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### Advances in date palm (*Phoenix dactylifera* L.) research programme in Morocco: A review

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#### ABSTRACT

Date palm (*Phoenix dactylifera* L.) is a woody monocot tree producing fruits with high nutritional and economic importance. Currently, date production suffers from several biotic and abiotic stresses that reduce its profitability and menace its productivity. Moreover, climate change due to global warming has negatively affected crop production worldwide including dates. Despite the high resilience of the date palm tree, there is a need to develop new cultivars that are higher yielding and possess highly valued agronomic traits, such as fruit quality, disease and pest resistance and tolerance of extreme environmental conditions. In order to address this uncomfortable situation, Morocco has undertaken a huge research program for control of Bayoud disease basically, based on selection or creation of tolerant genotypes. To this end, several breeding approaches have been pursued, including: mass selection, cross breeding and induced mutagenesis. Obtained results have permitted to select many tolerant genotypes to Bayoud disease including cv. Nejda that has been largely propagated. In order to rehabilitate devastated palm groves with selected genotypes, plant tissue culture techniques were developed including organogenesis and somatic embryogenesis both from offshoot shoot tips or inflorescence plant material. Developed propagation technologies were transferred to private labs for mass propagation of date palm. Collaboration between public and private sectors has permitted production of three million vitro plants up to 2020 and a new plant production program is launched to produce five million plants in the horizon of 2030. Overall, the major research aspects of the national strategy to develop date palm sector in Morocco are presented.

#### Introduction

The date palm (*Phenix dactylifera* L.) plays a vital role in the ecology and economy of the arid and semi-

arid regions. The total area of palm groves in Morocco is around 67 000 ha including 7.2 million palms, characterized by a high genetic diversity with

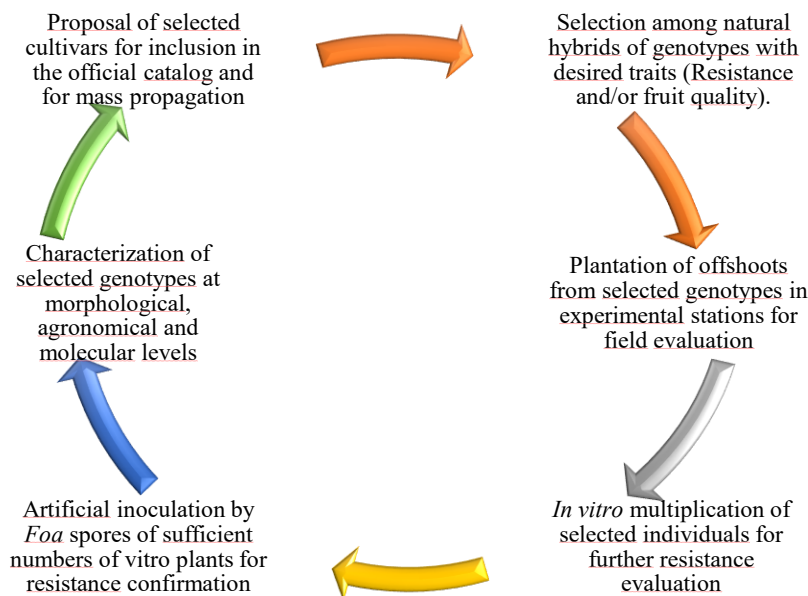
453 varieties and more than 2.7 million of natural hybrids. Average annual dates production is around 130000 MT for the last five years (Anonymous, 2025). However, Moroccan date palm sector suffers from many abiotic and biotic challenges particularly prolonged drought periods and Bayoud disease (*Fusarium oxysporum* f.sp. *albedinis*) (Foa). As direct consequences, Morocco is among the great importer of dates worldwide. Besides, there is a need of millions of date palm plants to rehabilitate the palm groves. To alleviate this uncomfortable situation, Morocco has undertaken a research program for control of Bayoud disease basically, based on selection or creation of tolerant genotypes and development of micropropagation techniques. Several breeding approaches have been pursued, including: mass selection, cross breeding and induced mutagenesis. In addition, the ongoing research program 2025-2028 is focused on

- i. Selection, characterization, conservation and valorization of palm genetic resources
- ii. Optimization of date palm production, protection and post-harvest techniques
- iii. Evaluation of agro-ecological practices, improvement of organic production and innovative uses of dates and by-products of palm groves.

**Mass selection**

Plant breeding success depends on the collection and

selection of germplasm, its evaluation for desired characters, multiplication, release and distribution of new varieties to farmers. Date palm is one of the oldest cultivated crops and up to now, most countries have followed conventional breeding methods (Al-Khayri *et al.*, 2018). The selection program conducted in Morocco aimed to find Bayoud resistant varieties and producing fruits of great commercial value. Taking into account that these two characters were never found together at the highest level in the most widespread cultivars, the first research works were focused on the selection of average quality dates in varieties with a high level of resistance then partial resistance for high fruit quality varieties (Saaïdi, 1990). The selection first took place within common varieties, then among natural populations of individuals from natural hybridization. Such a program required a rigorous methodology, especially at the stage of the Bayoud resistance assessment. The main results of this research program was the selection of many tolerant genotypes particularly: Nejda, Deraouia, Sedrat, Al-Amal, Al-Fayda, Bourihane, Mabrouk and INRA-3010 genotypes. Moreover, two male cultivars: Nebch-Bouskri and Nebch-Bouffeggous have been selected and characterized as resistant genotypes (Sedra, 2015). More details on genetic improvement to produce value-added date palm cultivars are available in a recent publication chapter of CABI (Abahmane, 2023).



**Fig. 1.** Selection steps for Bayoud disease resistant genotypes implemented in Moroccan context (Sedra, 2011)

**Cross breeding**

Despite the great spontaneous diversity that can be found in landraces, simply applying selection to pre-existing diversity is an eroding process that

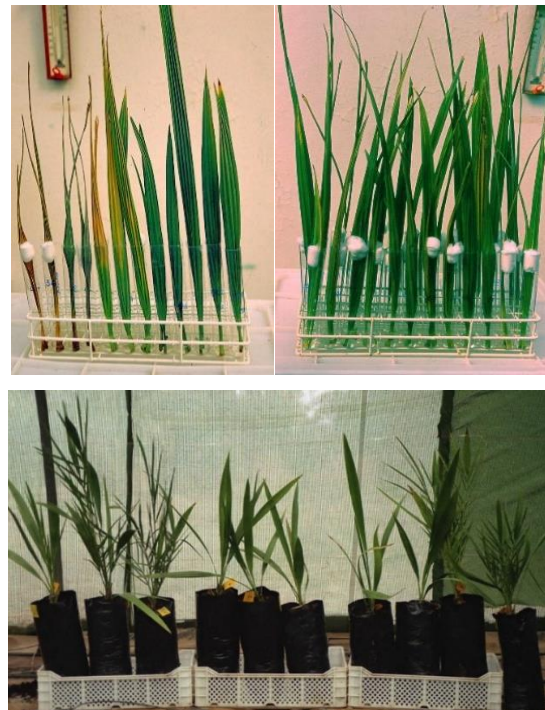
eventually comes to a limit. The true creative power of plant breeding resides in promoting recombination for shuffling favourable alleles. The combination of different alleles in many loci results in a virtually infinite number of genotypes (Bresghehlo and

Coelho, 2013). The controlled hybridization program aimed creating palm trees resistant to Bayoud disease and producing dates of better quality than those resulting from natural hybridization. The descendants of controlled crosses were assessed for their resistance to Bayoud by artificial inoculation and by planting in naturally infested lands. The survivors were maintained until fruit set for examining the quality of dates (Sedra, 2011). As much as possible, hybridization programs were started using wide range of parents, especially palm trees with a high level of resistance and palm trees producing fruits of good quality. Male parents are selected based on their pollen production, timing of flowering, metaxenic effects and tolerance to biotic stresses (Saaïdi, 1990). This program resulted in creation of 15 hybrids of good fruit quality and not showing symptoms of Bayoud disease. Although, cross breeding can make certain crosses between genotypes that can never occur naturally, this technique has some limitations. Indeed, it is time consuming, requiring 30 years to complete three backcrosses due to the palm's long-life cycle. Another constraint is gender identification, which is not possible before the onset of fruiting, 5-7 years after planting.

### Induced mutagenesis

Natural genetic diversity is gradually eroded and consequently there is a loss of valuable genetic resources, which hinders genetic improvement of crops including date palm. Moreover, the rate of spontaneous mutations is extremely slow and makes the availability of wide genetic diversity more limited for plant breeders (Jain, 2010). Induced mutations hasten the rate of genetic diversity in a short period and are readily available to plant breeders for developing new cultivars. Mutation breeding can be described as the purposeful application of mutations in plant breeding (Carimi *et al.*, 2012). A mutation is a sudden heritable change in the DNA of a living cell that is not caused by genetic segregation or genetic recombination (van Harten, 1998). Mutations are generally induced by physical and chemical mutagenic treatments in seed and vegetatively propagated crops including the date palm. Gamma irradiation breaks DNA into small fragments and secondly the DNA starts a repair mechanism. During this second step, new variations develop or mutations occur. Mutation induction in date palm is feasible now due to a reliable plant regeneration system via somatic embryogenesis and organogenesis techniques. The optimal mutagen dose is determined empirically in order to minimize the impact on growth and fertility. Thus, induced mutations can provide useful alternative or complement to natural variation as well as to hybridization (Chakraborty and

Paul, 2013). The undertaken research program in Morocco resulted in selection of 10 putative mutant plants that were later transferred to the "hot spot" in the field infested with Bayoud disease at the experimental station in Zagora. The performance of these mutant plants is under evaluation for other agronomic traits (Bougerfaoui *et al.*, 2006). Mutation breeding has many drawbacks. One issue is that large mutant populations must be generated due to the random nature of mutation induction. Theoretical calculations of the population size needed to find induced mutations in diploid plants suggest that tens of thousands of M1 lines are necessary (Roychowdhury and Tah, 2013). Producing and maintaining such numbers of line progenies can sometimes be impractical for species that are large or long-lived.

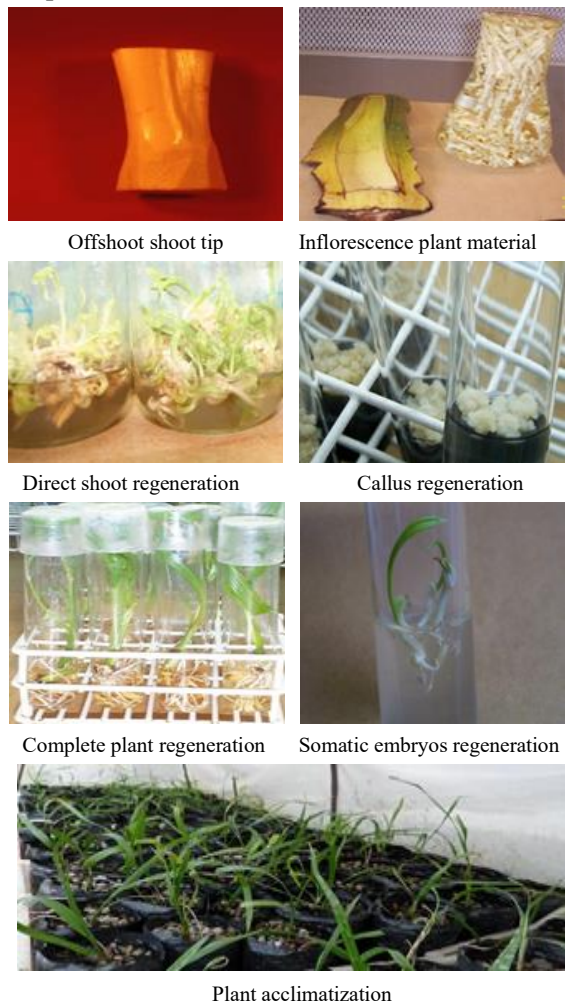


**Fig. 2.** Screening of plant material produced from irradiated Boufeggous variety (Gamma radiation at 20 gray) by using fungus toxins at 100 µg/ml

### Micropropagation techniques

Vegetative propagation by offshoots is the only conventional method to maintain genetic integrity of date palm cultivars. Due to its slow growth and limited number of offshoots, plant tissue culture (PTC) remains the ideal means for propagating and disseminating selected cultivars among oasis growers (Abahmane, 2011). The application of PTC techniques to date palm has many advantages: propagation of healthy selected female cultivars, large-scale multiplication, avoiding seasonal effects, production of genetically uniform plants, fast and

secure exchange of plant material, and economical profitability. Looking at these advantages, micropropagation techniques have been developed for rapid mass propagation of date palm (Abahmane, 2017). In order to rehabilitate devastated palm groves with selected genotypes, organogenesis technique from both offshoot and inflorescence plant materials was used. Produced propagation technology was transferred to private labs for mass propagation of date palm.



**Fig. 3.** Multiplication techniques for date palm micropropagation

Collaboration between public and private sectors has permitted production of three million vitro plants up to 2020. A new plant production program is launched to produce five million plants in the framework of Green Generation plan 2020-2030. Produced palm plant material is used for traditional palm groves rehabilitation as well as for creation of modern palm plantations.

### Conclusion

Obtaining Plant material resistant to Bayoud disease through conventional breeding is a time-consuming and tedious process. There is enormous scope in the

transformation technology to introduce disease-resistant traits in the date palm. The combined application of conventional breeding and applied biotechnological tools can generate genetic variations and produce fast propagating new genotypes with superior fruit quality, and resistance to biotic and abiotic stresses. Well-established plant tissue culture systems can be used for the rapid propagation of elite cultivars, to establish germplasm banks and for mutagenic studies *in vitro* to isolate useful mutants. Application of protoplast techniques can be utilized in somatic hybridization and introduction of desired genes through genetic transformation of date palm.

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### Conflict of Interest

The author declares that there is no conflict of interest.

### Data sharing

No data was used for the research described in the article.

### Informed Consent

Not applicable.

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