	4,8311	,41543	0
	Yellel	7	4,3571	,10242	0
	Mouhamadia	7	6,7929	,05908	0
	Bouhnifia	5	4,3640	,12095	0
	Tighenif	11	5,6755	,05126	0
	Sougueur	5	4,5800	,38685	0
	Tamda	6	2,3633	,18896	0
	Ghertoufa	9	2,3389	,15696	0
	Ain turk	8	7,3013	,99228	0
	Es-senia	5	6,9020	,17655	0

	betioua	7	6,7757	,02507	0
	Total	175	5,4295	1,65749	0
Length of large leaves (LIL)	Nedroma/djbala	12	8,5417	,44769	0
	Tirni/mefrouch	8	12,7250	,85917	0
	Marsa ben m'hidi/msirda el fouaga	21	9,8767	1,26077	0
	Mostapha ben brahim	4	5,9075	,74737	0
	Sidi ali benyoub	6	12,8350	,56053	0
	Ain berd	8	5,8475	,70144	0
	Ain hadjar	8	12,6525	,53219	0
	Hammam rebi	11	6,6155	2,14710	0
	Ouled khaled	12	6,0042	,66100	0
	Duhra	6	13,6017	,33660	0
	Zemmala	9	13,2967	1,05074	0
	Yellel	7	5,6914	,59387	0
	Mouhamadia	7	8,4014	,39066	0
	Bouhnifia	5	5,7960	,65148	0
	Tighenif	11	7,4255	,22232	0
	Sougueur	5	6,9520	,48283	0
	Tamda	6	4,7267	,21191	0
	Ghertoufa	9	4,7044	,18132	0
	Ain turk	8	9,5438	1,30412	0
	Es-senia	5	8,8880	,32935	0
	betioua	7	8,6914	,38779	0
	Total	175	8,5846	2,89316	0
Width of small leaves (WsL)	Nedroma/djbala	12	,9083	,09144	0
	Tirni/mefrouch	8	,8925	,05445	0
	Marsa ben m'hidi/msirda el fouaga	21	1,3543	,22549	0
	Mostapha ben brahim	4	1,0074	,08884	0
	Sidi ali benyoub	6	,8833	,06593	0
	Ain berd	8	,9688	,09702	0
	Ain hadjar	8	,8875	,07592	0
	Hammam rebi	11	,9918	,10206	0
	Ouled khaled	12	1,0100	,08811	0
	Duhra	6	,8583	,09411	0
	Zemmala	9	,8378	,01922	0
	Yellel	7	,9771	,08480	0
	Mouhamadia	7	,8829	,05469	0
	Bouhnifia	5	,9771	,09680	0
	Tighenif	11	,9780	,07332	0
	Sougueur	5	,5118	,02950	0
	Tamda	6	,4220	,90229	0
	Ghertoufa	9	1,0800	,87158	0
	Ain turk	8	1,1744	,14486	0
	Es-senia	5	1,4613	,14117	0
	betioua	7	,9140	,04488	0
	Total	175	,8614	,35524	0
width of medium leaf (WmL)	Nedroma/djbala	12	1,6092	,11115	0
	Tirni/mefrouch	8	1,4038	,18988	0
	Marsa ben m'hidi/msirda el fouaga	21	2,1895	,32085	0
	Mostapha ben brahim	4	,9900	,21085	0
	Sidi ali benyoub	6	1,3450	,13976	0
	Ain berd	8	,9625	,16932	0
	Ain hadjar	8	1,3325	,14109	0

	Hammam rebi	11	1,0355	,13477	0
	Ouled khaled	12	1,0108	,17874	0
	Duhra	6	1,3817	,13996	0
	Zemmala	9	1,4311	,06646	0
	Yellel	7	,9529	,13290	0
	Mouhamadia	7	1,5757	,11528	0
	Bouhnifia	5	,9560	,03735	0
	Tighenif	11	1,0082	,14293	0
	Sougueur	5	,9200	,14579	0
	Tamda	6	,3300	,10954	0
	Ghertoufa	9	,3356	,05727	0
	Ain turk	8	2,3238	,05028	0
	Es-senia	5	1,6520	,45464	0
	betioua	7	1,5671	,00756	0
	Total	175	1,3291	,55551	0
Width of large leaves (WIL)	Nedroma/djbala	12	1,9592	,07585	0
	Tirni/mefrouch	8	3,4825	,55636	0
	Marsa ben m'hidi/msirda el fouaga	21	2,7962	,46146	0
	Mostapha ben brahim	4	1,4450	,06245	0
	Sidi ali benyoub	6	3,9617	,53663	0
	Ain berd	8	1,4375	,05726	0
	Ain hadjar	8	3,9038	,57124	0
	Hammam rebi	11	1,7218	,85674	0
	Ouled khaled	12	1,4592	,05885	0
	Duhra	6	4,1133	,48903	0
	Zemmala	9	93,9756	,065900	0
	Yellel	7	1,4243	,05711	0
	Mouhamadia	7	1,9500	,07681	0
	Bouhnifia	5	1,4400	,06285	0
	Tighenif	11	1,4482	,05896	0
	Sougueur	5	1,3420	,19563	0
	Tamda	6	,6517	,02858	0
	Ghertoufa	9	,6544	,02506	0
	Ain turk	8	2,5875	,54959	0
	Es-senia	5	2,0140	,10854	0
	betioua	7	1,9486	,10040	0
	Total	175	2,2111	1,09710	0
Plant width (Pw)	Nedroma/djbala	12	78,3250	12,32810	0
	Tirni/mefrouch	8	150,8488	3,42769	0
	Marsa ben m'hidi/msirda el fouaga	21	58,8571	20,43107	0
	Mostapha ben brahim	4	139,2750	54,05278	0
	Sidi ali benyoub	6	99,1067	9,20148	0
	Ain berd	8	98,4525	6,09082	0
	Ain hadjar	8	93,1675	6,94223	0
	Hammam rebi	11	138,5091	50,62419	0
	Ouled khaled	12	146,8750	52,15658	0
	Duhra	6	153,7650	1,97174	0
	Zemmala	9	151,9667	1 ;72409	0
	Yellel	7	129,2286	40,38984	0
	Mouhamadia	7	84,22486	12 ;66586	0
	Bouhnifia	5	132,6600	47,36964	0
	Tighenif	11	153,0873	1,400841	0
	Sougueur	5	132,9400	47,99284	0

Small leaf surface (SLs)	Tamda	6	151,7000	1,43944	0
	Ghertoufa	9	152,0444	1,22792	0
	Ain turk	8	68,9100	20,30146	0
	Es-senia	5	79,4000	10,92016	0
	betioua	7	84,2143	8,65495	0
	Total	175	114,0941	43,40199	0
	Nedroma/djbala	12	6,6483	,25662	0
	Tirni/mefrouch	8	5 ,2775	,06112	0
	Marsa ben m'hidi/msirda el fouaga	21	5,2162	1,07737	0
	Mostapha ben brahim	4	5,7825	,20855	0
	Sidi ali benyoub	6	5,2550	,04889	0
	Ain berd	8	5,7150	,17768	0
	Ain hadjar	8	5,2575	,04301	0
	Hammam rebi	11	5 ,7491	,24873	0
	Ouled khaled	12	5,7900	,18201	0
	Duhra	6	5,2750	,05577	0
	Zemmala	9	5,2644	,04953	0
	Yellel	7	5,7400	,17282	0
	Mouhamadia	7	6,5814	,09974	0
	Bouhnifia	5	5,7480	,20572	0
	Tighenif	11	5,2427	,13123	0
Large leaf surface (LLs)	Sougueur	5	4,4560	,45352	0
	Tamda	6	3,8800	1,24619	0
	Ghertoufa	9	3,9956	1,22353	0
	Ain turk	8	5,1863	1,26710	0
	Es-senia	5	6,7180	,39156	0
	betioua	7	6,5286	,11231	0
	Total	175	5,4897	,91959	0
	Nedroma/djbala	12	15,6317	,48809	0
	Tirni/mefrouch	8	21,3825	1,32364	0
	Marsa ben m'hidi/msirda el fouaga	21	18,1452	4,08437	0
	Mostapha ben brahim	4	12,5025	,80214	0
	Sidi ali benyoub	6	22 ,0533	,98490	0
	Ain berd	8	12,4425	,74061	0
	Ain hadjar	8	22,3375	,81874	0
	Hammam rebi	11	13,4636	2,92031	0
	Ouled khaled	12	12,6392	,76551	0
	Duhra	6	23,2317	1,22560	0
	Zemmala	9	22,4233	1,96717	0
	Yellel	7	12,2343	,65775	0
	Mouhamadia	7	15,4700	,42395	0
	Bouhnifia	5	12,3820	,72386	0
	Tighenif	11	14,0182	,25238	0
	Sougueur	5	13,3380	,70297	0
	Tamda	6	10,5283	,22329	0
	Ghertoufa	9	10,5089	,18658	0
	Ain turk	8	18,1788	4,09806	0
	Es-senia	5	15,9700	44 340	0
	betioua	7	15,7943	,35944	0
	Total	175	16,0660	4,33425	0
	Nedroma/djbala	12	11,9142	,22310	0
	Tirni/mefrouch	8	9,8613	,54585	0
	Marsa ben m'hidi/msirda el fouaga	21	9,9843	2,13547	0

Medium leaf surface (MLs)	Mostapha ben brahim	4	8,8100	,15895	0
	Sidi ali benyoub	6	10,2550	,44334	0
	Ain berd	8	8,7488	,13737	0
	Ain hadjar	8	10,4513	,23099	0
	Hammam rebi	11	8,9791	,52592	0
	Ouled khaled	12	8,8225	,14385	0
	Duhra	6	8,3933	,49757	0
	Zemmala	9	9,7444	,49757	0
	Yellel	7	8,7614	,13656	0
	Mouhamadia	7	11,8314	,07221	0
	Bouhnifia	5	8,7840	,15437	0
	Tighenif	11	10,1309	,06379	0
	Sougueur	5	8,9600	,45678	0
	Tamda	6	6,1333	,1769	0
	Ghertoufa	9	6,1211	,15012	0
	Ain turk	8	10,0138	2,38120	0
	Es-senia	5	12,0020	,37326	0
	betioua	7	11,7643	,04276	0
	Total	175	9,6187	1,84994	0

We note that there is significant variability in the character "Number of Branches" in the Tighenif station (930.909 ± 21.412).

For the "Number of Leaf per Branch" character and the "Number of rods" character, the Yellel station ranks first with (974.000 ± 75.387) and (24.571 ± 4.995). As well as the Yellel station contains a remarkable variability for "Number of Branches per rod" with the stations: Sougueur; Bouhnifia; Ouled Khaled; Ain Berd and Mostapha Ben Brahim for a difference of (25.000 ± 0.000).

There is great instability of "Plant Height"; "Width of the Plant"; "Large Leaf Length"; "Width of the Large Leaf" and "surface of the Large Leaf" in the Duhra station with (78.570 ± 3.964); (153.765 ± 1.971); (13.601 ± 0.336); (4.113 ± 0.489) and (23.231 ± 1.225).

However, the Ain Turk station demonstrates very high variance values for the characters: "Small Leaf Length"; "Small Leaf Width" and "Medium Leaf Width" with (5.727 ± 0.550); (1.461 ± 0.144) and (2.323 ± 0.474). Also, we note that: the Nedroma station has an instability for the parameter "medium leaf Surface" by (11.914 ± 0.223); the station of Marsa ben m'hidi/ msirda el fouaga presents values of "medium Leaf Length" by (7.923 ± 0.826) and the station of Es-Senia with a variability of (12.002 ± 0.373) for the character "Surface of the Small Leaf".

Pearson correlation

The following table 6 summarizes the correlation test of the different characters studied of *Inula viscosa*.

After processing the statistical data with a Pearson correlation test, we noticed that there are strong positive links between NB and NLB (86.3%), Nr (84.7%), NBr (61.4%), and a low positive correlation between NB and HP (43.0%), Pw (26.2%); however a negative correlation was noticed between NB and WIL (-34.3%), NB and Lls (-38.4%), NB and LIL (-40.7%) (Table 6).

* Low signification $p < 0.05$, ** strong signification $P < 0.01$, [-1,-0.5]: strong negative correlation, [-0.5, 0]: low negative correlation, [0, 0.5]: low positive correlation, [0.5, 1]: high positive correlation

Table 6. Pearson correlation for the quantitative effects of *Inula viscosa*

	NB	NLb	Nr	NBr	HP	LsL	PW	WmL	WIL	LLs	MLs	SLs	WsL	LIL	LmL
NB	1														
NLb	0,863**	1													
Nr	0,847**	0.912**	1												
NBr	0,614**	0.712**	0.704**	1											
HP	0,436**	0.509**	0.501**	0.400**	1										
LsL	0,024	-0.095	-0.170*	-0.15*	-0.443**	1									
PW	0,262**	0.352**	0.454**	0.408**	0.718**	0.641**	1								
WmL	-0,151*	-0.310**	0.300**	0.327**	0.539**	0.819**	0.590**	1							
WIL	-0.345**	-0.396**	-0.322*	0.231**	0.272**	0.223**	-0.181*	0.515**	1						
LLs	-0.384**	-0.438**	0.357**	0.320**	0.252**	0.236**	-0.145	0.494**	0.891**	1					
MLs	-0.160*	-0.253**	0.291**	0.285**	0.455**	0.577**	0.417**	0.535**	0.307**	0.335**	1				
SLs	-0.039	-0.026	-0.101	-0.011	0.212**	0.483**	-0.199*	0.244**	0.020	0.068	0.502**	1			
WsL	-0.030	-0.059	-0.091	-0.122	-0.122	0.368**	0.236**	0.296**	0.016	0.002	-0.122	0.242**	1		
LIL	-0.407**	-0.469**	0.394**	0.344**	0.241**	0.233**	-0.138	0.529**	0.954**	0.914**	0.77**	0.053	-0.030	1	
LmL	-0.124	-0.267**	0.334**	0.416**	0.555**	0.834**	0.983**	0.875**	0.405**	0.396**	0.629**	0.298**	0.153*	0.455**	1

* Low signification $p < 0.05$, ** strong signification $P < 0.01$, [-1, -0.5]: strong negative correlation, [-0.5, 0]: low negative correlation, [0, 0.5]: low positive correlation, [0.5, 1]: high positive correlation

Multivariate analysis

Principal Component Analysis (PCA)

Principal component analysis (PCA) was performed on the variables studied. The result of this analysis showed that these variables presented 60.124% of the total inertia on the two axes, so the variability explained by this design is significant (Figure 2).

Axis 1 (42.26%): is represented by the following quantitative variables: Small leaf surface (SLs), Width of small leaves (WsL), Length of small leaves (LsL), and the number of branches (NB). These parameters are positively correlated, perhaps that is due to the fact that they are governed by a large number of genes in common.

Axis 2 (17.85 %): is represented by the following variables correlated positively by Length of the medium leaf (LmL), Medium leaf surface (MLs), Length of large leaves (LlL), Large leaf surface (LLs), the width of the medium leaf (WmL), Width of large leaves (WlL), and negatively by the Number of leaves per branch (NLb), number of rods (Nr), Number of branches per rod (NBr), Plant height (HP), and Plant Width (Pw). This result confirms perfectly the correlation found in the test of Pearson.

All those quantitative traits correlated negatively such as Length and Width of leaves with the Number of leaves per branch (NLb), Number of rods (Nr), Number of branches per rod (NBr), Plant height (HP), and Plant width (Pw) are governed by polygenes that have antagonistic effects or a negative epistatic effect.

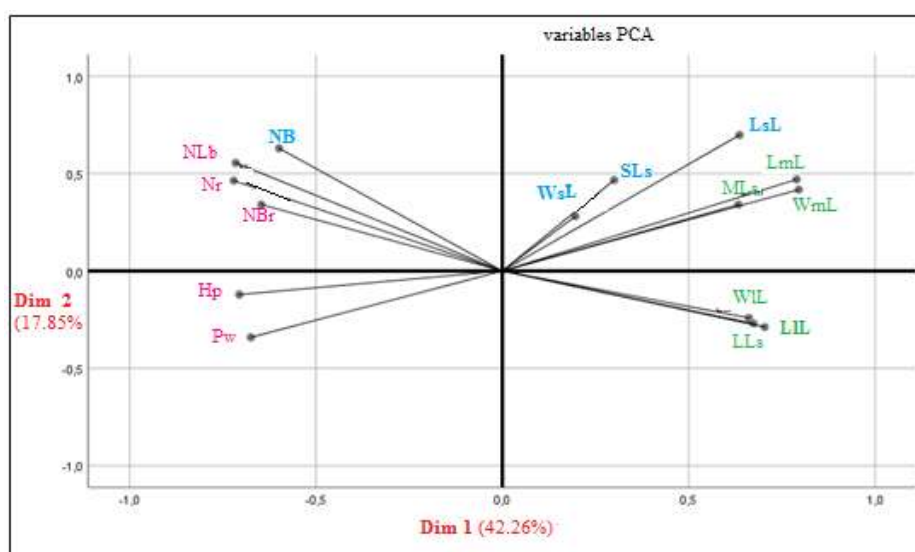


Figure 2. Principal Component Analysis of 15 quantitative traits of 175 accessions of *Inula viscosa*

The component analysis PCA (Figure 2) made it possible to determine three classes

Group 1: Small leaf surface (SLs), Width of small leaves (WsL), Length of small leaves (LsL), and the number of branches (NB),

Group 2: Length of the medium leaf (LmL), Medium leaf surface (MLs), Length of large leaves (LlL), Large leaf surface (LLs), the width of the medium leaf (WmL), Width of large leaves (WlL).

Group 3: Number of leaves per branch (NLb), number of rods (Nr), number of branches per rod (NBr), Plant height (HP), and Plant's width (PW).

PCA (individual)

After superimposing the graph of individuals on the graph of traits, we notice that there are 4 groups of *Inula viscosa* regarding their regions and traits (Fig 3).

Group 1: concerns the region of Oran (Ain Turk and E-Senia); Mascara (Mohamadia), and Tlemcen (Nedroma / Djbala and Marsa ben m'hidi / msirda el fouaga), which are geographically close.

Group 2: concerns the SBA region (Mostapha Ben Brahim); Relizan (Yellel); Tiaret (Souguer); Mascara (Bouhnifia and Tighenif), and Saida (Hammam Rebi and Ouelad Khaled), which are geographically close as well.

Group 3: concerns the SBA region (Ali Ben Youb); Saida (Ain Hadjer); Tlemcen (Nedroma/ Djebala, and Tirni /el Mafrouch), and Relizen (Duhra and Zemmal), which are geographically dispersed

Group 4: contains plants from the region of Tiaret (Souguet; Tamda and Ghertoufa) and SBA (Ain Berd).

We note a dispersion of *Inula viscosa* plants from the SBA region in the 3 other populations, which makes the population with the most genetic variability.

This result obtained can be explained by a certain selective pressure on this species inducing its evolution in its current geographical area.

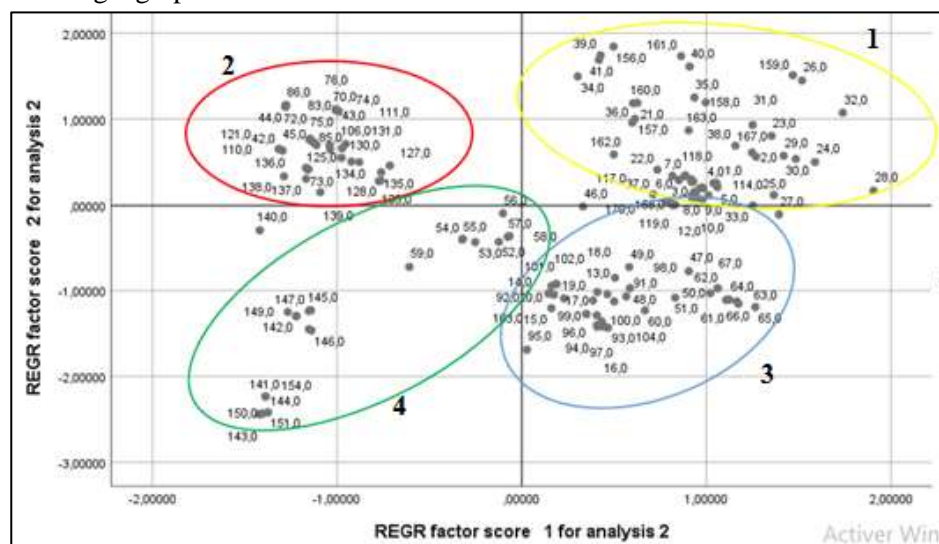


Figure 3. Principal Component Analysis of 175 accessions of *Inula viscosa*

Hierarchical Ascending Classification (HAC)

The HAC (Hierarchical Ascending Classification) is made from an input matrix made up of 175 individuals and 15 quantitative traits based on Euclidean distances and the Ward method. The dendrogram (Figure 4) resulting from this analysis distinguishes four clusters or groups:

- Group 1 contains plants from the region of Saida and Mascara.
- Group 2 contains plants from the region of Tlemcen and Oran.
- Group 3 contains plants from the region of Relizan and Tiart.
- Group 4 contains plants from the SBA (Sidi Bel Abbès) region.

The clustering of plants living in two different regions (G1, G2, and G3) can be explained by morphological similarity, which results in fact from the genotypic approximation between them and probably to the similarity of environmental factors (bioclimatic floor, soil; ground texture; and soil salinity etc.).

Multiple Correspondence Analysis (MCA)

Parameters (traits). The Multiple Correspondence Analysis (MCA) for the leaf, leaf blade, and plant habit variables is shown in Figure 5.

The two dimensions of the ACM explain 33.94% of the total variance across 33 modalities.

The statistical data shows that the roughness of the leaf, the type of the leaf, and the hairiness of the leaf, probably undergo a pleiotropic effect (a single gene or a reduced number of genes controls all of these parameters).

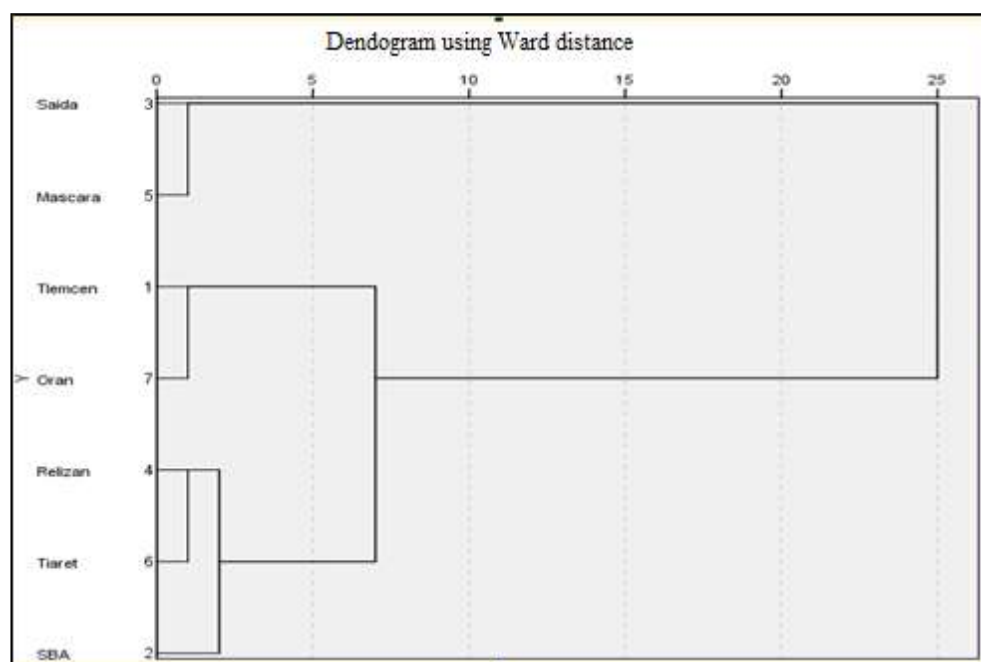


Figure 4. Hierarchical Classification Analysis (HCA) of 175 plants accessions of *Inula viscosa* based on 15 quantitative traits.

For plant habit, the distribution of the secondary color, edge incision; Leaf color, Stem hairiness, Position of the widest part, Edge Ripple, Bottom Shape and Top Shape, are influenced by the region (environment factors) since they change state from one region to another.

Modalities of parameters. Analysis of the multiple components divides plants into four classes according to modalities (Figure 6):

Class 1: most plants are characterized by average leaf hairiness; densely hairy stem; absence of secondary color distribution; an upright habit and a medium roughness of the leaf.

Class 2: most grouping plants represented the absence of the weak edge incision; leaf color dark; absent to weak leaf roughness; and compound leaf type.

Class 3: grouping plants are characterized by a sharp edge incision; leaf color light; single leaf type.

Class 4: grouping plants are typified by a medium edge incision; leaf densely hairy; spreading habit of the plant; marginal distribution everywhere of the secondary color on leaves; low sheet roughness and strong leaves waviness.

Ascending Hierarchical Classification (CAH)

The HAC (Hierarchical Ascending Classification) is made from an input matrix composed of 175 individuals and 12 qualitative; this dendrogram divided these populations into five clusters (Figure 7):

Cluster 1: includes genotypes from the region of Oran and Tlemcen.

Cluster 2: includes the SBA and Relizane region genotypes.

Cluster 3: includes genotypes from the Saida region.

Cluster 4: includes genotypes from the Mascara region.

Cluster 5: includes genotypes from the Tiaret region.

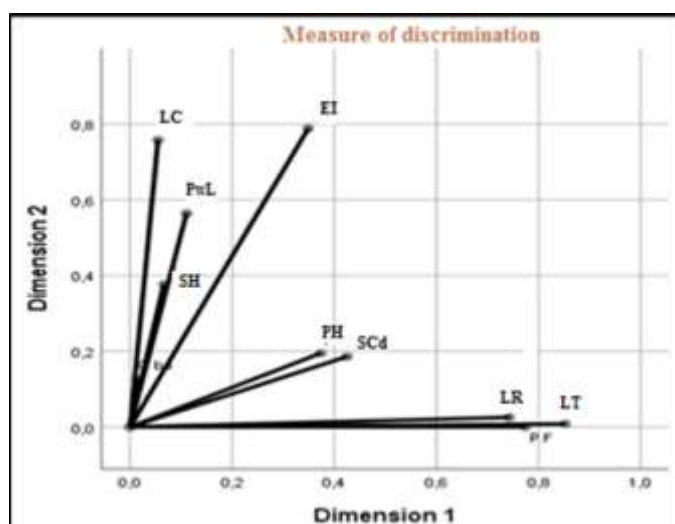


Figure 5. Analysis of the multiple components of the studied parameters (MCA)

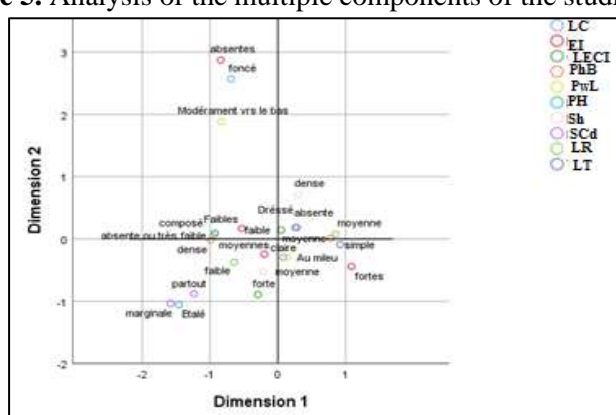


Figure 6. Analysis of the multiple components of the modalities of parameters (MCA)

Varieties include groups G4; G2; G5 and G3 are phenotypically close to each other. This result may be due to an environmental factor, which may be the type of soil; ground texture; rainfall, and soil salinity, or the genetic level of the variety.

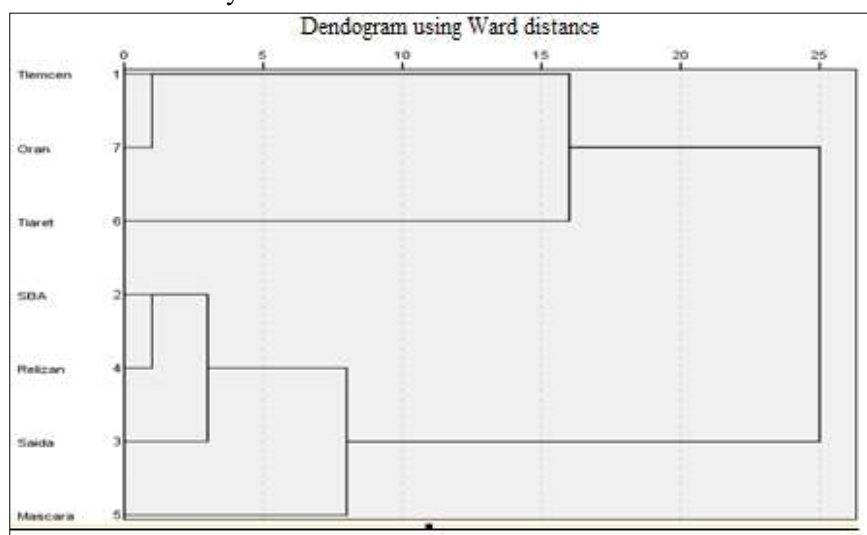


Figure 7. Hierarchical Ascending Classification (HAC)

Index diversity of Shannon and Weaver H'

After applying the Shannon and Weaver diversity index test, we obtained an overall rate equal to 0.38 for the population of Tlemcen; 0.24 for the population of SBA; 0.19 for the population of Saida; 0.38 for the Mascara population; 0.25 for the population of Relizane; 0.35 for the population of Tiaret and

0.24 for the population of Oran, which is almost identical. This index is relatively average for the seven localities, which is probably the reflection of significant genetic diversity (Table 7).

The characters which present the diversity index H' equal to 0.28 for the seven regions are probably not influenced by the environment and the genes which control them, also control important characteristics of the physiological plant for the species.

Table 7. Comparison of the Shannon-Weaver diversity index between the seven regions studied

Trait	Tlemcen	SBA	Saida	Mascara	Relizane	Tiaret	Oran	Total average
EI	0	0.68696	0.57102	0.61450	0.62549	0.56233	0	0,4371
PHb	0.66885	0.34883	0	0.61450	0	0	0.19851	0,2615
LC	0	0	0	0	0.39830	0.56233	0	0,1372
Sh	0.49356	0.52970	0	0.17884	0.62549	0.56233	0	0,3414
Asb	0.26176	0.34883	0	0	0	0.56233	0.50040	0,2390
SLLb	0	0	0	0	0	0	0	0
ASb	0	0	0	0	0	0	0	0
LECl)	0.19490	0	0	0.52358	0	0	0.50040	0,1741
SCd	0.86887	0	0	0.61450	0	0	0.68743	0,3101
LH	0.58155	0.21455	0.57102	0.61450	0.30463	0.68813	0.3250	0,4713
LT	0.52628	0.34883	0.57102	0.61450	0.39830	0.56233	0	0,4316
LR	0.98728	0.45056	0.57102	0.61450	0.62549	0.68813	0.61086	0,6496
Total average	0.38192	0.24402	0.19034	0.36578	0.24814	0.34899	0.23522	0,2877

Conclusion

A field survey criss-crossing western Algeria was conducted to inventory, sample and characterize the different varieties of *Inula viscosa*. The study was based on the morphological description of the plant using the morphological markers described in the international descriptor UPOV (Union for the Protection of Plant Varieties).

The results of the statistical analyzes of the morphological, qualitative and quantitative data showed that there is a high diversity due to the presence of qualitative and quantitative polymorphic characters.

The relative index of diversity (average H') of all the genotypes studied of this species is 0.287 of the qualitative characters corresponding to the average phenotypic diversity of the samples analyzed.

On the other hand, the Ascending Hierarchical Classification (AHC) test of quantitative and qualitative characters reveals that there is an environmental and genetic effect.

The approach used for the statistical processing of the data of the morphological qualitative and quantitative characterization, facilitated the task of distinguishing four varieties of which they are:

Variety 1. Characterized by medium leaf hairiness; dense stem hairiness; upright habit of the plant; average sheet roughness and lack of secondary color distribution on the limb. Thus, it qualifies for high values of the surface of the small and medium sheet; leaf length small and medium; width of the small and medium sheet. The latter is found in the Tlemcen region (Nedroma/ Djebala and Marsa ben m'hidi/ msirda el fouaga); Oran (Ain Turk and E-Senia); and Mascara (Mohamadia).

Variety 2. Characterized by the absence of an incision on the edge of the leaf; dark leaf color; absence of sheet roughness; the position of the widest part towards the bottom of the sheet and a compound leaf type. Thus, it qualifies for high bronchus number values; the number of leaves per bronchus; the number of stems, and the number of branches per leaf. It is located in the SBA region (Mostapha Ben Brahim); Relizan (Yellel); Tiaret (Souguer); Mascara (Bouhnifia and Tighenif) and Saida (Hammam Rebi and Ouelad Khaled).

Variety 3. Characterized by a strong leaf edge incision; a light leaf color; the position of the widest part in the middle of the leaf and a simple leaf type. Thus, it qualifies for high surface values; the width and length of the large sheet. It is in the region of SBA (Ali Ben Youb); Saida (Ain Hadjer); Tlemcen (Nedroma/Djebala and Tirni/el Mafrouch) and Relizen (Duhra and Zemmala).

Variety 4. Characterized by a medium incision on the edge of the leaf; leaf densely hairy; spreading plant habit; marginal distribution everywhere of the secondary color on the blade of the leaf; low sheet roughness and strong sheet waviness. Thus, it qualifies for high values of height and width of the plant. It is located in the region of Tiaret (Souguer; Tamda and Ghertoufa) and SBA (Ain Berd).

To summarize, based on the set of most discriminating traits identified on 27 qualitative and quantitative variables. This morpho-biometric description of the existing local populations of *Inula viscosa* will guide us in the future to approve this state by the molecular tool.

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Author contributions

Senhadji Alaa Abir Zohor designed the study, carried out the field and laboratory work and wrote the manuscript;

Bouri Amina wrote the manuscript, interpreted the results, revised, edited and supervised the work;

Mkedder Ikram contributed to the writing of the manuscript

Gaouar Semir Bechir Suheil participated in the statistical analysis; and contributed to the interpretation of results.

Disclosure statement

No potential conflict of interest was reported by the authors.

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