

Origin, Early History, Cultivation, and Characteristics of the Traditional Varieties of Moroccan *Cannabis sativa* L.

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Abstract

Background: *Cannabis* has been cultivated and used for centuries in the north Moroccan Rif (local name is *kif*). However, its history is poorly known and the date of its first introduction and dispersal in Morocco is still difficult to be precise.

Aim: The purpose of the present work is to review the literature on the origin, history, and cultivation of *Cannabis* in Morocco, as well as data on the morphological, genetic, and phytochemical characteristics of local cultivated varieties.

Discussion: Considering the importance of preserving the fragile environment of the Rif and the future development of the Moroccan medical *Cannabis* market, which will require authentication of the raw material, the use of local strains which are well adapted to the particular environment of the Rif is highly recommended. However, there is no document that summarizes and clarifies the nomenclature and the characteristics of local Moroccan *Cannabis*. In addition, the recent adoption by Rif growers of improved hybrid cultivars is obliterating the traits and peculiarities of Moroccan *Cannabis* through genetic introgression.

Conclusion: Summarizing and discussing the data from the literature on the characteristics of local Moroccan *Cannabis* varieties may be useful for their identification and the localization of the areas of the Rif region where their cultivation is still practiced.

Keywords: *Cannabis*; cultivation; Morocco; plant characteristics; Rif

Introduction

Cannabis is an ancient domesticate, cosmopolitan, and versatile plant. It has been used as a fiber, food, and drug plant. The use of *Cannabis* as a medicine dates back to 2500 before present (BP) in China and its use as an illicit drug in western China has been evidenced.¹

In Arab countries, *Cannabis* has been introduced for its medicinal properties, by Arab travelers, directly from India. The psychoactive effects of the plant were also well known in the Arab world and were spread to the Maghreb from Egypt between the 9th and 12th centuries.²

Although *Cannabis* is cultivated and used in north Moroccan Rif since ancient times, its origin, history, and specific characteristics are not well known. The objective of the present work, which is part of the “Project on Medical and Therapeutic use of *Cannabis* in the

Northern Region of Morocco” granted by the Tanger-Tetouan-Al Hoceima region to the Scientific Institute of Rabat as part of the Moroccan initiatives on the legalization of *Cannabis* for licit uses is to establish a review on Moroccan *Cannabis*.

Bibliographic research was carried out to present to the reader a useful reference concerning Moroccan *Cannabis* including its historical, phytochemical, botanical, and genetic characteristics. and more than 100 articles were consulted and 83 articles and books have been selected.

The *Cannabis* plant is well known for the synthesis of cannabinoids. Nearly 150 different cannabinoids are known.³ The main cannabinoids are delta-9-tetrahydrocannabinol (THC), cannabidiol (CBD), and cannabichromene (CBC). CBC is present in the plant at lower amounts compared with THC and CBD.

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Drug-type plants can be divided into two categories, labeled “Sativa” and “Indica” (Fig. 1). The majority of current *Cannabis* strains are hybrids between “Sativa” and “Indica” and are challenging to distinguish by their morphological characteristics.⁴ A practical classification based on the ratio of the two major cannabinoids THC and CBD or chemotypes (chemical phenotypes) has been used.

The harsh Rif mountain conditions and farmers’ expertise have allowed the development of a unique and well-adapted Moroccan *Cannabis* varieties.⁵ However, the recent adoption of new hybrid cultivars threatens local *Cannabis* with genetic contamination, depletes, and pollutes the region’s limited water resources.

In Morocco, *Cannabis* has been illegal but tacitly tolerated. In June 2021, after decades of prohibition and controversy, a law regulating *Cannabis* for medical, pharmaceutical, and industrial purposes has been adopted by the parliament.

Origin and Early History of *Cannabis* in Morocco

The classification of *Cannabis* and its exact geographic origin are still debated, Modern botany recognizes only one species of *Cannabis*: *Cannabis sativa* L. with two subspecies, *C. sativa* subsp. *sativa* and *C. sativa* subsp. *indica*,⁶ each one having wild and domesticated varieties. Genetic analyzes by molecular barcoding support the separation of *C. sativa* into two subspecies.⁷ The treatment of *C. sativa* and *C. indica* as different species is also common.^{8,9}

The putative center of origin of the genus *Cannabis* has been widely speculated in Central Asia.^{10,11} Based on subfossil pollen and archaeobotanical studies, McPartland et al.¹¹ deduced the northeast of the Tibetan plateau in the vicinity of Qinghai Lake as the center of origin for *Cannabis*, over 19.6 Ma. Furthermore, molecular studies of DNA chloroplast-specific regions estimated that *Cannabis* has diverged from its relative, *Humulus* between 27.8 Ma (Oligocene)¹² and 18.2 Ma

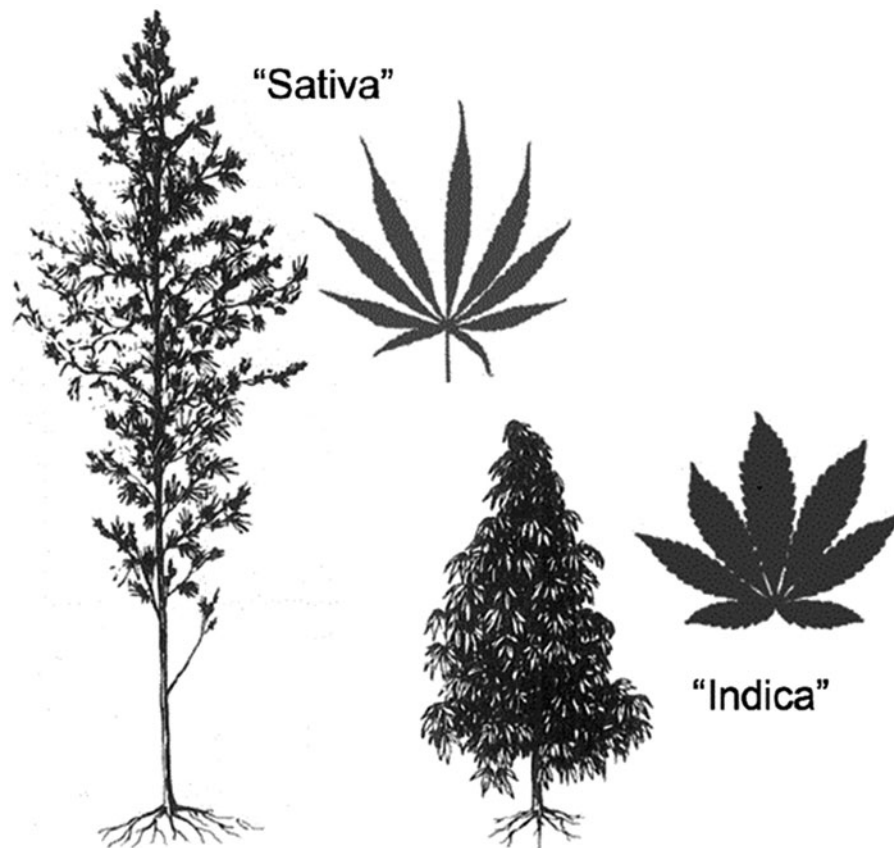


FIG. 1. Vernacular classification of *C. sativa* subsp. *Indica* (Adapted by McPartland and Small⁴ from Anderson⁷⁹). Reprinted from McPartland and Small.⁴ CC BY 4.0.

(mid-Miocene).¹³ The *Cannabis* spread from the Tibetan plateau, first to the west (Russia and Europe by 6 Ma), then to the east (eastern China by 1.2 Ma), and by the end of Pleistocene to the rest of Asia (except the southeast).¹¹

The evidence for human's use of *Cannabis* came from archeological sites of China, Japan, and Europe since the Neolithic period,^{14,15} but the earliest human use as a food source may date back to 10,000 BP in Japan.^{11,16,17} Evidence in the form of cord-impressed ceramics of *Cannabis* use as fiber plant is possibly as early as 1200 years ago.¹⁸ However, doubts persist in accurately differentiating these remains from other fiber plants.^{18,19}

Cannabis use as a medicine dates back to 2500 BP in China. Indeed, archeologists found *Cannabis* plant remains with high THC in 2500-year-old Yanghai tombs, northwest China, suggesting *Cannabis* ritual and/or medicinal uses.²⁰

However, recent evidence of earliest *Cannabis* use in drug context came from phytochemical analysis of the residues from archeological artifacts found in the 2500-year-old tombs of Jirzankal in western China.¹

Cultivated drug-type *Cannabis* may have been introduced early into Arabic countries for its medicinal properties by Arab travelers directly from India. By the eighth century, *Cannabis* was integrated into Arabic medicinal practices.² The early Arabic medical texts of the physician Al-Razi (865–925) and Avicenna (980–1037) refer to the use of *Cannabis* for its medicinal properties^{21,22} and the plant was used for several functions, such as an analgesic and anti-inflammatory agent.

The plant's psychoactive effects were also well known in the Arab world. The Moorish traveler and medical herbalist Ibn al-Baytar (1179–1248), in his diary *Al-Mukhassas*, described the hashish (*Cannabis* resin) use by Egyptian Sufis.²³ *Cannabis* preparations were spread to the Maghreb from Egypt where *Cannabis* has been cultivated since at least the twelfth century²⁴ by the successive Arab invasions (ninth to the twelfth centuries).²

In North Africa, *Cannabis* has been known since ancient times. Indeed, *Cannabis* stems were recovered from the Carthaginian Warship, which sunk off the coast of Sicily and was dated from the Punic Wars with the Romans in the third and second centuries B.C.E.²³ Carthage may have participated into the spread of *Cannabis* to Southern Europe and North Africa.

In Morocco, *Cannabis* drug-type, locally named *kif*, is very ancient and it has been cultivated and used for centuries in the north Moroccan Rif.^{25,26} However, its history is poorly known and the scenario and the date of its first introduction and dispersal are difficult to trace.²⁷

Moorish historians and botanists from the Islamic Golden Age, as Al-Bakri (11th century), Al-Maqrizi, and Ibn Al-Baytar (13th century) did not refer to any presence or *Cannabis* use in the Maghreb.²⁸ Most likely, *Cannabis* was introduced to Morocco by Arab conquerors around the 10th century, but the plant was not widely used or cultivated by the Berber inhabitant of the isolated Rif Mountains.²⁹ It is also possible that the plant was introduced to Morocco by travelers returning from pilgrimages to Mecca or by African slaves.²⁷

Based on the linguistic analysis of the words, *takrouri* used to name in the Maghreb the *Cannabis* (mid-1800) and *takrur* the name of the ancient Ghana Empire (800–1200), Duval³⁰ suggested that Africans from the Sahel may have introduced drug *Cannabis* into the Maghreb. By the early 1800s, drug type *Cannabis* growing in the Rif Mountains of Northern Morocco area became established.³¹

Local Traditional Landrace and Cultivated Varieties in Morocco

Drug-type *Cannabis* narrow-leaflet "Sativa" and broad-leaflet "Indica" have a distinct morphology and geographical provenance. Landraces from South Asia were designed as narrow-leaf-drug (NLD) biotypes and landraces from Central Asia as board-leaf-drug (BLD) biotypes.^{8,32} Hem-type *Cannabis* corresponds to varieties with low THC and high CBD from Europe used for fiber and seed production and denoted as *C. sativa* "hemp biotype"⁸ or narrow-leaf-hemp (NLH) biotype.⁹

Recently, McPartland and Small assigned taxonomic names to "Sativa" and "Indica" as *C. sativa* subsp. *indica* var. *indica* and *C. sativa* subsp. *indica* var. *afghanica*, respectively. Their wild relatives are *C. sativa* subsp. *indica* var. *himalayensis* (from South Asia) and *C. sativa* subsp. *Indica* var. *asperrima* (from Central Asia).

In Morocco, the original pure NLD landrace is rare⁹ and faces extinction through introgressive hybridization with other *Cannabis* plants. Clarke and Merlin³³ noticed that the local drug-type *Cannabis* presented as NLD is likely to be a hybrid between NLD and NLH European varieties. This variety was named

C. indica ssp. *indica* var. *mediterraneana*. The variety *mediterraneana* is also reported to be present through the Middle East.³³

In the early 1900s, *Cannabis* was marginally cultivated for fiber in the north Rif lowlands.^{34,35} However, the hybridization would have probably occurred several hundred years ago. Indeed, hemp-type *Cannabis* was introduced to Morocco before the 10th century and has been cultivated for food, textile, and paper.³⁶ In any case, there is a considerable chance that NLH European genetics were introduced into the Moroccan landrace.

European hemp and North African *Cannabis* grow in the same Mediterranean floristic region, *Cannabis* plant produces abundant pollen (e.g., 70,000 grains in one anther) that has a long-range transport; for example, *Cannabis* pollen from northern Morocco reaches southern Spain³⁷ and crosspollinated plants and offspring are fully fertile.⁹

During the 1960s, the sieving method used to collect the *Cannabis* resin powder for hashish production came to Morocco most likely from Lebanon,³³ but it is not surprising that the Lebanese hashish seed was brought to Morocco with the sieving technique. In the early 1980s, new *Cannabis* varieties were introduced in Morocco from the Middle East, most probably from Lebanon.³⁸

The cultivation of local varieties was progressively abandoned as a consequence of the production of hashish for export and was replaced by the improved, more productive, and more potent western hybrid cultivars that need more water and chemical fertilizers. In 1980, BLD Central Asian genetics were intentionally introduced into the local traditional *Cannabis*⁹ and in 2013 about 10 hybrid cultures and seeds were reported from Moroccan farmers by Chouvy and Afsahi.³⁸ Consequently, the local traditional Moroccan varieties are becoming genetically contaminated, they acquired the traits of the western varieties⁹ and are rapidly disappearing.³⁹

Characteristics of Moroccan Local Varieties

Bibliographical research on characteristics of Moroccan *Cannabis* has identified a limited number of studies and only three were realized in Morocco.^{40–42}

Morphological aspects

The Moroccan *Cannabis* plant rarely exceeds 2 m in height and has sparse ramifications, even when the cultures are less dense.⁵ In contrast to drug-type *Cannabis*

varieties that are more robust and more branched. Often, cultures of local varieties resemble European hemp fields in appearance. This is consistent with the Clarke and Merlin³³ conclusion for Moroccan populations identified by their morphology as probably NLH-NLD hybrids.

Recently, McPartland and Small,⁴ in a large study, including the morphological analysis of 1100 herbarium specimens around the world, observed intermediate forms in specimen's native to North Africa (from Egypt to Morocco) belonging to the Kew Museums and the British Museum in London. These populations would either be hybrids between the domesticated forms of "Sativa" and "Indica": *C. sativa* subsp. *indica* var. *indica* and *C. sativa* subsp. *indica* var. *afghanica*, or hybrids of either with European hemp *C. sativa* subsp. *sativa*.⁴

Phytochemistry

Cannabinoids are produced mainly in the stalked trichomes of mature female flowers.⁴³ While the absolute cannabinoid content may be influenced by environmental factors,^{44–46} the THC/CBD ratio is independent of the environment and remains constant throughout the entire plant's life cycle.⁴⁷ The main chemotypes are: chemotype I, characterized by a high THC and a high ratio THC/CBD; chemotype II or "intermediate," in which THC and CBD are present in varying substantial concentrations and chemotype III, having a very low ratio THC/CBD, due to the very low content of THC.^{48,49}

To explore the main cannabinoids and the THC/CBD ratio of Moroccan varieties, studies of accessions collected in the years before the wide diffusion of hybrids are very useful.⁴

The majority of identified studies were carried out before 1990 before widespread hybridization and abroad. These studies have been performed either on locally grown Moroccan seeds, plant seizures, or resin. Moroccan studies are very rare. Only two studies were carried out by the Laboratory for Technical and Scientific Research and Analysis (LARATES).^{40,41} The 2005 study was carried out on *Cannabis* cultivated in Morocco as part of a UNODC and APDN survey on *Cannabis* cultures in northern Morocco.⁵⁰ The other study carried out in 2016 concerned the resin seizures made by the National Security Authorities between 2005 and 2014 in Morocco.⁴¹

The analysis of cannabinoids in these studies was carried out by gas chromatography (gas chromatography/flame ionization detection or gas chromatography/mass

Table 1. % of Cannabinoids and Tetrahydrocannabinol/Cannabidiol Ratio Reported in Studies Involving Moroccan Cannabis

Material; period; number of specimens	Citation; method	% CBD	%THC	%CBN	%THC + %CBN/%CBD	Note
Dry female plant leaves	Davis et al. ⁵⁸ ; GC-FID	0.48	0.31	0.24	1.15	
Flowering tops of fresh plants. CGE in Sweden	Ohlsson et al. ⁵¹ ; GC-FID					
Outdoor cultivation		0.04	0.4	No CBN detected	10	
Indoor cultivation		0.04	0.1		2.5	
Resin and plant seizures in UK; 1968–1969; n = 10	Jenkins and Patterson ⁸⁰ ; GC-FID	29.6–40.1* Mean = 34.24	45.0–66.0* Mean = 55.01	3.0–17.1* Mean = 10.77	1.92	THC + CBN/CBD ratio of the two specimens was similar * % of total cannabinoid content
Fresh female and male plants. CGE in Mississippi; 3 variants A1, B and C	Holley et al. ⁵⁴ ; GC-FID with silylation					Crosspollination has been reported
A1 (Mean of female and male)		1.28	0.24	0.19	0.34	
B (female)		1.84	0.54	0.02	0.32	
C (Mean of female and male)		0.54	0.44	0.1	1	
Resin seizures in the UK; 1975; n = 6	Baker et al. ⁸¹ ; GC-FID				Mean = 0.55	%CBD has not been reported
1976; n = 2			4.0–16.0 Mean = 9.5			Starks (1990) ⁸² indicated for the 15 resin specimens %
1978; n = 7			3.8–9.4 Mean = 6.6			THC: % CBD ratio of 2:1
Plants seizures; 1978; n = 2			4.7–9.2 Mean = 7.4			
Plants seizures; 1979; n = 2	Baker et al. ⁸³ ; GC-FID		0.9–1.3 Mean = 1.1			
1980, n = 1			6.8–7.1 Mean = 7			
DEA seizures. 1985; n = 3	Clarke ⁵⁶	4.5–10.4 Mean = 8.3	7–13.6 Mean = 11.3	0.6–0.9 Mean = 0.8	1.5	
Resin seizures in the UK 1984; n = 2	Pitts et al. ⁵⁵ ; GC-FID	CBD content is ~50% of that of THC			2	
1985; n = 3			11.7–26.0 Mean = 18.8			
1986; n = 6 (plant; n = 1)			0.9–6.6 Mean = 4.5 ± 3.1			
1987; n = 4			0.5–10.1 Mean = 6 ± 3.3 (8.2)			
1988; n = 4			1.1–11.2 Mean = 5.4 ± 5.0			
1989; n = 6			6.8–8.9 Mean = 8.0 ± 0.8			
6th Generation of plants from ⁵² , Two types of plants in the original seed stock: Indoor cultivation.	Pitts et al. ⁵³ ; GC-FID		11.0–15.0 Mean = 13.1 ± 1.5			

(continued)

Table 1. (Continued)

Material; period; number of specimens	Citation; method	% CBD	% THC	% CBN	%THC + %CBN/%CBD	Note
Without CBD (n = 4)		0	0.16–1.00 Mean = 0.74		-	
With CBD (n = 4)		0.49–2.23 Mean = 1.72	0.99–1.81 Mean = 1.37		0.8	
Total (n = 8)		0–2.23 Mean = 0.86	0.16–1.81 Mean = 1.05		1.23	
Fresh female plants Flowering tops (n = 60)	Strambouli et al. ⁴⁰ ; GC-MS		0.1–2.2 Mean = 0.6			
Leaves (n = 60)			0.1–1.1 Mean = 0.4			
Dry female plants: Flowering tops (n = 26)			1.0–7.5 Mean = 3			
Leaves (n = 26)			0.2–2.6 Mean = 1.2			
Dry female plants; n = 26			0.7–4.8 Mean = 2.1			
Powder; n = 13			5.5–11.3 Mean = 8.3			
Resin seizures in ISR and the CZ; n = 30	Hanuš et al. ⁵⁹ ; GC-MS	1.52–5.14 Mean = 3.72 ± 0.19	5.08–13.4 Mean = 5.21 ± 0.40	0.65–2.94 Mean = 1.76 ± 0.13	2.08–3.98 Mean = 3.06 ± 0.10	Classification of seizures into 3 categories: LD THC < 10% MD 10% < THC < 20% HD THC > 20%. The values in bold are estimated from authors' graphical representation. ⁴¹
Resin seizures in MR; 2005–2014 n = 1004	Strambouli et al. ⁴¹ ; GC-MS					
2005–2006; n = 65			0.6–16.8 (83% LD; 17%MD; 0%HD)			
2007; n = 70			0.5–28 (40%LD; 60%MD; 0%HD)			
2008; n = 109			0.4–19.5 (70%LD; 30%MD; 0%HD)			
2009; n = 104			0.6–29.6 (60%LD; 35%MD; 5%HD)			
2010; n = 85			0.3–31 (58%LD; 28%MD; 14%HD)			
2011; n = 126			0.1–21 (59%LD; 26%MD; 15%HD)			
2012; n = 191			1.4–33 (38% LD, 48%MD; 14%HD)			
2013; n = 141			0.2–29.3 (45%LD; 43%MD; 12%HD)			
2014; n = 109			0.5–25 (55% LD; 35%MD; 10%HD)			

The cannabinoid content depends on the part of the plant used and increases with maturity (flowering tops and dry plants are richer). The transformation of plants into powder or resin is accompanied by an increase in the cannabinoid content.

CBD, cannabidiol; CBN, cannabinol; CGE, common garden experiments; DEA, Administration Drug Enforcement (U.S.); GC-FID, gas chromatography/flame ionization detection; GC-MS, gas chromatography/mass spectrometry; HD, highly dosed; LD, low dose; MD, moderately dosed; THC, tetrahydrocannabinol.

spectrometry). It should be noted that GC studies carried out before the mid-1970s overestimated the CBD content, as they used columns that did not allow separation of CBD and CBC.⁴ To separate CBD from CBC, silylation and capillary columns have been then used.

The content of THC and CBD is expressed as a percentage of the weight of the dried material, and cannabinol (CBN) (a product of THC degradation) if present is added to the ratio, as THC+CBN/CBD. Data on the phytochemical characteristics are presented in Table 1.

Cannabinoids in fresh plants. Seeds of Moroccan origin were cultivated in CGEs (common garden experiments) and tested for their cannabinoid content in Sweden,⁵¹ United Kingdom (seizure of germplasm),^{52,53} and Mississippi.⁵⁴

Seeds grown outdoors in Sweden showed a THC level of 0.4% in flowering tops and a THC/CBD ratio of 10. In Mississippi, the average THC level was about 0.41% and the THC/CBD ratio ranged from 0.32 to 1 (mean ratio 0.55), with crosspollination reported. In the United Kingdom, two types of plants emerged from a seedstock. One was without detectable CBD and the second had a slightly higher total CBD percentage than THC for all generations.⁵³ In the sixth generation, the plants were also of two types, those without CBD detectable and those with substantial amounts of CBD. Furthermore, the cannabis prepared from plants grown in the United Kingdom from Moroccan seeds has shown physical appearance and cannabinoid pattern of the samples related to Moroccan origin.

To recapitulate, plants obtained from seeds of Moroccan origin had variable THC/CBD ratios (0.55 to 10) and only two types of plants emerged from Moroccan seed studies: plants rich in THC with little or no CBD (Type I) and plants of intermediate chemotype (Type II) with less THC and more CBD. There was no evidence of CBD-rich plants (Type III), probably due to plant selection done by *Cannabis* growers.⁵²

Plants cultivated locally are characterized by the presence of CBD as attested by THC and CBD profile of Moroccan *Cannabis* products.^{55,56} The presence of CBD in Moroccan *Cannabis* is explained by the preparation process of the traditional resin, which is done by pooling large numbers of plants, seed selections are made rarely, and therefore without human selection for THC, the CBD content tends to be closer to that of THC.⁵⁷

In 2005, a Moroccan study showed that the average THC levels (leaves and inflorescences) in 60 fresh female plants harvested in northern Morocco was 0.5% (0.1–2.2%).⁴⁰ However, the THC/CBD ratio could not be calculated because the % of CBD has not been reported.

Cannabinoids in dry plants. Two studies have analyzed cannabinoids in dried female plants of Moroccan origin. Analyzes from the leaves showed an average THC content of 0.31% and a THC/CBD ratio of 1.15.⁵⁸ It should be stressed that CG carried out at the time of the study overestimate the CBD content. The study by Stambouli et al. reported an average THC level of 1.2% (0.2–2.6%) in leaves and 3% (1.0–7.5%) in flower tops. However, THC/CBD ratios could not be calculated because CBD percentage has not been reported.

Cannabinoids from resin. Studies on *Cannabis* resin have shown that the content of THC and CBD varied considerably in the seizures (Table 1). The potency of the resin samples ranges from 0.1% THC up to 29.6%. The low THC content found in some Moroccan samples was explained by the longstanding practice of adulterating Moroccan resin with henna powder or wax.⁵⁵ Samples of resins adulterated by wax were found among those of 1987 and 1988.⁵⁵

The average THC content of Moroccan resin samples seized between 1975 and 1988 was about 7.9%, but resin seized in 1989 showed an increase in the THC content to 13.9%.⁵⁵ In 2004, during the UNODC survey, the average THC content in Moroccan resin was 8%.^{40,50} These resins were generally low in THC (less than 10%) and would come from traditional Moroccan varieties.⁴⁰

Evidence suggests that the average potency of *Cannabis* seized in Morocco has increased in recent years (as early as 2005). This development is in line with the increasing trend recorded since 2004 in Europe (the main consumer of Moroccan hashish). Indeed, Stambouli et al., in a study including a large series of 1004 samples of *Cannabis* resins seized in Morocco between 2005 and 2014, has shown an upward trend in THC compared with the average of 8% in 2004. The levels evolved from the range 0.6–16.8% in 2005–2006 to 0.5–25% in 2014.

This increasing trend has been attributed to the appearance of new categories of resins in Moroccan seizures from 2005 of resins moderately dosed at more

than 10% and from 2009 of resins strongly dosed at more than 20% as a result of the introduction by Moroccan growers from Europe of a new hybrid rich in THC.

Contrary to the great variability observed in THC content, the THC/CBD ratios determined for the resins dating from 1968 to 1989 were less variable (from 1.5 to 2), in general, the CBD content is around 50% of the THC. This ratio is in line with the THC and CBD profile (ratio 2:1) reported for local Moroccan *Cannabis*.⁵⁶ This specific characteristic of Moroccan *Cannabis* made it easy to chemically distinguish it from the two other main world producers of resins, Pakistan and Lebanon.⁵⁵ THC/CBD ratios of Moroccan, Pakistani, and Lebanese resins are approximately 2:1, 1:1, and 1:2, respectively. Also, a study of 30 recent seizures of Moroccan resins in Israel and the Czech Republic showed that the average THC/CBD ratio of Moroccan *Cannabis* had increased to 3 (between 2.08 and 3.98).⁵⁹

Genetics

The syntheses of the main cannabinoids, tetrahydrocannabinolic acid-synthase (THCAS), and cannabidiolic acid-synthase (CBDAS) are encoded by single exon genes.⁶⁰ A single gene with two codominant alleles has been proposed to explain the chemotype.^{61,62} Recently, several data suggest a multilocus model coupled with a monogenic mode of inheritance.^{63,64}

Studies of the polymorphism of gene syntheses have identified highly discriminating single nucleotide polymorphisms (SNPs) that make it possible to differentiate between hemp-type and drug-type *Cannabis*.^{42,65,66} In addition, some THCAS and CBDAS sequences exhibited specific SNPs that affect the activities of the corresponding syntheses and have been associated with the chemotype.⁶⁶

Bibliographical research on the genetics of *Cannabis* of Moroccan origin identified two studies dating from 2015 to 2016. The study by El Alaoui et al.⁴² was carried out on 12 seizures of Moroccan resins. The complete sequence (1635 bp) of the THCAS gene was obtained for the 12 *Cannabis* resins tested. Comparative analysis of the sequences obtained with the THCAS sequences available in GenBank for drug-type *Cannabis* showed a significant polymorphism of the THCA synthase gene in Moroccan *Cannabis* compared with exotic ones.

Twelve complete genomic sequences of THCAS (JQ437481 to JQ437492) having a high number of SNPs (21 in total) were identified. These sequences do not coincide with any of the sequences already iden-

tified and deposited in GenBank by other groups. Furthermore, phylogenetic analysis showed that Moroccan accessions were well separated from other accessions and the authors hypothesized that most likely they correspond to the new hybrid cultivars newly introduced to Morocco by drug traffickers.

Onofri et al.⁶⁶ analyzed 18 accessions belonging to different *Cannabis* chemotypes, including one local Moroccan drug-type landrace. The THCAS and CBDAS sequences obtained from the transcriptome of *Cannabis* inflorescences and the THC and CBD contents were used to identify which polymorphisms normally expressed the syntheses, and which polymorphisms affect the catalytic activity of these enzymes.

Comparison of the expressed sequences made it possible to identify mutations (SNPs) that were linked to the cannabinoid composition in the inflorescence. The Moroccan landrace and two drug-type accessions of Afghan origin showed four nucleotide substitutions (positions: 187, 366, 399, and 1179) in the gene THCAS. The SNP at position 1179 (A → T transversion) was identified as present only in Moroccan and Afghan accessions. It was not present in any of the other fiber and drug-type accessions analyzed.

The presence of unique SNPs was also reported in a recent study of THCAS polymorphism in Pakistani *Cannabis* (from Central Asia). Two missense mutations at positions 851 and 883 were unique to Pakistani *Cannabis* and could potentially help to distinguish Pakistani products during seizures.⁶⁷

Cannabis Cultivation in Morocco

The presence of *Cannabis* in the Rif dates back to several centuries ago, but its culture is fairly recent,²⁵ dating only to the early 1800s.³¹ Although cannabis provides fiber and seed, its use has mostly been for psychoactive effects. In the 1880s, *kif* smoking in Rif was widespread mainly in Ketama (a small rural Moroccan town).²⁵

In Morocco, *Cannabis* was illegal but often tolerated. The history of its prohibition started by the end of the 19th century, when the sultan Hassan I (1873–1894) issued strict laws to limit *Cannabis* trade,⁶⁸ but authorized its cultivation in five *douars* (villages) of the Amazigh (Berber) Ketama and Beni Khaled tribes in the Rif.⁶⁹

Under Spanish and French protectorates (1912–1956), *Cannabis* sales were authorized under the monopoly of the multinational company of the tobacco grower “*Régie Marocaine des Kifs et Tabac*.” On

November 12th (1932), a *Dahir* (Royal decree-law) prohibited its cultivation only in the area under the French protectorate but its sale continues until 1953. Since Morocco's independence in 1956, *Cannabis* cultivation has been forbidden throughout the country, but tacitly tolerated in the traditional cultivation area.^{69,70}

In June 2021, law no. 13–21 regulating *Cannabis* for medical, pharmaceutical, and industrial purposes was adopted by the Moroccan parliament, while recreational use remains prohibited and liable to prosecution. This law will be applied through the creation of the National Agency for the Regulation of Cannabis Activities that will insure the implementation of the government strategy in the fields of cannabis cultivation, production, manufacture, processing, marketing, export, as well as import of its products.

The Rif is an unfavorable land for agriculture. The soil is poor, the climate is characterized by hot, dry summers and cold, wet winters. Annual precipitations are highly variable, generally insufficient, and drought is recurrent. At high altitudes, precipitations are more abundant, and 2 to 3 m of snow can fall in winter. In these very difficult conditions, the growing season is limited to spring and fall or when irrigation is possible.

In Morocco, *Cannabis* was originally cultivated traditionally in small quantities on small plots of land for self-consumption. Until the early 1980s, the traditional cultures were limited to the historical region (less than 10,000 hectares in the late 1970s),³⁸ which is covering about 40 km² between the communes of Ketama in Al Hoceima province and Bab Berred in Chefchaouen province of the Central Rif⁷⁰ (Fig. 2).

Cultivation was generally practiced with a minimum of plowing, on waste heaps, and in small plots near farmer's houses. Culture density did not exceed eight plants per plot and the soil was well fertilized with animal manure and watered when necessary, and the plants were larger and better branched in appearance.^{5,38} Harvesting was done when the plants were mature, dried in the shade, and handled with care to preserve the phytochemical and organoleptic characteristics of a final product. During the following year, seeds were harvested from the most powerful and vigorous plants. In this way, the expertise of the Rif farmers and the time spent in the selection of the best plants produced the local varieties.⁵

When *Cannabis* became profitable, cultivation was more intensively practiced in fertilized and irrigated plots, it required more investment and care. Women

are heavily implicated in cannabis culture but have less visibility than men as they are not implicated in processing and marketing activities.⁷¹

Virtually, all arable lands were used for *Cannabis*.²⁵ Sowing is done in spring (in March at low altitudes and in April at higher altitudes) to be harvested in late summer. The plants are sown seed by seed and close together. The plots are terraced often on steep slopes. Irrigation is generally done by flooding,⁵ especially during May in a dry climate, and up to eight watering are required.²⁵ Irrigation water comes from seasonal wells and streams that are alimented by precipitations and snowmelts. Cultures are fertilized with animal manure produced locally through association with small goat farms.

The less branched morphology of the local varieties, combined with the high culture density, results in unbranched plants with only one terminal inflorescence.⁵ In contrast, harvesting depends on water availability. The lack of water in hot, dry summers, especially at low altitudes, forces farmers to start harvesting earlier when the plants are not fully mature.⁵ Even though yields of the traditional culture were relatively low, they were well suited for herbal material production mostly for local needs and until the mid-1960s they were the only *Cannabis* cultures present in the Central Rif.

European demand, the advent of the sieving method in the 1960s, and rising incomes led to a rapid expansion of *Cannabis* cultivation. By the mid-1970s, *Cannabis* cultivation had spread outside the traditional area.⁶⁹ In the 1980s, *Cannabis* cultivation in Central Rif would undergo significant qualitative and quantitative changes.⁷² To satisfy the international market and especially an increasing European demand for hashish, traditional cultures have been progressively abandoned in favor of modern cultures and sometimes monocultures in some villages.⁷²

Gradually, the region specializes in mass production of hashish, and new, high-yielding, THC-rich hybrids have been adopted by farmers of the historical region. Thus, in the mid-2000s, *Cannabis* cultivation had never been so widespread in Morocco.⁷³ *Cannabis* cultivation reached a historical peak in 2003, with 134,000 hectares.⁷⁴ Between 2003 and 2013, *Cannabis* cultivation decreased by 65%, to 47,500 hectares in 2011.⁷⁵ In a decade, there has been an increase in the yield produced by new hybrids in parallel with a two-thirds drop in the area under *Cannabis* cultivation. Thus, the decrease in cultivation areas would have been offset by an increase in yields of about three to five times.^{38,76}

The introduction of new high-yielding hybrids, the modernization of agricultural practices, and hashish

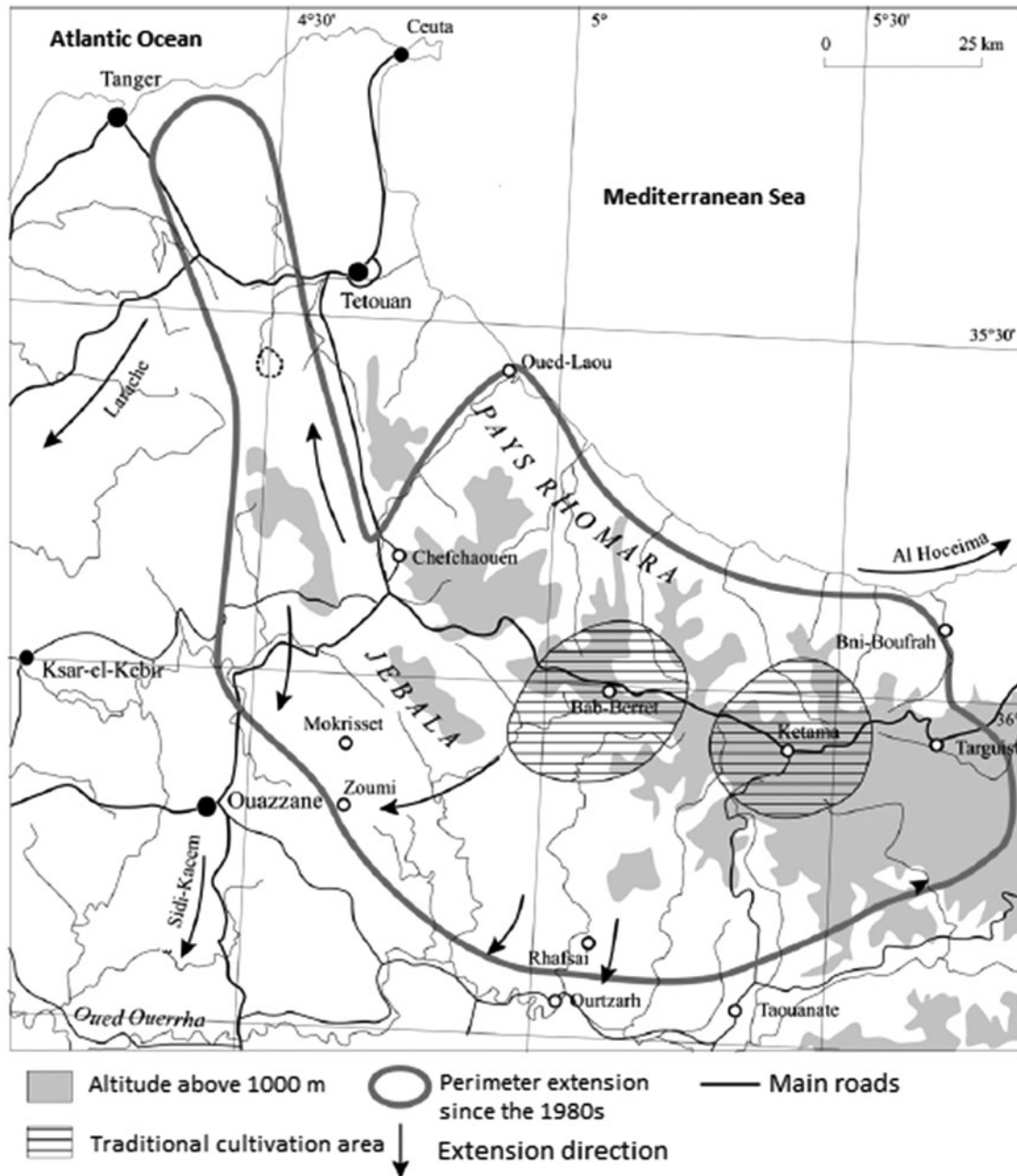


FIG. 2. Traditional area of *Cannabis* cultivation in the central Rif.⁶⁹ Reprinted from Labrousse and Romeo.⁶⁹ Copyright 2001. Reprinted with permission of OFDT.

production techniques that had started in the mid-2000s and accelerated after 2005, resulted in a significant increase in yield.⁷² More potent new *Cannabis* derivatives with better facture are produced as observed in the large quantities of seizures in Europe during the last decade.^{72,76}

Conclusion

The valorization of *Cannabis* in the Rif for therapeutic purposes must go through the adoption of local strains that are well adapted to the particular environment of the Rif³⁹ and/or probably the use of hybrid cultivars that are less water demanding.⁷²

The development of the future Moroccan medical *Cannabis* market, due to the recent legislative change, will necessarily need the authentication and the standardization of the raw material by linking the cultivars with morphological, genetic, phytochemical characteristics, and therapeutic applications.⁷⁷

However, the prevalence in the Rif of hybrid culture alongside rudimentary traditional *Cannabis* will make the identification of local traditional *Cannabis* more challenging. Furthermore, no document gives a clear botanical description and chemical properties of local strains. The Moroccan flora mentions the genus *Cannabis* and its one species *Cannabis sativa* L.,⁷⁸ but the criteria for classifying and naming Moroccan *Cannabis* plants has not been given. Summarizing in one document the data available in the literature on the morphological, phytochemical, and genetic characteristics of ancient Moroccan *Cannabis*, especially those before the diffusion of hybrids in the Rif, may help in its identification.

The phytochemical data and morphological aspects of Moroccan *Cannabis* populations are in favor of a physiological and morphological intermediate phenotype.

Studies on *Cannabis* of Moroccan origin during the period between 1973 and 1989, before the diffusion in the world of hybrids, showed that the plants or the resins analyzed seem to be derived from the local Moroccan populations of plants that contain substantial levels of THC and CBD; with more THC and less CBD in cannabis product (a ratio of 1.5 in 1 study and a ratio of about 2 in 3 other studies).

The most recent studies (after 2004) showed the qualitative change that has affected Moroccan *Cannabis* following the introduction and diffusion of more potent hybrid cultivars. The two large Moroccan studies of 2004 and 2016 unfortunately did not report CBD or provide the morphological description when plants were involved. This information could be useful to ascertain the origin of plants, especially those whose resins were underdosed in THC (less than 10%).

The available genetic data have shown the presence in a Moroccan landrace of a genetic marker in common with Afghan accessions related to Central Asian origin. To elucidate the evolutionary history of Moroccan *Cannabis*, a sampling of heirloom populations especially from the herbaria would be of great interest.

Our study is limited by the scarcity data. The information compiled in this review on the characteristics of Moroccan *Cannabis* remains very incomplete and more research is needed.

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Abbreviations Used

BLD = board-leaf-drug
 BP = before present
 CBC = cannabichromene
 CBD = cannabidiol
 CBDAS = cannabidiolic acid-synthase
 CBN = cannabinol
 DEA = Administration Drug Enforcement (U.S.)
 GC-FID = gas chromatography/flame ionization detection
 GC-MS = gas chromatography/mass spectrometry
 CGE = common garden experiments
 HD = highly dosed
 LARATES = Laboratory for Technical and Scientific Research and Analysis
 LD = low dose
 MD = moderately dosed
 NLD = narrow-leaf-drug
 NLH = narrow-leaf-hemp
 SNP = single nucleotide polymorphism
 THC = tetrahydrocannabinol
 THCAS = tetrahydrocannabinolic acid-synthase