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Acclimatization, distribution and potential economic use of *Argania spinosa* (*Sapotaceae*) in southern Italy

Abstract

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The authors report updated notes on the acclimatization, distribution, areas suitable for cultivation and, potential use of *Argania spinosa* (*Sapotaceae*) in southern Italy. Based on observations carried out on the plants cultivated in Bari and the Botanical Garden of Palermo, and on ecological requirements of the species it is possible to consider *A. spinosa* as a woody species easily adaptable to the coastal climate of southern Italy.

Key words: *Argania*, medicinal plant, zoning model.

Introduction

Argania spinosa Skeels (syn. *Argania syderoxydon* L., *Sideroxydon spinosum* L.), the argan tree, belongs to the *Sapotaceae* family and it is the only species of its genus (Khallouki & al. 2005; Zunzunegui & al. 2010; Ait Aabd & al. 2019).

As a plant of particular botanical interest, ecological services, and socioeconomic value, it has been investigated at different levels. The structural organization and phylogenetic relationships in *Sapotaceae* was clarified by Khayi & al. (2020). Chakhchar & al. (2020) highlighted morphological aspects and physiological and biochemical mechanisms related to the roots to justify the tolerance of *A. spinosa* to abiotic stresses.

The adaptation to aridity of *A. spinosa* has been pointed out by Tahrouch & al. (2011) analyzing the leaves, stems and thorns which show a high concentration of myricetin. An ethobotanical investigation was carried out by Moukal (2004) in the rural areas of South-West Morocco on the several uses of the argan tree as therapeutic and cosmetic. Guillaume & al. (2019) highlighted the antioxidant and pharmacological properties of argan oil and the value of by-products derived from it.

Description

A. spinosa is a slow growing spiny tree with a maximum height of ca. 10 m (Charrouf & Guillaume 1999), able to live up to an age of about 200 years. (Khallouki & al. 2005). The leaves are small (20 mm), with entire margin and spatulate shape. Although the plant is evergreen, the leaves may fall off, totally or partially, especially in response to summer stress. So it is preferable to consider this species as a facultative summer semi-deciduous (M'Hirit & al. 1998).

Flowering occurs mainly in spring, with great variation among individuals, and with a secondary peak in autumn. Fruits are olive-like, stalkless drupes with a hard endocarp protecting an oil rich kernel (Zunzunegui & al. 2010). Therefore, fruit production extends over a long period and fruits can be found in different ripening phases from April to September (M'Hirit & al. 1998).

Ecology and distribution

A. spinosa is endemic to the arid and semiarid areas of South-western Morocco, mostly in the Souss Valley, between Safi and Goulimime (Msanda & al. 2021), where it occupies more than 8.000 km² on a wide range of altitude, from sea level to 1.500 m (Justamante & al. 2017). Other populations are found in Algeria in the Tindouf region (Khallouki & al. 2017; Kechairi & Benmahiou 2019). The range is in the transitional area between the Mediterranean iso-climatic zone in the north and the Saharan region in the south and has a wide opening to the Atlantic Ocean (Msanda & al. 2021). This species is cultivated and subsponaneous in the Canary Islands (WCSP 2021), continental Spain (Castroviejo 1997), and Libya (APD 2021).

A. spinosa is the second most common tree in Morocco, preceded only by *Quercus ilex* L. (Khallouki & al. 2005). The argan tree is adapted to grow in a harsh environment, surviving extreme drought and poor soil. The optimal rainfall pattern for the species is 500 mm per year; nevertheless, 120 mm of rain make up the minimum necessary for its development (Raimondo & al. 2005). It can resist to temperatures below 0 °C only a short time (Alouani & Bani-Aameur 2017).

A. spinosa is the only species of the tropical *Sapotaceae* family, whose range extends to the subtropical zone (Charrouf & Guillaume 2002). It could be a relict of the Tertiary flora and in that period its range could have been wider, also including the northern part of Africa and Southern Europe; after, the Quaternary glaciations contracted its range. This hypothesis would justify the current existence of the small relict populations distributed in the area of Rabat and even further north, near the Mediterranean coast of north-east Morocco (Raimondo & al. 2005; Ait Aabd & al. 2019).

In Morocco, *A. spinosa* has an indispensable ecological function. Its roots grow deep in search of water and thus help retain the soil, preventing erosion and limiting the advance of the desert (Khallouki & al. 2005). In addition to these important ecological aspects, argan trees also economically support indigenous populations (Morton & Voss 1987; Mechqoq & al. 2021). Their large canopy maintains soil fertility by shading domestic cultures that guarantee most of the dietary needs of small scale farmers (Charrouf &

Guillaume 2002). Furthermore, the argan leaves constitute a real pasture suspended for dromedaries and goats. Indeed, these last they climb up to the highest branches to graze the leaves that have considerable forage value (Nouaim & al. 1991).

However, nowadays, the argan woodlands is steadily decreasing in terms of density and surface covered. This is mainly a consequence of the overuse of argan trees, for wood or forage production, by the native dwellers but has also recently been deeply accentuated by several consecutive unprecedented arid years (Charrouf & Guillaume 1999). Therefore, sustainable management strategies are needed for the conservation of the species and its genetic diversity (Msanda & al. 2021).

Economic use

The argan tree also supports more directly the economy of the region (M'Hirit & al. 1998) since its fruits provide an edible and marketable oil for cooking, cosmetic and, medicinal purposes (Khallouki & al. 2005).

The oil provides up to 25% of the dweller daily lipid diet (Collier & Lemaire 1974) and possesses a lot of dietary interesting properties. Its quality makes it a great product sought after, much more expensive than olive oil in reason also of its limited availability (Yaghmur & al. 2001).

In the traditional pharmacopoeia the argan oil is used to fight physiological aging and drying of skin, in the treatment of children's pimples, and more particularly in juvenile acne. By its pharmacological properties, argan oil is also included in the composition of creams used in cosmetics (Khallouki & al. 2005).

Recognizing its ecological value and local economic importance, the argan forest region was declared a UNESCO Biosphere Reserve in 1998 (Msanda & al. 2021).

Distribution in Italy and acclimatization

Acclimatization tests for *A. spinosa* date back to the 17th century in Holland, the 18th century in Germany, the 19th century in France and, the early 20th century in America (Southern California and Illinois). Recently they have also been carried out in Tunisia, Libya, and Israel, Kuwait, and Mexico (Peltier & al. 1990; Raimondo & al. 2005; Falasca & al. 2018).

In Italy, a plant of *A. spinosa* is cultivated in the Botanical Garden of Cagliari (Sardinia), where the plant is cultivated in open field and vegetatively multiplied by layering. The oldest argan tree, at the side of the central tank of the Botanical Garden and producing fruits, died about 15 years ago (G. Bacchetta, *in verbis*). Since 1998 two plants have also been cultivated in the Botanical Garden of Palermo (Sicily) where they bloom and bear fruit regularly (Raimondo & al. 2005).

Two plants were introduced and cultivated outdoors, initially in pots. The plants showed a regular and vigorous growth, keeping their leaves all year round, contrary to what happens in nature. Flowering, occurred for the first time in 2003, was followed by fructification 6 years after planting. As part of a census of the trees and shrubs of the city of Bari

(Apulia, southern Italy) (Gargano & al. 2021), a vigorous tree of *A. spinosa* was observed inside the University Campus near the Department of Agricultural and Environmental Science (DiSaat) while the other plant is located in the Botanical Garden of Bari (Fig. 1).

This is one of the plants previously pointed out by Campese & al. (2011) who reported five argan trees in the University Campus, including two of about 3 m in height in the ground and three others in pots, in the greenhouses of the former Department of Biology and Plant Pathology of the University of Bari. Campese & al. (2011) also reported other two specimens cultivated in the province of Bari. Argan plants were introduced from Morocco by Prof. Daniele Sisto, plant pathologist at the University of Bari. A plant was given to Prof. Francesco Macchia, at the time director of the Botanical Garden of Bari for acclimatization. Another was planted in the University Campus, near the former Faculty of Agriculture. In about 20 years, the plant has reached the typical size of the species, bears fruit regularly and abundantly and does not present particular pathologies.

Suitable areas for cultivation in Italy

A preliminary bibliographic search was undertaken to highlight the sites of the wild plant populations of *Argania spinosa*. The Moroccan populations have been chosen as a reference because the range in Algeria has been enlarged by man and many populations have been artificially reinforced (Kechairi & Benmahioul 2019). For trees favoured or cultivated by man, sometimes for millennia, it is necessary to develop approaches combining phylogeography and paleoecology at the scale of the distribution area (Médail & al. 2019). The selected Moroccan populations were mapped on a GIS system. The climatic requirements and tolerances of *A. spinosa* have been outlined in relation to the environmental conditions of its natural distribution range. Similarly to Falasca & al. (2012; 2018) an agroclimatic zoning model was developed on the basis of the WorldClim data from the period 1950-2000 (<https://www.worldclim.org/>). The WorldClim data consist of climate grids with a resolution of 1 km² with an interval of 30". Basic data in determining this similarity were: Annual Mean Temperature, Minimum Temperature of Coldest Month, Temperature Annual Range, Mean Temperature of Coldest Quarter, Annual Precipitation, Precipitation of Coldest Quarter. We present four suitability classes based on the percentages of surface occupied in the native range of the species: Optimal, Very suitable, Suitable and, Unsuitable and we have projected with the GIS system the areas that represent these classes on the Italian territory.

Results

According to our elaborations, in its native range the Argan tree is found in coastal and intra montane areas. Most localities have an annual mean temperature from 13.5 to 20.2 °C and average rainfall from 127 to 413 mm. The minimum temperatures of the coldest month fluctuate from -2.0 to 9.8 °C. The average temperature of Coldest Quarter ranges from 6.0 to 15.4°C. The ranges of the 4 classes that have been defined on the basis of the percentiles are shown in Table 1. These data, obtained directly on the basis of the climatic

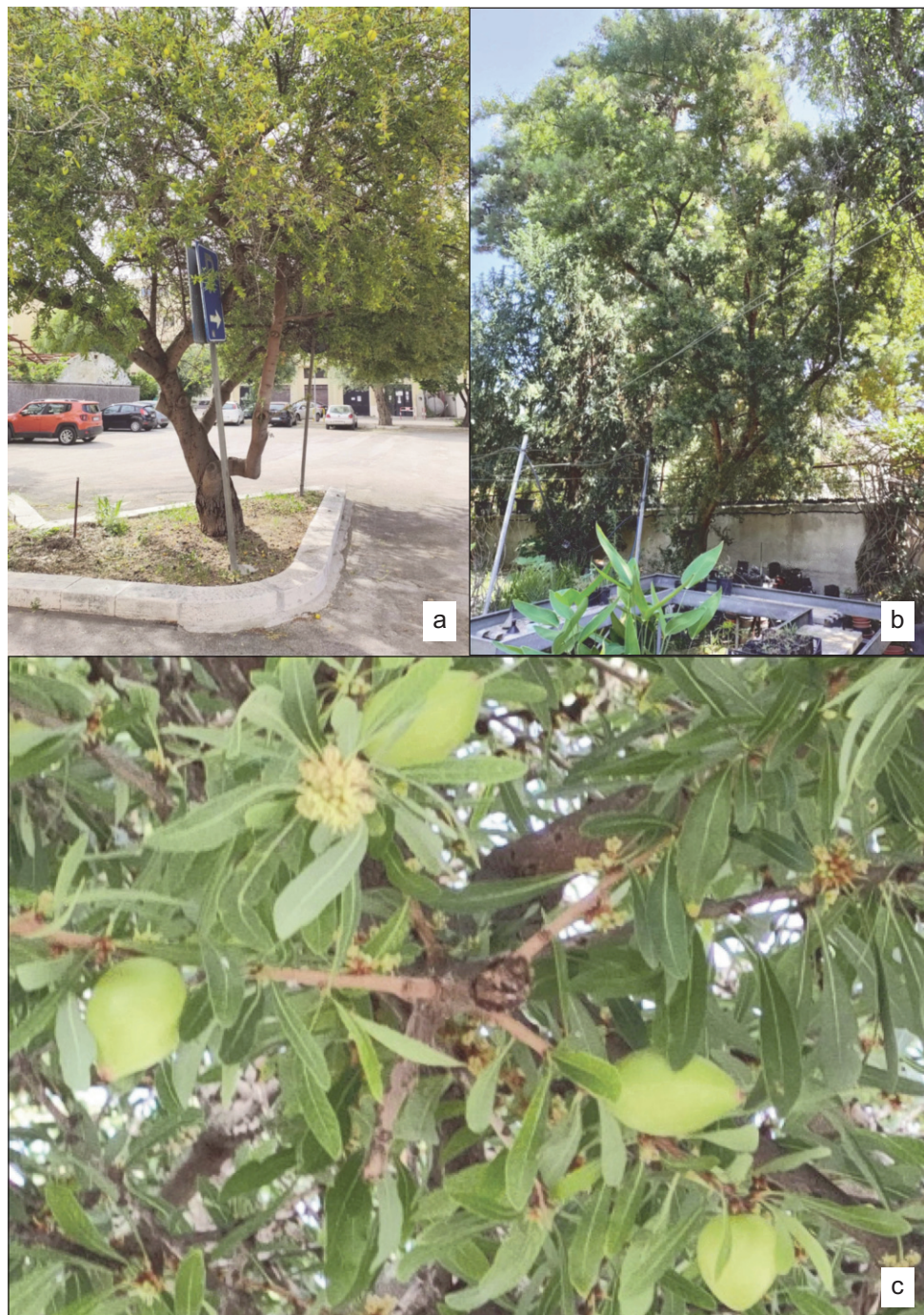


Fig. 1. *Argania spinosa*: a) in the University Campus of Bari; b) in the Botanical Garden of Bari; c) detail of flowers and fruits.

Table 1. Climatic parameters of the suitability classes realized.

Suitability	Annual Temp. (°C)	Min. Temp. Coldest Month (°C)	Mean Temp. Coldest Quarter (°C)	Max Temp. Warmest Month (°C)	Annual Rainfall (mm)	Precipitation Coldest Quarter (mm)
Optimal	16.4–18.3	2.8–6.8	10.2–13.2	27.5–31.2	221–307	104–135
Very suitable	15.1–16.3, 18.4–19.5	-0.1–2.7, 6.9–8.2	8.3–10.1, 13.3–14.5	24.0–27.4, 31.3–33.4	163–220, 308–352	79–103, 136–144
Suitable	9.6–15.0, 19.6–23.4	-4.3–0.2, 8.3–10.9	2.9–8.2, 14.6–15.8	22.9–23.9, 33.5–45.1	28–162, 353–579	10–78, 145–210
Non suitable	<9.6, >23.4	<-4.3, >10.9	<2.9, >15.8	<22.9, >45.1	<28, >579	<10, >210

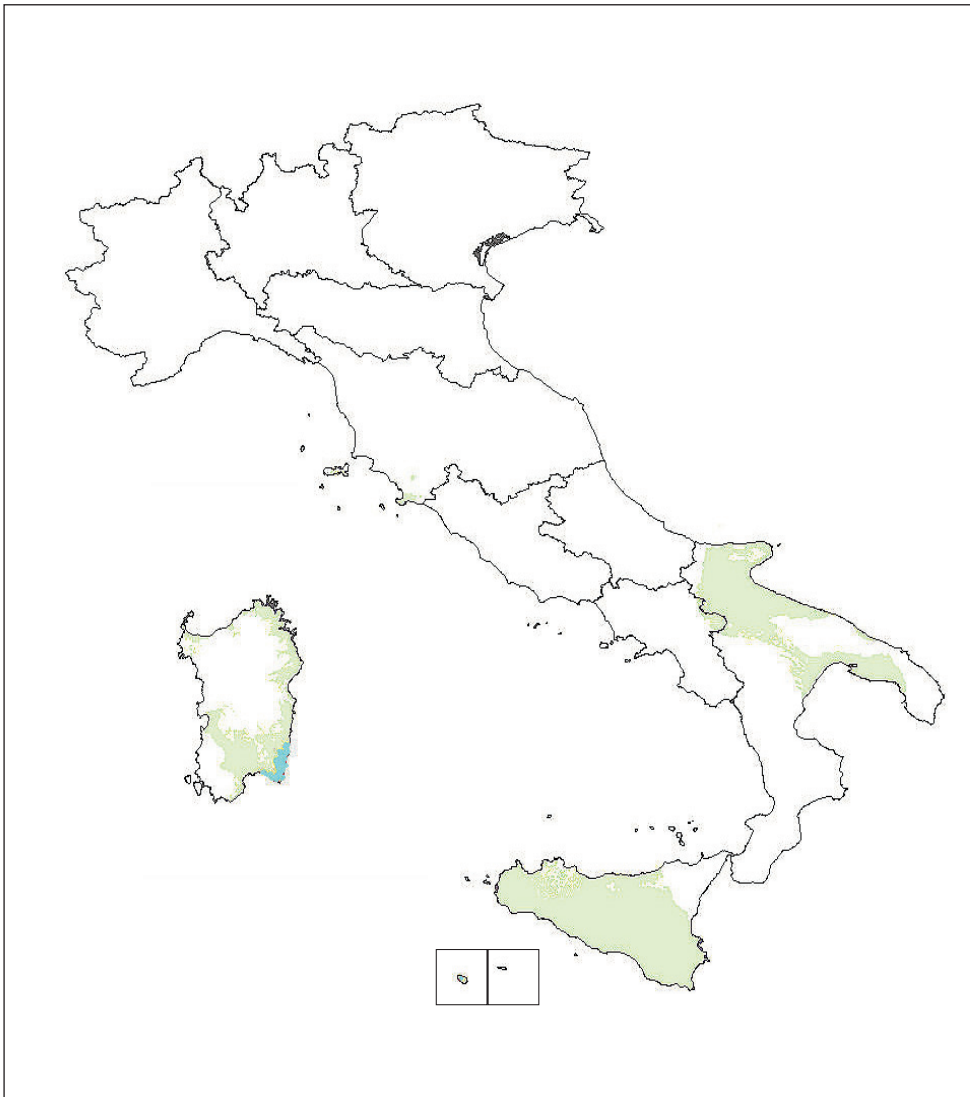


Fig. 2. Areas where the cultivation of *Argania spinosa* is possible in Italy divided into suitability classes: Very suitable in light blue; Suitable in green.

indices of the cells in which the plant is present in Morocco, are more accurate than those presented by Falasca & al. (2018) on the basis of available literature.

It should however be considered that the Argan takes advantage of the occult precipitations derived from oceanic influence which is difficult to quantify.

The successful introduction of this species outside the natural range depends essentially on the degree of similarity of climate in the natural area to that of the new areas with agro-climatic suitability.

Of the four defined suitability classes identified there are no optimal zones for the Argan tree in Italy, and few areas are very suitable for its cultivation in the southeast coast of Sardinia and on the island of Pantelleria. Anyhow, large areas in Sicily, Sardinia and, Apulia are suitable for its use (Fig. 2). The plants grown in Palermo and Bari, which fall into areas classified as suitable, demonstrate the good adaptability of the argan tree in this areas.

Conclusion

Based on observations carried out on the plants cultivated in Bari and the Botanical Gardens of Cagliari and Palermo, it is possible to consider *A. spinosa* as a woody species easily adaptable to the coastal climate of southern Italy and other areas in Mediterranean Europe. The presence of leaves on trees throughout the years shows that the character of deciduous plant, in *A. spinosa*, depends on climatic conditions and that the plant, in a cooler and rainy climate, recovers, recovers its possible nature of evergreen species typical of tropical climates.

An experimentation on the territory, based on these forecasting model, can provide further data on the use of this species for urban green, agriculture in marginal areas and reclamation of deteriorated land in south Italy.

The seeds of the argan plant can be find through commercial channels from the Canary Islands however the acclimatization of the *A. spinosa* plants in southern Italy would provide seeds and material for vegetative reproduction of plants that have already proved to be adapted to the territory for a future use for cultivation and to improve the economy of marginal agricultural areas.

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