Journal of the Association of Arab Universities for Basic and Applied Sciences (2017) xxx, xxx–xxx

University of Bahrain

Journal of the Association of Arab Universities for Basic and Applied Sciences

www.elsevier.com/locate/jaaubas
www.sciencedirect.com

ORIGINAL ARTICLE

The effect of domestication on seed yield, essential oil yield and antioxidant activities of fennel seed (*Foeniculum vulgare Mill*) grown in Moroccan oasis

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Received 20 May 2016; revised 8 November 2016; accepted 24 June 2017

KEYWORDS

Foeniculum vulgare Mill.;
Domestication;
Essential oil;
Antioxidant activity

Abstract The objective of this study is to clarify, for the first time in Morocco, the impact of culture on seed yield, growth parameters, yield and antioxidant activity of seed essential oils obtained from wild and cultivated fennel. The cultivation test was installed according to the principles of organic agriculture in a parcel at the oasis of Oukhite South East of Morocco under a completely randomized design with three replications. The agro-morphological characteristics were evaluated during two successive years (2014 and 2015). The results showed that fennel produces more of seed and total dry matter under culture conditions and both are more important in second year. The best performance of seed yield and total dry matter are 20.53 qx/ha and 199.79 qx/ha respectively. Domestication has not improved the yield and the antioxidant activities of fennel seed essential oils. In fact, wild fennel presented an essential oil yield significantly high (3.67%) compared to cultivated fennel (2.13%). For both applied tests DPPH and reducing power, essential oil obtained from wild plant presented the most important antioxidant power (IC_{50}:10.62 ± 0.33 and 29.49 ± 0.52 mg/mL) compared to that extracted from cultivated plant (IC_{50}:13.08 ± 0.34 and 32.30 ± 0.02 mg/mL). However, fennel cultivation is promising. It will permit to achieve interesting seed yields and may be good alternative to safeguard this species as well as to be used as an antioxidant natural source.

1. Introduction

Foeniculum vulgare Mill. commonly known as Fennel is one of the most important medicinal and aromatic plants in the Mediterranean, in Europe and in Egypt (Kandil, 2002). It is a rustic perennial plant that can stand droughts and it is

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Peer review under responsibility of University of Bahrain.

http://dx.doi.org/10.1016/j.jaubas.2017.06.005
1815-3852 2017 University of Bahrain. Publishing services by Elsevier B.V.

Please cite this article in press as: Abdellaoui, M. et al., The effect of domestication on seed yield, essential oil yield and antioxidant activities of fennel seed (*Foeniculum vulgare Mill*) grown in Moroccan oasis. Journal of the Association of Arab Universities for Basic and Applied Sciences (2017), http://dx.doi.org/10.1016/j.jaubas.2017.06.005

generally considered native to the Mediterranean shore (Rather et al., 2012). However, it has become widely naturalized in many regions of the world, and it is often found on roadsides, in pastures and other cleared areas. The fennel seeds contain:protein (9.5%), lipids (10%), carbohydrates (42.3%), fiber (18.5%), minerals (calcium, potassium, sodium, iron, phosphorus) and vitamins such as vitamin C, vitamin E, vitamin B6, thiamine, riboflavin and niacin (Badgujar et al., 2014; Rather et al., 2012). The stem, fruit, leaf, seed and the whole plant are widely used in many culinary traditions around the world (Özbek et al., 2003; Rasul et al., 2012). It is also used as a spice to add flavor to bread, fish, liquors, ice cream, salad and cheese (Rather et al., 2012). Due to characteristic smell of the anise seeds (Díaz-Maroto et al., 2006). The smell is caused by terpene compounds isolated from its essential oil (Abdallah et al., 1978). Fennel pollen is also a popular spice (Kimberly and Jazmine, 2013) but, it is extremely expensive (Malhotra, 2012). In Addition fennel is used in traditional medicine for the treatment of several diseases (Badgujar et al., 2014). The preparation methods and uses of fennel are well documented in the ethnobotanical literature (Guarrera and Savo, 2013). In fact, some therapeutic and pharmacological proprieties have been attributed to the extract and essential oils of different parts of the fennel such as anti-inflammatory (Choi and Hwang, 2004), hepatoprotective (Özbek et al., 2003), antihirsutism (Javidnia et al., 2003), antitumor (Pradhan et al., 2008), estrogenic (Malini et al., 1984), antistress (Koppula and Kumar, 2013), antioxidant (Singh et al., 2006), antidiabetic (El-Soud et al., 2011), Oculohypotensive (Agarwal et al., 2008), anticarcinogenic (Mohamad et al., 2011), antiaging (Rasul et al., 2012), antithrombotic (Tognolini et al., 2007), apoptotic (Bogucka-Kocka et al., 2008), antiulcérogenic (Birdane et al., 2007), antibacterial (Ghouati et al., 2014; Lo Cantore et al., 2004), acaricide (Lee, 2004), antifungal activity (Abed, 2007), antispasmodic (Reynolds, 1982). Therefore, it is clear that the whole fennel plant has received renewed interest by medical, culinary and cosmetic industries. In the last few years, demand has increased considerably, especially for organic fennel in Europe, USA, Canada and Japan (Malhotra, 2012). This increase on demand can only be satisfied through cultivation, though 75–90% of medicinal plants marketed in the world always come from wild harvest (Rapporto ISMEA - Osservatorio delle piante officinales, giugno, 2013). Moreover, the drug and pharmaceutical industry, preferred cultivated plant material of aromatic and medicinal plants because it is easier to control production in terms of quality and quantity. This also provides opportunities for its diversification. The use of cultivated plants essentially eliminates problems such as adulteration or misidentification of material (Lubbe and Verpoorte, 2011).

The fennel by-products in oasis environment are qualified to be used as fodder for livestock specifically for sheep breed named "D'Man" known for its prolific and lactating qualities as the fennel promotes the secretion of milk due to its properties galactogogues (Agarwal et al., 2008). In addition, biomass fennel can be used to extract natural dyes that can be applied in the textiles industry as an alternative to synthetic dyes (Haddar et al., 2014). Moreover, Rao et al. (2010) reported that fennel residues, after the extraction of essential oil, can be used to sequester Cd cadmium (II) ions from waste water.

In fact, fennel domestication, which grows in a wild sate in oasis, would ensure a regular and sustainable supply of this plant and in a long-term would guarantee ex situ conservation of this species which is threatened with extinction, under the combined effect of population pressure and climate aridity. Furthermore, the effect of cultivation on contents of fennel seeds essential oils and their antioxidant activities has not been widely studied, especially in the oasis environment where this species is wide spread.

The present work intends to examine the impact of domestication on seed yield, growth parameters as well as yield and antioxidant activities of essential oils obtained from seeds of wild fennel and fennel cultivated based upon principals of organic agriculture principles in the Moroccan oasis.

2. Material and method

2.1. Plant material

The seeds of wild fennel (Foeniculum vulgare Mill) were collected at the beginning of October 2014 from 40 tufts (each tuft contains 6–25 individual) with an interspace in the range 5–30 m, belong to the natural population located in Gourama, Southeastern Morocco (N 32 °18′25.719″ W 3 °58′59.281″), at an altitude of 1277 m where the soil is sandy clay. The total rainfall recorded in the collection site during the period framing, from September 2013 until October 2014, of the crop cycle is 139 mm. the collected seeds are stored in a refrigerator at 4 °C until use.

2.2. Experimental assay

The cultivation of wild fennel was carried on January 21st, 2014 in a plot set fallow for the previous 4 years, located in the oasis of Oukhite Southeastern Morocco (N 31 ° 27′21″-W 4 ° 36′19″) at an altitude of 909 m above the sea level. The plot of our experiment is located in an isolated farm, which makes it optimal for organic production. The type of the soil was sandy loam (according to USDA soil textural classification) (80% sand, 5% clay and 15% loam) containing 0.63% of organic matter, 0.06% of total nitrogen 0.82 meq/100 g of potassium, 75 mg/kg of available phosphorus and having a pH of 8.58. Fennel was cultivated according to the principles of organic farming. Thus, no chemical inputs were used. The plot was organically fertilized (2.2 tonne/ha) (Table 1). Each elementary plot consisted of 6 lines of 5 m in length with a space of 25 cm between the lines. Fennel seeds were sown manually in line with sowing dose calculated to be 12 kg/ha and irrigated by a drip system every two days

Table 1 Characterization of organic fertilizer used in the study.

Compounds	Value (%)
Total nitrogen	5
P_2O_5	5
K_2O	8
MgO	2
CaO	4
Trace elements (Fe, B, Zn, Mn, Mo)	0.2
Organic matter	60
Moisture	8

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