



Impact of the Climate Change on Jojoba Cultivation

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Abstract

Jojoba (*Simmondsia chinensis* (Link) Schneider) one of the xerophyte plants belonging to Simmondiaceae family, it is a perennial evergreen woody shrub that grows up to (2-4 m) height, that produces small seeds which contain precious liquid wax. Jojoba could play a significant role in protecting the environment and provide proper income for a poor community in marginal lands. Jojoba tolerant for salinity, high temperature, and drought stresses. In addition, jojoba tolerates irrigation with different types of water and could grow in all types of soil with good drainage except heavy clay soil. There are numerous benefits of jojoba cultivation include develop the marginal lands in arid and semi-arid regions, improve local communities' income, protect the environment, fighting desertification.

Keywords: Climate Change; Drought; Jojoba; Marginal Lands; Soil Salinity

Introduction

Due to the climate changes, there is more stress on cultivated lands particularly in arid and semi-arid regions worldwide. Rising temperature, drought, salinity, Greenhouse emission, and malnutrition considered the main adverse conditions affect plant growth. In the same time, there are wide areas of marginal land not used economically because of the high cost to reclaim. Furthermore, the local communities in these areas typically suffering from poverty and low income and are vulnerable to threats related to food security [1]. Desertification and marginal lands become a constraint for developing countries, increasing salinization of soil and water resources in different regions was a result of both climate conditions and human activities like excessive use of fertilizers, continual application of irrigation water, over-extraction of groundwater, and incorrect drainage [2].

Jojoba or hohoba (*Simmondsia chinensis*) is a perennial deciduous (single-sex) evergreen woody oilseed shrub, belonging to the family Simmonsiaceae. Jojoba is native

to the Mexican Sonora desert and in the South-West of the United States, the vegetative system jojoba shrubs consists of several stems that make up a circular shrub Figure 1.



Figure 1: Field image for jojoba shrubs in Egyptian desert 2021.

Jojoba is a desert plant grown in the Arid and semi-arid region [3]. It tolerates extreme conditions, hot weather, and high soil salinity. For instance, jojoba can tolerate salinity up to 6000 ppm, also, the plants hold a temperature of -5 to 50 C to grow and production. In addition, the plants are characterized by their high resistance to little water, and other harsh conditions of arid lands. In addition, it is growing well in different types of soil with good drainage from light-textured soils to clay soil [3,4].

Jojoba has promising economic potential due to its fruit, which is composed of high-quality liquid wax that reaches up to 50% of seed weight approximately. There is a rapid growth in the global production of jojoba due to increased demand for jojoba oil in the global market, which is expected to continue over the next decades. Jojoba is used in different industries like cosmetics, medical, and lubricant producing industries; it has been used to produce biofuel [5]. For that, Jojoba production is considered one of the most practical solutions for marginal land development mainly in Africa, Asia, and South American countries [6,7]. It is claimed that the cultivation of jojoba on marginal lands will improve the livelihoods of poor communities in developing countries [8]. Jojoba is a drought-tolerant shrub that could be growing under various climatic conditions except freezing.

In addition, it is adapted to malnutrition conditions. So, Jojoba cultivation could play a vital role in developing local communities and reducing poverty in order to enable marginal land-dwellers to maximize their resource management capacities and increase their income to improve their ability to achieve sustained living [9]. Currently, Jojoba has received more attention from scientists and policymakers as an economic crop to protect the environment through using different types of water like brackish water and wastewater without competing for lands and fresh water; hence, it is a suitable crop for developing marginal lands in developing countries [10]. There are various aspects of using jojoba, including producing cosmetics, medicine for treating skin, protecting soil from dilapidation, fighting desertification, and protecting the environment through using brackish water and wastewater in irrigation and decreasing the emission of carbon dioxide.

Botanical

Jojoba (*Simmondsia chinensis* (Link) Schneider) sole species in Simmondsiaceae family is classified as a dicotyledonous perennial woody evergreen plant that is native to the Mexican Sonora desert and growing naturally in the South-West of the United States. Jojoba annually produces small seeds covered with a somewhat thick brown shell [11]. Which contain liquid wax; furthermore, the economic value of this plant has been known for several years as it contains 40-50 % of its weight

pure liquid wax (commercially known as jojoba oil) similar in specifications to cod liver oil. Jojoba bush grows up to (2-5 m) height (Figure 1). It reaches a diameter of about 2.5 m and it has more than one main stem, many branching and circular in shape with a wide, dense crown [12]. Leaves are oval grey-green waxy thick leaves that reach 2-3.5 cm long and 1-1.7 cm width (Figure 2), covered with fine, waxy hairs to reduce water loss, carrying opposite and vertical on the branches, which minimize exposure to sunlight [13,14].



Figure 2: Jojoba leaves Photo by Dr. Abobatta [13].

The plant has a strong root system consisting of a deep wedge root that may reach a length of more than 10 meters down, and a group of non-superficial lateral roots branch from the rootstock which increase the surviving rate under high temperatures and drought conditions [13]. The plant is characterized by that the root system may reach a length of more than ten times the vegetative growth, depending on the quality of the soil, the ability of the roots to penetrate it, and availability of irrigation water [15]. The feminine jojoba flowers are odorless and their colors are not attractive to insects. Therefore, the pollination process is carried out by the wind, due to the pollen grains and their shape, which helps to move distances of more than 1000 meters. The jojoba fruits are of the can type and are carried sideways on the modern branches. The fruit is usually single, sometimes even, or in clusters, the number of fruit ranging from 2 to 10. Jojoba seeds are rich in liquid wax, commonly mistaken for jojoba oil [16]. The physical properties of jojoba oil are: high viscosity, high flash and fire point, high dielectric constant, high stability and low volatility. Jojoba oil is very popular in the cosmetics industry as it's used in the manufacture of engine oil especially air craft engines.

Propagation

Jojoba is propagated by various techniques, seedly or vegetative cuttings, that including stem cuttings, grafting, and tissue culture. While stem cutting considered the most proper method to produce high-yielding plants. Jojoba could be propagated by seedy and vegetatively techniques that including stem cuttings, grafting, and tissue culture [12]. To improve rooting of stem cutting, preferable treating cutting with exogenous hormones like IAA, in addition, choose cutting with thickness about 5-7 mm during dormancy period [3]. Propagation by seeds by sowing seeds directly in the field easier but produce high male plants ratio which could reach up 50% which causes missing in yield production with undesirable characters of female plants, while, using various vegetative propagation technique could avoid this problem and produce healthy plants with high seed production [17].

Jojoba and Climate Conditions

Due to harsh climate conditions that include rising temperature, increase drought and decrease perception, elevating carbon dioxide, etc, there is water scarcity particularly in arid and semi-arid regions which reflected in increased soil salinity. Therefore, there is more attention to use all water types like saline water and treated wastewater for agriculture [1]. So, looking for plant adapted for such water types become reliant in arid and semi-arid countries, whereas, there are wide areas of saline desert in these regions that rarely used. Thus, non-edible crops such as jojoba and *Jatropha* represent a good potential crop to using different types of water to developing these areas, produce valuable products, and protect the environment from pollution of [18].

Temperature

Jojoba classified as a desert plant that tolerates high temperature and harsh conditions includes drought, high temperature, salinity, malnutrition, etc., while, it could tolerate low temperature for short period but cannot tolerate freezing. Jojoba grows in warm regions with temperature ranging from 20 to 27°C which considered the ideal temperature for the growth and productivity of jojoba [3]. Furthermore, Jojoba has a high ability to adapt to high temperature, jojoba could grow in a wide range of temperature ranging from 13 to 42°C, as the high temperature stimulates the vegetable growth, which is positively reflected on enhancing produces dry matter that increases the quantity and quality of the produced oil. Therefore, jojoba could be growing satisfactorily under aridity conditions, so, it could be exploited by the introduction as an economic crop for developing marginal lands in arid and semi-arid regions furthermore, jojoba has more attention to cultivation in

various arid countries like Australia, Argentina, Chile, Peru, Egypt, and Israel, also, jojoba grown in South Africa and India [19].

Soil

Due to Jojoba nature, it could grow in various soil textures including rough, light, and medium textured, sandy, or gravelly soils, while sandy soil that contains low organic matter considered the proper soil for jojoba growth (Figure 3). Furthermore, Jojoba growing with moderate pH ranging from 5 to 8.5 in different soil types ranging from rough sandy soil to clay soil with good drainage [20]. From another side, Jojoba cannot grow under flooding conditions, therefore, all waterlogged clay soil improper for jojoba cultivation and must be avoided from any planning for jojoba planting.



Figure 3: Jojoba shrubs in Egyptian farm Photo by Dr. Abobatta.

The jojoba requires minimum nutrients of established and maintained during the first stages of its cultivation, so, it could grow under poor nutrients conditions, also, jojoba could tolerate salinity up to 6000 ppm without loss crop and could grow up to 10000 ppm as hedges or to protect the new communities and fight desertification [21].

Water Requirement of Jojoba Plants

Jojoba plants are considered as dry trees that do not need large a moment of water. Jojoba water requirements very low compared to other oily crops, jojoba tolerates drought conditions while regular irrigation during growth season improves seeds productivity, adult jojoba shrubs need about 500-600 mm water yearly due to the deep root systems and tolerance of both arid and saline conditions [15]. The water requirement of jojoba plants ranged between 50 to 70

liters of water per week in summer and between 10 to 30 liters of water per week in the winter [3]. A mature shrub would survive for a whole year without being watered jojoba particularly tolerates salinity up to 3000 ppm without any impact of the yield [22]. Jojoba could tolerate irrigation with various types of water including marginal water like brackish water, treated wastewater, and moderate salinity water (Figure 4), which not proper for edible crops.



Figure 4: Jojoba seedlings irrigated with saline water in Egyptian desert Photo by Dr. Abobatta.

The Effect of Salinity Irrigation Water on Jojoba Growth

Jojoba is a drought and salt-tolerant plant average, it is known that jojoba trees stand harsh conditions of salinity and drought, whether it is the salinity of soil or the salinity of the water, also, salinity affected the water status of the plant by reducing water potential. It was found that salinity barely inhibited the rate of net photosynthesis. Although it did affect stomatal conductivity reducing it by about 50 % [23]. The growth of Jojoba was not greatly affected by salinity, due to jojoba ability to accumulate sodium and chloride ions in their leaves (Figure 3) and use as strategy typical of many halophytes to cope with salinity [24]. Some woody plants exhibit varied salt tolerance, for example, only a small effect on canopy volume was reported for Valencia oranges grown under salinity of 2.5 dsm^{-1} for two years [25]. Benzioni, et al. [26] showed that, NaCl is preferentially damage. Jojoba resembles crops like cotton or typical halophytes [27]. Salinity of 3000 to 10000 ppm would negative affect on the plant.

Fertilizing

The jojoba could grow with a minimum quantity of nutrients

and maintenance in the first stages of its cultivation, although, proper fertilization increase jojoba tolerant for abiotic stress, and improve seedlings survival rate under harsh conditions [28]. While, proper fertilizing enhancing flowering, fruit set, and increase yielding. Furthermore, jojoba respond to fertilizing application, so, sufficient fertilizing particularly Nitrogen and phosphorus of adult shrubs could improve growth, seed development, and high yield [29].

Flowering and Productivity

The jojoba plants are dioecious (unisexual) and the female jojoba flowers are odorless and their colors are not attractive to insects. Therefore, the pollination process is carried out by the wind, and the lightness of pollen grains and their disc shape helps them to be transported by the wind for distances of more than 1000 meters. Flowers bud initiation occurs in autumn, white, flowers form in the winter and after fruit set, continuously grow and reach maturity stage in July or August depending on the climate conditions. The fruits of jojoba are box-type and are carried sideways on new branches, the fruits are usually single, sometimes even, or in clusters, the number of fruits ranging from 2-10 fruits. The fruit of jojoba usually contains one seed that is elongated and of a circular diameter, but it may sometimes have two semi-circular seeds, and the number of seeds in the fruit depends on the number of ovules that are fertilized, as the ovary of the female flower contains three carpels (each with an ovule) can form 1-3 [30].

Seedlings start flowering from the third year after cultivation with an small quantity of seeds about 250-350 g of seeds per tree. Fully-grown trees could produce up to 1-3 kilos of seeds per tree during the eighth year depending on various factors. An acre with 700 females produces an average of 1 ton of seeds. Production increases proportionally with the life cycle of the plant. The seed skin dries, shrinks, splits and hundreds of seeds drop on the soil below where they can be collected. Seeds can be left uncollected for several months or get stored for several years without any impact on the oil that resists oxidation even under harsh conditions. Jojoba is typically hand collected and is vacuumed in large farms [31].

Insects and Diseases of Jojoba Trees

Jojoba is infected with about 100 types of insects, but all of them do not pose and danger and may not require the use of pesticides. Jojoba is also infected with some fungal diseases such as Alternaria, Fusarium and phytophythra [32]. The risk of fungal diseases increases when the relative humidity and poor aeration of the soil are also exposed. Jojoba is also exposed to attacking birds and rodents, but it is ineffective. It has been proven that the jojoba plant rarely needs preventive of curative spraying, as the plants have not been infected

since their cultivation until now with insects or diseases that require intervention [33], also, sometimes, under harsh conditions, locusts and grasshoppers attack jojoba plants, so, chemically control used to protect the shrubs.

Economic Benefits of Jojoba

The economic importance of jojoba due to its seeds contains a soluble wax usually called jojoba oil, reach up to 40 to 50% W/W approximately and considered similar to Whale sperm oil. There is more global interest in jojoba cultivation as an oily shrub that produces a unique type of oil, offer-promising properties and completely different from all vegetarian oils, as it is completely free of glycerol. Thus, remains a liquid wax and does not turn into solid fat, which allowing to be used in multiple fields like cosmetics, pharmaceuticals, and lubricants. Moreover, its uses as a replacement of sperm whale oil, while, the pressing cake waste used as compost in the agricultural sector [34], Jojoba oil is used for various industrial purposes like manufacturing candles, soaps, varnishes, and as a lubricant, also press seedcake is used to produce compost or stock-feeding after removing semmondsin compound [3]. Due to low requirements of establishment of jojoba, it could be profitable under marginal land conditions even at reasonable prices, therefore, Jojoba considered the ideal crop for developing the marginal land in different areas worldwide particularly in developing countries in different regions like Africa, Asia, and South America. Jojoba offers promise for agriculture in harsh environments where many other crops cannot survive [35].

Jojoba Advantage

There are numerous benefits achieved from cultivation in one wonderful jojoba include:

- Jojoba considered one of the most practical and scientific solutions for marginal land development.
- Jojoba tolerate harsh conditions include (degradable soil, hot summers, poor nutrient soil, irrigated with low-quality water, and tolerate salinity up to 6000 ppm).
- Jojoba has great potential to use for rehabilitation as the provision of income to the poor communities.
- Jojoba has been used to fighting desertification.
- Long life span, over 100 years in some cases.

Conclusion

Jojoba (*Simmondsia chinensis* (Link) Schneider) shrubs tolerate various abiotic stress like rising temperature, drought, salinity, heat waves, but cannot tolerate freezing or flooding for long time. Jojoba grow in different types of soil with good drainage and Jojoba could tolerate irrigation with various types of water like brackish water, treated wastewater, and

moderate salinity water, which not proper for other crops. Jojoba could play an important role in developing marginal lands particularly in developing countries, protecting the environment and fighting desertification.

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