Shri Mohan Jain · Jameel M. Al-Khayri
Dennis V. Johnson *Editors*

Date Palm Biotechnology

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Chapter 24
Development of New Moroccan Selected Date Palm Varieties Resistant to Bayoud and of Good Fruit Quality

MyH. Sedra

Abstract Bayoud disease, caused by *Fusarium oxysporum* f. sp *albedinis*, is one of the date palm diseases of the world which is difficult to control. The elite commercial cultivars have shown high susceptibility to the disease. The genetic strategy to use resistant cultivars is the most predominant method, up to now, to control this disease. The diffusion of existing resistant cultivars has been limited due to the mediocre quality of the fruits that do not possess the commercial quality wanted by producers. Research undertaken by INRA on genetic improvement of date palm has permitted the selection of cultivars combining good fruit quality and resistance to bayoud. Studies of the performance of these cultivars have shown that they possess several agro-morphological characters that are more desirable than those of the major common and commercial cultivars in Morocco. Some of these new cultivars have already been multiplied on a large scale by tissue culture and distributed to farmers, not only to rejuvenate palm plantations ravaged by bayoud but also to enhance productivity of traditional low-yielding palm groves. Given their diversity in agronomic characters, the selected cultivars can be of value to other countries contaminated with and threatened by bayoud. Research continues, to identify and multiply other new more effective cultivars.

Keywords Cultivar characterization • Micropropagation • New cultivars • Selection

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24.1 Introduction

The date palm tree, *Phoenix dactylifera* L., is a tree of major interest because of its high productivity, the high nutrient value of its very desirable fruits and its adaptation to conditions of the Saharan regions. In fact, it constitutes the keystone species of the oasis ecosystem because of the favorable microclimate it creates for the growth of annual crops and other fruit trees in the shade created by the palms.

The exact origin of the date palm is not known with certainty. According to ancient writings (3,000 years BC), the geographical origin of date palm tree is probably the region of Mesopotamia and the valley of the Nile in Egypt (Al-Bakr 1972). The species was likely spread in association with human migrations. The culture of date palm tree extended eastward (Iran and the Indus River valley) and westward, from Egypt, then to Libya as well as the other countries of North Africa, the countries of the Sahel; also to Iberia, during the period of the Arabian presence. The introduction of date palm into a given region typically is made by offshoots that generate progeny identical to the mother palm, maintaining a high level of conformity in contrast to seed multiplication, used in older times, which produces heterogeneous progeny (i.e. both genders and different agro-morphological criteria).

Nevertheless, the selection process followed by farmers in their palm groves was focused for centuries not only on certain fruit criteria (taste, quality, appearance, color, use of fruit, etc.) but also on the local adaptation of cultivars; all the factors which help in understanding the makeup of the cultivars existing today. The selection criteria farmers employed were subjective and took into consideration their own preferences and those of tradesmen, for large brown dates which can be stored under ambient conditions. In Morocco, as in some other countries of North Africa, sexually-propagated palms descended from natural crosses were important and given names (*khalts*, progeny of spontaneous seedlings) which exhibit variability according to the regions and the technological level of the farmer. Cultivars of agronomic interest were multiplied and then designated, deriving common names from individual people, a location, agronomic character, shape of the fruit or other distinctive feature. These palms were propagated by offshoots in surrounding lands, then in other more distant localities. The individual tree types retained the names they were given and become cultivars. Currently, more than 4,000 named cultivars exist under different local and regional names in the more of 30 countries that produce dates. However, in general for every country, only about ten cultivars are most important some recognized for their good commercial fruit quality and these have come to dominate the national markets (Table 24.1).

Moroccan date palm groves occupy a surface area of more than 48,000 ha with a population of 4.8 million trees; they are composed of about 55.6% seed-derived *khalts* representing about 2.5 million trees, each of which is genetically different. The rest of the material is composed of known cultivars (more than 223) represented by about 2.3 millions trees (Anonymous 2009). The number of cultivars recently has been more than doubled to some 450 cultivars by Sedra (2010, unpublished results) and can be further enriched by new cloned cultivars in future. The average annual per tree fruit productivity (18–20 kg/tree) is relatively low and national

Table 24.1 List of important date palm cultivars in several countries (cultivars in alphabetical order)

Countries	Cultivars
Algeria	Deglet Noor (60%), Ghars, Hartan, Hmira, Takerboucht, Tazerzayte,Tinnnacer
Saudi Arabia	Al Chalabi, Anasefri, Khalas, Nabout Saif, Rhziz, Rothona
Egypt	Amhat, Amri, Apremi, Bentaîcha, Bertoma, Eglani, Gendila, Hayani, Saâidi, Semani, Sioui
United Arab Emirates	Achahl, Anouane, Chechi, Debbassi, Hassab, Jabri, Kenzi, Khadraoui, Khalas, Loulou, Mektoumi, Naghel, Raziz
Iraq	Aghrass, Barhee, Borbon, Braîme, Hallaoui, Khadraoui, Khastaoui, Maktoume, Texbarzal, Zahdi
Jordan	Ahmartalal, Aqabaoui, Barhee, Hayani, Khadraoui, Zahdi
Kuwait	Barhee, Hallaoui, Khadraoui, Khalas, Sammaran
Libya	Abel, Adoui, Broumi, Deglet Noor, Halima, Hallaoui, Jedoug, Khadri, Mersim, Saâidi, Soufir, Tabouni, Tafsirt, Tagyiat, Talis, Tedis
Morocco	Aguelid, Ahardane, Assiane, Azigzao, Aziza bouzid, Boucerdoune, Boufeggous, Bouittob, Bouskri, Bouslikéne, Bousthammi Noire, Bourar, Jihel, Medjool, Taâbdounte
Mauritania	Ahmar, Oum-aârich. Soukkani,Tiguedert, Tinterguel, Tijib
Qatar	Arzaizi, Barhee, Chechi, Hilali, Khalas, Khassab, Khénazi, Nebtat Sif
Sudan	Abdelkrim, Barakaoui, Deglet Noor, Gondalla, Koulma, Medino, Michreg/oued Khatib, Michreg/oued Laggai, Tamoud
Oman	Berni, Bounerinja, Chahla, Fard, Hilali, Jabri, Khalas, Khassab, Khenazi, Mabsali, Madlouki, Naghel, Oach, Unsilla, Salani
Tunisia	Ain Hnach, Alig, Bouhatime, Deglet Noor, Grin lghzal, Igoua, Kenta, Lemsi, Rochdi, Smiti
Yemen	Ajoua, Arkdi, Azar, Bakiah, Baomairah, Batahi, Bator, Boram, Dabach, Dalil, Deniari, Dkhara, Dhkour, Foufal, Hachadi, Hajoui, Hamraâ, Hokabi, Jabri, Jahara, Jazaz, Khabri, Khafouch, Khoudari, Koui, Loban, Machtoum, Madyani, Majabrah, Makari, Maksab, Mechar, Mokbaran, Mokhalis, Omani, Oraegi, Saâfani, Sabai, Sareh Maktari, Tael, Tobaki, Zaneki, Wak

Some information derived from a meeting of the national experts held to the United Arab Emirates (FAO 1995)

annual production of dates rarely reaches 100,000 mt. Otherwise, the palm groves are characterized by the advantage of a notably long production season which begins in June and extends until the end of November, and by very important exceptional plant biologic diversity (Fig. 24.1). However, the development and the modernization of the date palm sector are hampered by several important constraints.

Indeed, deterioration of the palm groves has continued in various localities because of constraints which can be summarized as follows:

- Permanent stress from the impact of the destructive bayoud disease caused by the soil fungus (*Fusarium* f. sp *oxysporum albedinis*) (Fig. 24.2); one of the known diseases which is difficult to control in the world and which has decimated more than 10 million trees in Morocco over a century (Djerbi 1988; Sedra 2003a, b, c, 2007b), contributing to ecosystem degradation of oases, desertification and accentuating the rural-to-urban exodus. Moreover, the steady loss of date palm genotypes also constitutes a perilous threat to phytogenetic resources of the oases.

Fig. 24.1 Some date cultivars showing the diversity of the Moroccan date patrimony

Fig. 24.2 Example of bayoud disease effects on Jihel cv. in Draa Valley, southern Morocco

- Prolonged drought and traditional water management.
- Inefficient management of the array of cultivars.
- Insufficiency of suitable palm practices in relation to the physiognomy of palm groves.
- Insufficient valorization of predominant cultivars having low commercial value.

Many efforts are being extended to overcome these constraints and results of these actions are positive and promising for a satisfactory future of the oases and their date palms.

The spread of bayoud disease in North Africa has destroyed 3 million palms in Algeria (Djerbi 1988) and some thousands of palms in Mauritania since its discovery there in 1999 (Sedra 1999, 2002, 2003a, b, c, 2007a, b). The best Moroccan commercial cvs. (Medjool, Boufeggous, Jihel, Bouskri) and Algerian cvs. (Deglet Noor, Ghras) are all very susceptible to the disease. Bayoud has certainly killed several thousands of individuals of natural-occurring *khalts* (Sedra 2003a), as well as two Moroccan cvs. Idrar and Berni (Pereau-Leroy 1958). The disease has also reduced significantly the populations of extensively-cultivated cultivars like Medjool, Boufeggous and Jihel.

24.2 The Genetic Method to Combat Bayoud Using Resistant Cultivars

In order to combat bayoud disease, the use of resistant cultivars appears, up to now, the only practical means to protect and cultivate date palm trees, even in the presence of the disease. Although complex and requiring much time, it is promising and the genetic approach was adopted by INRA (Institut National de la Recherche Agronomique) in Morocco in the 1960s and also in Algeria in the 1980s. The selection of productive cultivars having good fruit quality and with resistant to the disease requires a rigorous methodology, especially at the stage of the resistance assessment. To that end, reliable and rapid methods of cultivar screening have been developed in the field using artificial inoculation of palm trees with the pathogen, and in the laboratory on young plants (Sedra 1993, 1994a, b; Sedra and Besri 1994), or by the use of pathogen toxins (El Fakhouri et al. 1996, 1997; Sedra et al. 1993, 1998b, 2008)

Among 32 Moroccan cultivars tested at the Zagora Experiment Station of INRA, six (Boufeggous ou Moussa, Black Bousthammi, White Bousthammi, Iklane, Sair-Layalate and Tadmainte) were found to have bayoud resistance, the research dating back to 1973 (Louvet and Toutain 1973; Saaidi 1992) and a seventh cv. (Boukhanni) was selected 20 years later (Sedra 1992, 1993, 1995). In Algeria, only the Takerbouchte cv. is recognized as resistant (Bulit et al. 1967). Tirichine (1991) added another resistant cv., Akerbouch, in the M'zab region of Algeria. Among these resistant cvs. only Boukhanni, Sair-Layalate and Takerbouchte were relatively acceptable but not as good as elite cvs. like Medjool and Deglet Noor. As for Moroccan-grown foreign cvs., notably six from Iraq (Barhee, Hallawy, Khastawy, Khadrawy, Sair and Zahdi) and six Tunisian cvs. (Boufeggous, Besser Lahlou, Gondi, Horra, Kenka and Kentichi) have all shown susceptibility to bayoud disease (Djerbi and Sedra 1982; Sedra 1992, 1993, 1995). The last synthesis concerning the selection of new genotypes for their resistance and fruit quality from different genetic sources was made by Sedra (1990, 1995, 1997, 2003a, b), Sedra et al. (1996)

Fig. 24.3 Plantation and development of vitroplants derived from selection using an irradiation and screening test with pathogen toxins. These selected mutants, and other plants as controls, are under field study at the Zagora Experiment Station, INRA

and Zaher and Sedra (1998). Several clones have been identified from mass selection among a population of *khalts*, derived from controlled crosses. In addition, several hundred crosses (F_1, backcross, sib) have been achieved in order to explore their variability, to obtain new effective hybrids and to study heredity of the characters (Sedra 2003b). A first series of a quarantined individuals has been selected, some of which have been identified and characterized (Sedra 1990, 1995, 2003a, b; Sedra et al. 1996; Zaher and Sedra 1998). Other genotypes are under assessment and characterization. A process of micropropagation by tissue culture has been developed by INRA and adapted to more than 30 cvs. (Abahmane 2010; Anjarne et al. 2010) and this technology transferred to private companies that can multiply and market more than 700,000 acclimatized vitroplants to farmers for their date palm groves, not only to rejuvenate plantations ravaged by bayoud disease but also to improve traditional date groves with low productivity. Research led by INRA, in partnership with the International Atomic Energy Agency (IAEA), permitted *in vitro* propagation of some resistant mutants of the commercial susceptible cv. Boufeggous employing gamma irradiation and *in vitro* selection using pathogen toxins (Bougerfaoui et al. 2006; Sedra et al. 2008). The selected mutants are under study in the field at the Zagora Experiment Station (Fig. 24.3). In order to preserve genetic date palm resources, cultivar collections have been established at five different INRA Experiment Stations, representing more than 5,000 genotypes and in excess of 8,000 specimen plants (Sedra 2007b).

Table 24.2 Different steps of selection and evaluation of new selected cultivars of date palm

Sequence	Procedures
Step 1	Selection of genotypes (a single tree) among sexually propagated palms descended from seeds on the basis of fruit quality in comparison with dates of good commercial cultivars but susceptible to bayoud
Step 2	Planting of offshoots at the Zagora Experiment Station within the framework of a larger experiment concerning a number of raised of genotypes tested in comparison with susceptible and resistant cultivars as a control. The trees have been inoculated in the field with the pathogen, the causal agent of bayoud, using the technique of inoculation and production of contamination on the roots according to methodology developed by (Sedra 1994a), then monitored for several years. Afterwards, preliminary selection is done in comparison with control cultivars
Step 3	Proposal of selected individuals for rapid multiplication by tissue culture. After production of rooted vitroplants in sufficient number by genotype, evaluation of the levels of resistance or susceptibility to bayoud using a statistical approach by testing a sufficient number of vitroplants inoculated by the pathogen in the greenhouse under controlled conditions according to the methods developed by (Sedra 1994b; Sedra and Besri 1994) and using the pathogen toxins according to the technique of (Sedra et al. 1993, 1998b)
Step 4	Confirmation in the field of resistance of selected cultivars by planting of vitroplants in sufficient numbers for statistical analysis in experimental plots contaminated with the pathogen in comparison with susceptible and resistant cultivars as a control. Moreover, testing the true-to-type of tissue culture-derived plants using organogenesis of some Moroccan cultivars determined by using phenological descriptors and molecular markers (Sedra 2005)
Step 5	Identification and characterization of selected cultivars. This step begins before field planting while evaluating some important criteria of vegetative organs and fruits. Then overall description of the trees and characterization of cultivars based on morphological and agronomic characters, as well as molecular markers
Step 6	To name and propose selected cultivars for inscription into an official catalogue then proposing them for mass multiplication carried out by private laboratories within the framework of agreements and conventions. Thereafter, multiplied cultivars are handled by the state (Ministry of Agriculture), and distributed to farmers whose groves have been destroyed by bayoud in order to rejuvenate those ravaged areas and to investors to encourage establishment of new groves

This paper presents initial results of the characterization of new selected cultivars having good fruit quality and exhibiting resistance to bayoud disease, as well as certain other selected cultivars with high fruit quality but susceptible to the disease that need to be preserved. A population of common cultivars is being grown as controls for comparison.

Promising clones of cultivars derived from mass selection among several hundred genotypes are under field cultivation at the Zagora Experiment Station, and are composed of 15 female and 2 male cvs. Selection has been achieved through several steps and time periods: assessment in the laboratory and the field, mass multiplication of selected cultivars, and farm assessment by producers and at the market level. The different steps of evaluation and selection are presented in Table 24.2. Since

Fig. 24.4 Development of a screening resistance test on date palm vitroplants inoculated by the pathogen causal agent of bayoud (test duration 2–3 months)

being planted, these date palms have been monitored over 25 years in the field for their susceptibility to bayoud and for their productivity. They have been inoculated experimentally with the pathogen according to a screening method developed by Sedra (1994a). Most of these cultivars have been proposed for *in vitro* multiplication but only some have been multiplied and distributed to farmers. The behavior of vitroplants at the young stage of some of these new cvs., and their reactions to the pathogen and its toxins has been evaluated under greenhouse and growth-room conditions, following techniques developed by (El Fakhouri et al. 1996, 1997; Sedra 1994b; Sedra and Besri 1994) (Fig. 24.4) and Sedra et al. (1993) (Fig. 24.5). The new cvs. studied and their INRA references numbers, are: Najda (3014), Ayour (3415), Hiba (3419), Tanourte (3414), Al-Baraka (3417), Tafoukte (3416), Mabrouk (1394) and Khair (3300). According to the availability of material, cultivars used as resistant controls (Black Bousthammi and/or Sairlayalate) and susceptibility control (Medjool and/or Boufeggous and/or Jihel and/or Bouskri*)* have always been part of the trials. The agronomic, morphological and physical characteristics of trees and fruits have been recorded in accordance with the descriptors developed by Sedra (2001). The results presented, concerning only some chosen characteristics, correspond to calculated global averages based at least on about 15 years of observations, according to the cultivar.

Table 24.3 presents a listing of new selected cultivars nominated and proposed for mass micropropagation in order to rejuvenate areas in Morocco ravaged by bayoud and to renovate underproductive palm groves to improve date production quality and quantity. The Najda cv. (INRA-3014) (Fig. 24.6) was the first new

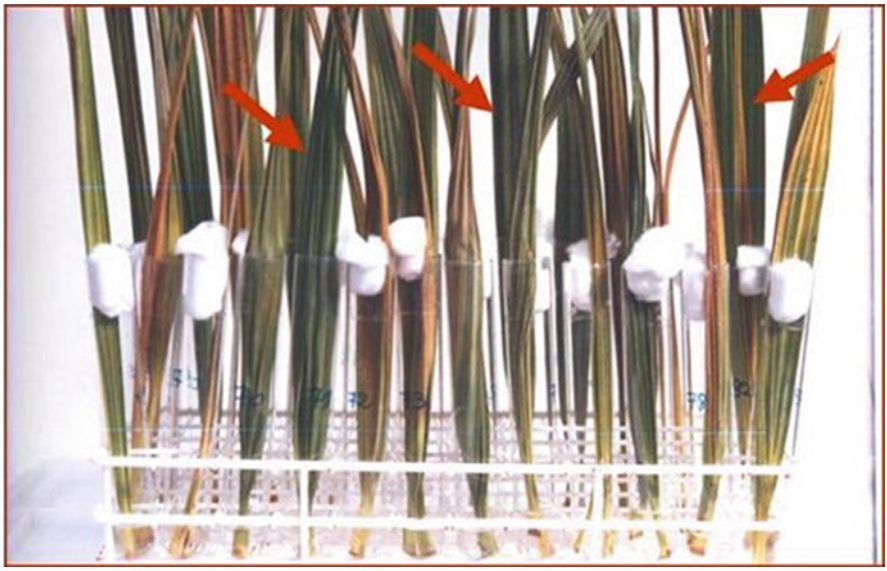


Fig. 24.5 Development of a screening resistance test on leaves of date palm using pathogen toxins. The green leaves without symptoms correspond to resistant cultivars (test duration 7–10 days)

Table 24.3 New selected date palm cultivars proposed for mass micropropagation

Series	Cultivar	INRA reference no.	Name significance
1	Najda	3014	First-help
	Mabrouk	1394	Newborn
2	Ayour	3415	Moon
	Hiba	3419	Grant
	Tanourte	3414	Big round bread
	Tafoukte	3416	Sun
	Al-Baraka	3417	Sufficiency
	Khair	3300	The good
	Al-Fayda	1447	Benefit
	Bourrihane	1414	Father of challenge
	Al-Amal	1443	Hope
	Nebch-Bouskri	NP3	From locality Nebch-Parcel Bouskri cultivar
	Nebch-Boufeggous	NP4	From locality Nebch-Parcel Boufegous cultivar
3	Sedrat	3003	For Mr Sedra
	Darâaouia	1445	From the Draa valley
	Not yet named	3010	–

selected cultivar released to farmers, especially for a plantation in Foci infected with bayoud. More than 60,000 plants have been distributed over the past 20 years. The dates produced from the Najda cv. are well accepted and are beginning to

Fig. 24.6 (**A**) Date production of selected cv. Najda (INRA-3014); (**B**) Area ravaged by bayoud then repopulated by the planting in rows of the vitroplants of the cv. Majda; (**C**) Example of a tree in production of selected cv. Al-Amal (INRA-1443)

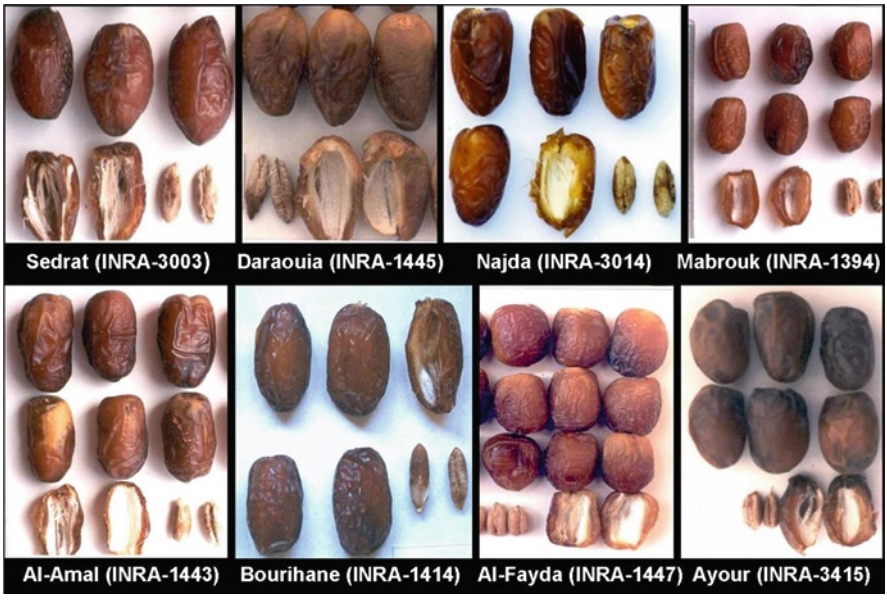
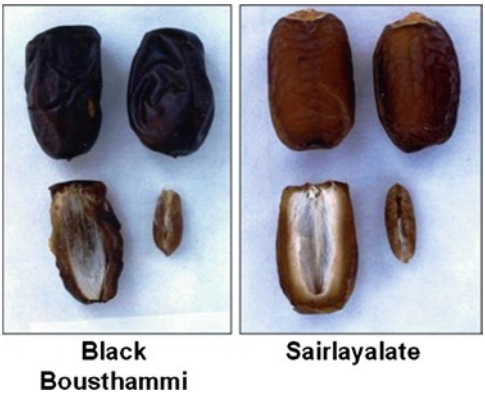


Fig. 24.7 Examples of new selected cultivars effectively resistant to bayoud, except for cv. Ayour

appear in the markets. This has precipitated an increased demand for plants by the farmers. The second and third series of new cultivars are enriching the national date patrimony of cultivars in order to improve date production and/or to contribute

Fig. 24.8 Examples of the major common commercial cultivars susceptible to bayoud

Fig. 24.9 Examples of the major common commercial and resistant cultivars to bayoud



to the control of bayoud; for example: Ayour (3415), Hiba (3419), Tanourte (3414), Tafoukte (3416), Al-Baraka (3417), Khair (3300), Al-Amal (1443), Al-Fayda (1447), Bourrihane (1414), Mabrouk (1394) and INRA-3010 (unnamed). Most of these cultivars are undergoing mass multiplication. The last series of new selected cultivars proposed in 2010 were: Darâaouia (1445) and Sedrat (3003). Figures 24.7–24.9 illustrate, respectively, some examples of selected cultivars, both commonly susceptible and resistant ones. Other new selected cultivars released from different crosses (F_1, backcross) are under evaluation and characterization. Additional new cultivars will be proposed at the beginning of 2011.

Table 24.4 presents important quantitative and qualitative agro-morphological characters of the first selected cultivars and the major commercial cultivars in Morocco that, in addition to high productivity of the trees, should be of interest to date producers.

24.3 Behavior of Selected Cultivars to Bayoud

Field evaluations showed that the susceptible control (cv. Jihel) and selected cultivars for their fruit quality, notably Ayour (3415), Hiba (3419), Tanourte (3414), Tafoukte (3416), Al Baraka (3417) and Khair (3300), are attacked by bayoud

Table 24.4 Agro-morphological characteristics of new selected female cultivars compared to major common Moroccan cultivars

Cultivars (INRA reference numbers)	Behavior towards bayoud	Fruit appearance	Fruit color	Fruit consistency	Fruit weight[b]	Fruit pulp (%)	Heat requirements for fruit maturity (°C)[a]	Fruit stalk length (cm) and characterization	Leaf length (cm) and characterization	Thorns, total number	Thorn angle at middle of rachis
Selected cultivars											
Daraouia[c] (1445)	Resistant	Excellent	Clear brown	Semi-soft	21.9 VH	93 VH	4,000–4,500	121 (very long)	502 (very long)	68 VH	37 M
Sedrat[c] (3003)	Resistant	Excellent	Clear brown	Dry	21.2 VH	91.5 VH	<3,500	96.5 (long)	463 (very long)	30 L	27 L
Al-Amal (1443)	Resistant	Excellent	Clear brown	Dry	21 VH	95.2 VH	3,501–4,000	65 (moderate)	426.5 (long)	40 M	32 L
INRA-3010[c]	Resistant	Excellent	Clear brown	Semi-dry	18 H	93.9 VH	4,000–4,500	93 (long)	443 (long)	36 M	30 L
Al-Fayda (1447)	Resistant	Excellent	Clear brown	Semi-soft	14.2 M	92.4 VH	3,501–4,000	170 (very long)	442 (long)	24 H	52 H
Bourihane (1414)	Resistant	Excellent	Clear brown	Semi-soft	14.1 M	92.9 VH	3,501–4,000	60.6 (moderate)	329.2 (moderate)	43.5 H	30 H
Mabrouk (1394)	Resistant	Very good	Clear brown	Semi-soft	14.3 M	90.9 VH	4,501–5,000	63 (short)	440.5 (long)	43.5 H	57 H
Najda (3,014)	Resistant	Good	Clear brown	Semi-soft	17.7 H	92.1 VH	4,000–4,500	77.2 (moderate)	417 (long)	41.5 H	20 L
Khair (3,300)	Susceptible	Good	Clear brown	Semi-soft	12.9 M	86 M	4,501–5,000	65 (moderate)	360 (moderate)	36.5 M	32 L
Tanourte (3414)	Susceptible	Good	Brown	Semi-soft	13.5 M	90.3 VH	3,501–4,000	75 (moderate)	305 (short)	34 M	40 M
Ayour (3,415)	Susceptible	Very good	Clear brown	Semi-soft	24 VH	92.5 VH	4,501–5,000	97 (long)	472 (very long)	40.5 H	30 L
Tafoukte (3416)	Susceptible	Fair	Brown	Semi-dry	10 L	89 H	<3,500	74.3 (moderate)	555 (very long)	28.5 L	22 L
Hiba (3419)	Susceptible	Good	Clear brown	Dry	18 H	91.4 VH	3,501–4,000	65.3 (moderate)	439.5 (long)	44 H	38 M
Common cultivars											
Medjool	Very susceptible	Excellent	Dark brown	Semi-soft	25 VH	93.6 VH	>5,000	143 (very long)	308 (short)	34 M	20 L
Boufeggouss	Very susceptible	Good	Dark brown	Soft	19 H	92 VH	4,501–5,000	115 (very long)	270 (very short)	29.5 L	22 L
Jihel	Very susceptible	Good	Clear brown	Dry	12.2 M	90 H	>5,000	77 (moderate)	363 (moderate)	38 M	19 VL

Bouskri	Very susceptible	Fair	Dark brown	Dry	9,8 L	84 M	4,501–5,000	66.2 (moderate)	305 (short)	27.5 L	20 L
Aguélid	Fairly susceptible	Poor	Clear brown	Semi-dry	8,8 L	86 M	<3,500	107.2 (long)	380 (moderate)	32 M	40 M
Iklane	Resistant	Poor	Black	Soft	9.55 L	93 VH	>5,000	71.4 (moderate)	398 (moderate)	22 VL	41 M
Saîrlayalate	Resistant	Fair	Clear brown	Semi-dry	10.9 M	90 H	4,501–5,000	105.5 (long)	369 (moderate)	30.5 M	15 VL
Bousthammi Noire	Resistant	Poor	Black	Soft	6 L	90 H	4,501–5,000	120 (very long)	498 (very long)	22.5 VL	41 M

VH very high, *H* high, *M* medium, *L* low, *VL* very low

[a]The sum of the daily average of temperature above 18°C since flowering until the date maturity that influences the precocity or lateness of fruit maturity: precocious cultivars (<3,500°C), fairly precocious (3,501–4,000°C), in season (4,000–4,500°C), fairly late (4,501–5,000°C) and late (>5,000°C)

[b]The presented value represents the average of values of 12 samples. The calculated median weight of date fruits represents the average of the weight of 100 sampled dates at random from normal productions based on at least 15 years of production. These descriptors of date palm are defined by Sedra (2001)

[c] New cultivars proposed in early 2010: Daraouia (INRA-1445) and Sedrat (INRA-3003); the clone-variety INRA-3010 is not yet named)

(Table 24.4). Some of these cultivars have been lost and to preserve them, genetic material was produced by tissue culture and preserved in the collection of the INRA Menara Experiment Station, in the Marrakech region, in an area free of bayoud . All of the susceptible cultivars have been distributed to farmers for their fruit quality and not for their bayoud resistance. It is advisable to plant these cultivars, as is the case of the susceptible cvs. Medjool and Boufeggous, in areas free of bayoud in order to better valorize them without risk. On the other hand, the following cultivars grown as a resistant control group (cv. Black Bousthammi) (Table 24.4) as well as the male clones Nebch-Bouskri (NP3) and Nebch-Boufeggous (NP4) (Table 24.5), showed no symptoms of the disease in spite of numerous artificial inoculations with the pathogen in the field. After cv. Najda (3014) is added, the seven new selected and promising cultivars to control bayoud are the following: Drâaouia (1445), Sedrat (3003), Al-Amal (1443), Al-Fayda (1447), Bourihane (1414), Mabrouk (1394) and 3010 (unnamed) as well as the selected males Nebch-Bouskri (NP3) and Nebch-Boufeggous (NP4). Some of these cvs. such as Sedrat (3003), Al-Amal (1443) and Daraâouia (1445), exhibit high performance and are resistant to bayoud.

24.3.1 Fruit Characters

Most of the selected cultivars are attractive, bearing fruits of a clear brown color and with flesh of moderate consistency (semi-soft), comparable to Medjool. Others are dry dates such as the Jihel cv. (Table 24.4 and Fig. 24.7). Among 66 genotypes composed of 32 cultivars and a sample of 34 selected clones (Sedra 2003a), a ranking of these genotypes based on the fruit weight (tamar stage) revealed that of the first 20 common and selected cultivars, Medjool and Boufeggous occupy first and sixth places, respectively. Indeed, the fruit of Medjool cv. is the largest with only 40 fruits to the kg. Cultivars that occupy the last five positions, not in descending order, are namely: Oum'hal, Bouittob, Black Bousthammi, Azigzao and Hafs; these bear fruits weighing on average 3.4 g, requiring about 294 dates to the kg. On the other hand, the majority of selected cultivars are regrouped in the first half of the ranks of the set of genotypes. The selected cultivars with fruit weight exceeding 20 g, and the same approach to the Medjool cv. are, in descending order: Daraâouia (1445), Sedrat (3003) and Al-Amal (1443) (Table 24.4). Ayour cv. (3415) which has the highest fruit weight among the first selected cultivars, is unfortunately susceptible to bayoud. Others such as the clone-cvs. 3010 and Najda (3014) are classified in the group of Boufeggous cvs. The Najda cv. (3014) was selected about 15 years ago (Sedra 1993, 1995, 2003a, b) and has been important for distribution to farmers up to the present. The selected cvs. Al-Fayda (1447), Bourrihane (1414) and Mabrouk (1394) are classified in the group as being similar to the Jihel cv. Besides, most cultivars selected for their bayoud resistance and fruit quality possess a percentage of fruit flesh above 92%, with a maximum of 95.2% in the Al-Amal cv. (1443) and 93.9% for cultivar-clone (3010), comparable to that of Medjool (93.6%) (Table 24.4).

Table 24.5 Some agro-morphological and biologic characters of selected male cultivars to control bayoud

Males cvs. (INRA Ref No.)	Leaf length (cm)	Density of leaves in crown	Pollen production	Germination rate of pollen	Pollen fertility	Distorted or aborted pollen	Resistance to bayoud
Nebch-Bouskri (NP3)	383 moderate	Slightly open	Moderate	Very high	Very high	Low	Resistant
Nebch-Boufeggous (NP4)	438 long	Open	High	Very high	Very high	Low	Resistant

24.3.2 Heat Requirements, Precocity and Late Fruit Ripening

The heat requirement is a biologic and ecological character determining possible cultivation areas and localities, as well as the period of date maturity. For the selected and promising cultivars to control bayoud, and under the conditions at Zagora, the Sedrat cv. (3003) is precocious; Al-Amal (1443), Bourrihane (1414) and Al-Fayda (1447) are fairly precocious; cvs. Darâaoui (INRA-1445), Najda (3014) and the unnamed variety (3010) produce fruits in season, whereas the Mabrouk cv. (1394) is late (Table 24.4). Except for the precocious cv. Aguelid, as a reference, the other commercial cvs. such as Medjool and Jihel are relatively late. Boufeggous and Bouskri are somewhat late and resistant common cvs., notably Iklane, Black Bousthammi and Sairlayalate, are late ripening.

24.3.3 Length of Leaves and Fruit Stalks

Date palms selected as common cultivars have long to very long leaves requiring tree spacing of at least 10 × 10 m (100 trees per ha), whereas in the case of those having short to medium length leaves, the planting field can be more intensively utilized by adopting a higher a density of up to 8 × 8 m (150 palm trees per ha). On the other hand, cultivars with long stalks are most desired by farmers because this character facilitates certain agricultural practices such as bending, reducing length and number of inflorescences, fruit covering for protection during ripening and during harvest. Such is the case with the commercial cvs. Deglet Noor, Medjool and Boufeggous and some selected cvs. like Darâouia (1445), Al-Fayda (1447) and Sedrat (3003). It appears that the best cvs. are Medjool, Boufeggous, Jihel and Bouskri; some common bayoud-resistant cvs. (e.g. Black Bousthammi, Iklane and Slairlayalate) present favorable agro-morphological characters (Table 24.4). Figure 24.6 shows an example of a tree of selected cv. Al-Amal (1443).

24.3.4 Thorns – Number and Angle of Insertion

Those cultivars with thorns borne at a low angle to the rachis are very desirable because this character facilitates entering into the crown for pollination, bunch thinning, harvesting, etc. It is no surprise that the major and most cultivated cvs., such as Bouskri, Boufeggous and Medjool, possess these characters (Table 24.4). The eight selected resistant cultivars showed a diversity of these characters, notably for the number of thorns (Table 24.4) but only four among them present a low thorn insertion angle at the leaf midpoint. The Sedrat cv. (3003) is the only resistant and effective variety that possesses a low number of thorns along with a low insertion angle.

24.3.5 Selected Male Cultivars

The selected male cvs, Nebch-Bouskri (NP3) and Nebch-Boufeggous (NP4) possess, in addition to their resistance to bayoud, an important character of notably good quality pollen (Table 24.5), according to the descriptors developed by Sedra (2001). These males deserve to be exploited to the scale of palm groves within the framework of the national program of rejuvenation of palm groves ravaged by bayoud.

24.4 Conclusion and Prospective

Based on morphological and agronomic characters, results have shown a diversity of selected clones and cultivars with regard to some important characters in date palm cultivation. The characterization of some cultivars by using molecular approaches has been made (Sedra 2001; Sedra et al. 1998a) and continues, currently using new molecular biology techniques. The results of molecular characterization and identification are not presented here. Except for the Najda cv. (3014), multiplied and distributed in relatively significant quantities, the other affected cultivars did not exhibit satisfactory results. In order to control bayoud disease and to preserve genetic diversity within the date palm groves, and to rebuilt the framework of the national plan of reconstitution of oases set forth in the *Green Plan Morocco*, it is urgent to focus efforts on mass multiplication of these new selected cultivars that have been developed; their performances are reported in this paper. In fact, several of the new cultivars are currently being multiplied on a large scale and they will contribute to improve the quantity and quality of date production, leading to increased farmer income and the promotion of human development in the Saharan areas.

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