

## Prospects of Moringa Cultivation in Saudi Arabia

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Received: January 1, 2014

Accepted: February 8, 2015

### ABSTRACT

The Moringa is a fast-growing evergreen or deciduous, multipurpose tree species comprised of 13 species. They are thought to be native to India from where they have been introduced in many different tropical and subtropical countries and are now growing throughout the world including Saudi Arabia (*Moringa peregrina* - a native species). Moringa tree is regarded as an excellent source of nutrition for human food and as treatment of many different ailments in the indigenous system of medicine for human diseases. Leaves, green pods, flowers and roasted seeds are used as vegetable; roots are used as spice; seeds are used for cooking and cosmetic oil. Plants contain important preventive and curative compounds, which are being used as antimicrobial agent. Moringa plants are also used for many other purposes like water purifier, green manure, mycotrophic plants, reforestation, alley crop, gum, ornamental, pest control, animal feed etc. Because of its numerous economic importances, easy propagation and sustainability for cultivation under a wide range of climatic and soil conditions; the plant is suitable for cultivation in Saudi Arabia. The plant is highly drought tolerant and is widely cultivated in arid and semiarid regions. It can be cultivated in a wide range of soil type, but prefers a well-drained sandy loam or loam soil. It tolerates a soil pH 5.0–9.0 with an optimum of 6.3-7.0. Moringa is resistant to most pests and diseases. All these environmental factors and soil conditions are highly favorable for cultivation of Moringa in Saudi Arabia. *M. oleifera* another widely cultivated species, may be introduced along with the native species as a future crop in arid and semiarid conditions in Saudi Arabia for economic importance as well as for reducing the desertification. Further studies on population ecology and genetic variation are very important to help protect this valuable tree in Saudi Arabia.

**KEYWORDS:** Prospect, Cultivation, Moringa, Saudi Arabia.

### INTRODUCTION

The genus *Moringa* (Moringaceae family), a fast-growing evergreen or deciduous, multipurpose tree species comprises of 13 species<sup>[1]</sup> and is well known for its various medicinal properties; antimicrobial activities; excellent nutritional value for human food; animal feed, fodder, forage and green manure from leaves; animal food and fertilizer from treated seed-cake; fuel wood; oil from seeds as industrial use; reforestation; environmental use (agroforestry, boundary, barrier or support, shade and shelter); used as materials (carved material, dye/tanning, essential oils, fiber, gum/resin, lipids, wood/timber, rope etc ) from tree trunks; ornamental; pest control; water purification, honey and sugar cane juice-clarifier from powdered seeds, biopesticide ; a source of vegetable oil etc<sup>[2, 3, 4, 6, 7, 8, 9]</sup> especially different plant parts (leaves, roots, seed, bark, fruit, flowers and immature pods) are being used for the treatment of different ailments in the indigenous system of medicine<sup>[6, 7, 10, 11, 12]</sup> in many different developing countries of the world.

Moringa originated in the Indian subcontinent and then distributed into many different tropical and subtropical countries of the world including Saudi Arabia (*Moringa peregrina* - a native species). *M. oleifera* Lam is the most widely cultivated species, which is indigenous to south Asia<sup>[13]</sup> and was introduced and became naturalized in other parts of the world<sup>[3, 9, 14]</sup>. Because of multifarious use and medicinal properties as well as environmental importance, the tree is known as Miracle Tree or Tree of Life. So there is an urgent need to assess the prospect of Moringa cultivation in the Kingdom of Saudi Arabia (KSA).

#### Distribution

According to the CABI organization data sheet<sup>[9]</sup> various species of *Moringa* are distributed throughout the world. Moringa are growing either as native or introduced plants in more than 60 different countries: in Asia there are 20 countries, in Africa (18), in North America (3), in Central America and Caribbean (14), in South America (3) and in Oceania (4). The fast growing plants were utilized by the ancient Romans, Greeks and Egyptians; it is now widely cultivated and has become naturalized in many locations in the tropics<sup>[3, 14]</sup>. Moringa is thought to be indigenous to India, Pakistan, and Bangladesh. From India, they have been introduced to many different tropical and

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subtropical countries and is now growing throughout the world including Kingdom of Saudi Arabia (KSA) (*Moringa peregrina* - a native species <sup>[13, 15, 16, 17, 18, 19]</sup>). *M. oleifera* is the widely used species out of the thirteen species (*M. oleifera*, *M. arborea*, *M. borziana*, *M. concanensis*, *M. drouhardii*, *M. hildebrandtii*, *M. longituba*, *M. ovalifolia*, *M. peregrina*, *M. pygmaea*, *M. rivae*, *M. ruspoliana* and *M. stenopetala*), recognized so far in the genus *Moringa* of family Moringaceae<sup>[1]</sup>.

Saudi Arabia is one of the main native distribution areas of *M. peregrina* in the Middle East <sup>[20]</sup>. Considerable research was done in Saudi Arabia with *M. peregrina* to understand the distribution and ecology of the plants, nutrient status and medicinal properties, threats and conservation status, protection and sustainable use of the plants <sup>[see 15]</sup>. In Saudi Arabia, *M. peregrina* is mainly distributed in South and North Hijaz along the Red Sea coast north of Jeddah <sup>[21]</sup>, and extending south of Jeddah to Yemen boundaries. The plants are also available in Fayfa Mountains <sup>[22, 23]</sup>, Medina <sup>[24]</sup>, Al-Wajh <sup>[24, 25]</sup>, Tabuk <sup>[25, 26]</sup> and Al Ula<sup>[27]</sup>. In addition, the tree is also observed in 'Uruq Bani Ma'arid, a protected area located along the western edge of the Rub' al-Khali <sup>[28]</sup>.

### Common uses and ecosystem services

Almost all parts of the plants are used as nutrients and vitamins for human consumption as well as for fodder. *Moringa* has many other different uses. It is generally known in the developing world as a vegetable, a medicinal plant and a source of vegetable oil <sup>[7]</sup>. According to Fuglie<sup>[4]</sup> and Adebayo *et al.*, <sup>[2]</sup> the plants are used for ecosystem services (such as erosion control; soil improvement; ornamental; boundary/barrier/support; intercropping; pollution control etc.) and also as animal forage, biogas, fuel, domestic cleaning agent, blue dye, fencing, fertilizer, foliar nutrient, green manure, gum, honey and sugar cane juice-clarifier, medicine, biopesticide, pulp, rope, tannin, water purification etc. Various parts of this plant such as the leaves, roots, seed, bark, fruit, flowers and immature pods act as cardiac and circulatory stimulants, possess antitumor, antipyretic, antiepileptic, anti-inflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol lowering, antioxidant, antidiabetic, hepatoprotective, antibacterial and antifungal activities and are being employed for the treatment of different ailments in the indigenous system of medicine <sup>[see 6, 10, 11, 12]</sup>. The seeds are also eaten green, roasted, powdered and used for tea or in curries and also for oil extraction. This tree has been advocated in recent times as an outstanding indigenous source of highly digestible protein, calcium, iron, vitamin C and carotenoids suitable for utilization in many of the so-called developing regions of the world where undernourishment is a major concern <sup>[29]</sup>.

### Cultivation

#### Climatic conditions and soils

*Moringa* is an important multipurpose tree species that has been observed to be well suited to all kinds of soils and wide range of environment, especially tolerant to poor soils of arid and semi-arid regions. In general, according to the information provided by <http://www.cabi.org/isc/datasheet/34868>, 2014 <sup>[9]</sup> for the growth of *Moringa*, the absolute minimum temperature is (-1°C), mean annual temperature (25-27°C), mean maximum temperature of hottest month (32-40 °C), mean minimum temperature of coldest month (4-10 °C), rainfall: dry season duration (0-6), mean annual rainfall (300-2500mm), soil reaction: acid, alkaline or neutral, soil texture: heavy, light or medium. *Moringa* can tolerate humid tropics and can grow in hot dry lands; it can survive adverse soils conditions and a pH of 5.0–9.0 <sup>[31]</sup> and is little affected by drought <sup>[30]</sup>

*M. peregrina* growing in KSA is adapted to wide range of environmental conditions <sup>[28, 32]</sup>. The tree was found 0-300 m above sea level and on hillsides of upper escarpment areas (1600-2200 m above sea level) on hard sandy-silty and sandy stony soil, respectively. It was found together with *Acacia asak* and some succulent shrubs such as *Aloe* spp. and *Euphorbia* spp. <sup>[22]</sup>. According to Cossalter <sup>[33]</sup> *M. peregrina* is a drought resistant tree, may be due to its xerophytic characteristics and modification of its leaves and stem <sup>[34]</sup>. This drought tolerance was also observed in newly germinated *M. peregrina* <sup>[35]</sup>. The drought resistant characteristic of *M. peregrina* will facilitate these plants to grow in arid and semi-arid regions, where water deficiency is a major problem.

#### Methods of cultivation

Methods for cultivation of *Moringa* plants are yet to be fully explored. International interest is growing because of its numerous economic importance, easy propagation and sustainability for cultivation under a wide range of climatic and soil conditions. The plant is propagated by planting limb cuttings 1-2 m long, from June to August. It can also be propagated by seed. Tissue culture methods may be used for large-scale cultivation of *Moringa*. The plant starts bearing pods 6-8 months after planting, but regular bearing commences after the second year. The tree bears for several years. It does not tolerate freeze or frost. As with all plants, optimum cultivation depends on producing the right environment for the plant to thrive. *Moringa* is a sun and heat loving plant. Seeds are planted an

inch below the surface and can be germinated year-round in well-draining soil. India is the largest producer of Moringa, with an annual production of 1.1 to 1.3 million tones of tender fruits from an area of 380 km<sup>2</sup>. Tamil Nadu is the pioneering state insomuch as it has varied genotypes from diversified geographical areas and introductions from Sri Lanka. Moringa is common in India, where its triangular, ribbed pods with winged seeds are used as vegetable crop. It is particularly suitable for dry regions. Moringa can be grown using rainwater without expensive irrigation techniques. The yield is good even when the water supply is not sufficient and the tree can be grown even on land covered with 10-90 cm of mud [36].

### Pests and diseases

Moringa is resistant to most pests and diseases but outbreaks may occur under certain conditions. The species is not affected by any serious diseases in its native or introduced ranges, although several diseases causing minor damage to trees growing in southern India have been reported, including a root rot caused by *Diplodia* sp. [18]. A new disease of drumstick edible pods of *M. oleifera* in Maharashtra was caused by *Drechslera* [*Cochliobolus*] *hawaiiensis*, a previously unreported host [37]. Mandokhot *et al.*, [38] reported a new disease of *M. oleifera* in India. The disease was caused by *Fusarium pallidoroseum* and it has been reported for the first time as the causal agent of twig canker on *M. oleifera*. The tree is the collateral host of *Leveillula taurica*, a powdery mildew that causes serious damage in papaya (*Carica papaya* L.) nurseries in south India [39].

Although the Moringa tree is rarely attacked by insect pests but the reports indicated the attack and damage by several insect pests: namely bark eating caterpillar (*Indarbela quadrinotata*); caterpillar pests (*Eupterote mollifera*) and *Noorda blitealis*); bud worm (*Noorda moringae*); stem borers (*Indarbela tetraonis*, *Diaxenopsis apomecynoides* and *Batocera rubus*); ash weevil (*Myllocerus viridanus*); aphids, aphid (*Crassivora Koach*); leaf eating caterpillars (*Tetragonia siva*, *Metanastria hyrtaca* and *Helopeltis antonii*); bud midges (*Stictodiplosis moringae*); scale insects (*Diaspidiotus* sp., and *Ceroplastodes cajani*) [18, 30, 40, 41, 42, 43, 44, 45, 46]. Recently, Mahesh *et al.* [47] reported first time from India drumstick pod fly, *Gitona distigma* as a pest of Moringa, which has become one of the most serious pests of the crop with infestation starting from fruit initiation and persisting till harvests causing very heavy losses especially under poor management conditions. Similarly, Ojiako *et al.*, [48] identified several nursery insect pests of *M. oleifera* Lam. in Owerri, Nigeria, but added that such attacks were of non-significant nature. Several other insect pests causing minor or only occasionally serious damage have also been reported. In Puerto Rico, the tree is reportedly very susceptible to attack by termites and the seed to unidentified insect [43].

### Conservation Status

According to Robiansyah *et al.*, [15] the conservation status of Arabian *M. peregrina* is unknown due to the absence of study assessing the population size and structure, population trend, occurrence and occupancy areas, and threats associated with the species. In general, the species has also not been assessed for the IUCN Red List. Populations in Egypt, however, are reported to experience rapid decrease mainly due to over-harvesting for fuel and medicinal uses, over-grazing by animal and habitat destruction by unmanaged human activities [49]. Robiansyah *et al.*, [15] also mentioned that the same population decrease may already happen to the Arabian populations as human populations is steadily increasing, which in turn may affect the natural ecosystems of the country.

## PROSPECTS

Moringa is an important multipurpose agro-forestry tree species, well suited to all kinds of lands and wide range of environment and grown in poor soils of arid and semi arid regions and adapted to the warm, frost free, tropical dry conditions. *M. peregrina* - a native species is well adapted in part of the Kingdom. Plantation of this species and other widely cultivated species (*M. oleifera*) may be extended to other parts of the Kingdom of Saudi Arabia as an economic tree and also minimize the desertification under changing climatic conditions and improve the environmental condition of the country.

### Cultivation

Moringa tree could easily and cheaply be cultivated and grown in Saudi Arabia. The soils and climatic conditions for the growth of Moringa must be considered before raising any plantation in KSA. The drought and salinity is a major problem in growing plants under Saudi conditions. To overcome these problems, urgent research is needed to understand how to alleviate the drought and salinity for growth of Moringa. As water is very important in Saudi Arabian agriculture conditions, research may be designed for proper usages of water for irrigation during

summer months. Requirement of nutrient and judicious application of nutrient is to be determined under plantation after assessing soil nutrient status in the prospective plantation sites. The use of fertilizer and regular irrigation is not essential but it grows under irrigation and well fertilization conditions. In Saudi Arabia, studies have shown that the tree contains valuable nutrient and medicinal properties. All these environmental factors and soil conditions are highly favorable for cultivation of Moringa in Saudi Arabia. *M. oleifera* (another widely cultivated species) is a promising candidate for future crop and may be introduced and cultivated in Saudi Arabia not only for environmental importance but also for reducing the desertification.

#### **Non chemical (green) approach of cultivation:**

Non chemical approach means the way of green cultivation with microbial inoculants particularly inoculation of arbuscular mycorrhizal fungi and other beneficial soil microorganisms under nursery conditions to raise mycotrophic seedlings for plantation in the field; and also improve the growth; drought tolerance and alleviation of salinity under field conditions; addition of organic fertilizers under field conditions to improve the soil physical and chemical properties; mycotrophic green manure plants (both legumes and non-legumes) for life mulch; supply of green manure as well as essential nutrients through microbial activities and plant residues. This method of cultivation may be practiced for successful plantation of Moringa throughout the Kingdom. The pest and disease are not a major threat for cultivation of Moringa. That is another plus point to cultivate Moringa in Saudi Arabia.

#### **Common uses in Saudi conditions**

The Moringa tree is regarded as an excellent source of nutrition for human food. Different parts of the plants are used for the treatment of many different ailments in the indigenous system of medicine against a large number of human diseases. The country should promote planting and use of Moringa as vegetable for human consumption. Moreover, each and every house may have one or two Moringa plants in their home state garden to have fresh fruits for home consumption as the plants has lots of medicinal importance including stimulatory effects.

#### **Industrial as well as medicinal use and antibiotic agents**

Moringa seeds are used for the production of good quality cooking and cosmetic oil; the bark of the tree provides gum and tannin. Oil may be extracted from the Moringa seeds for home consumption and industrial use. The seeds contain about 35–40% oil. This oil is of excellent quality, similar to olive oil, and is slow to become rancid. It is used as fuel for cooking purposes and burnt for light in developing countries. It is also used in perfumes, as a lubricant in watches and other fine machinery, and for making soap. The press-cake remaining after oil extraction has been shown to retain the active ingredients for coagulation, making it a marketable commodity as a flocculent. The oil from the Moringa tree is considered to be a more sustainable biodiesel. Plants contain important preventive and curative compounds, which are being used as antimicrobial agent. The traditional medicine may be prepared from the Moringa plants in the country for treatment of common ailments.

#### **Animal feed and fuel**

Under Saudi field condition, the plants may be a potential source of forage for free ranging native and domestic animals and may provide feed for camel and other animals as well as a source of wood products. The leaves of the Moringa tree have become known for their high nutritional content and potential benefits for human consumption. Because these leaves are high in protein and other essential nutrients, they may also provide benefits in livestock feed. Feeding animals with Moringa leaves and green stems can increase cattle's weight up to 32% and milk production up to 43-65%. Moringa also improves the digestibility of other food that cattle eats and improves the health of animal. As fast growing plants, Moringa provides lots of dry materials under desert environment. In other parts of the arid world, the plants are being used for fuel and medicinal uses, grazing by animal etc. The local desert community and wood pickers may have fuel wood for their consumption from the plants. Also the people who are having day out for spending time in desert environment can get fire wood from the dry materials of Moringa.

#### **Ecosystem services**

Moringa may provide the following ecosystem services under Saudi conditions:

**Soil improver as green manure and seed cake as fertilizer:** Since Moringa are fast growing plants, there is a great prospect of using them as a green manure crops, especially in the plantation crops like Date palm, Olive and others. The green leaves are useful for mulching and dry shaded leaves may act as organic manure. The oil cake from seeds can be used as a soil conditioner or as fertilizer. A green manure crop is grown for a specific period, and then plowed under and incorporated into the soil. Green manures usually perform several functions that include soil

improvement and soil protection: the growing and turning of green manure plants provides additional nutrients and organic matter to the soil. When incorporated into the soil, these plants break down, eventually releasing important nutrients, such as nitrogen, that is necessary for adequate plant growth. It also increases soil drainage and water retention capabilities. In addition to adding nutrients and organic materials to the soil, green manure crops can be grown to scavenge leftover nutrients following the harvest season. This helps prevent leaching, soil erosion, and weed growth and also improves the physical, chemical and biological properties of the soil.

**Reforestation:** In Saudi Arabia, reforestation with Moringa can help in improving environment conditions of the country. Reforestation is the natural or intentional restocking of existing forests and woodlands that have been depleted, usually through deforestation. Reforestation can be used to improve the quality of human life by soaking up pollution and dust from the air, rebuilding natural habitats and ecosystems, mitigating- global warming since forests facilitate biosequestration of atmospheric carbon dioxide, and harvesting for resources, particularly timber.

**Alley cropping:** Alley cropping is broadly defined as the planting of single or multiple rows of trees into a field of crops or forage. The tree rows create protected alleys for the agricultural or horticultural crops. There are numerous roles that alley cropping can play on a farm: e.g. diversify farm products, supplement income, reduce soil erosion from wind and water, improve soil conditions etc. Moringa can be used as alley crops in agriculture crop fields in Saudi Arabia.

**Erosion control, boundary, barrier and support:** The Moringa plants may be suited to control soil erosion in areas where strong winds and long, dry spells occur. The Moringa plants may also be planted as hedge crop and provide wind protection, reduce sand storm, barrier in the agricultural crops, shade and support for climbing garden plants. The species is widely planted as an ornamental in many different countries and it may be planted as ornamental plants in KSA. Intercropping with Moringa may provide semi-shade where intense direct sunlight can damage crops may be advocated. By doing all these activities, cultivation of Moringa can generate employment for raising seedlings, tissue culture plantlets, planting, cultivation, harvesting, processing, industrial use etc. in the country.

#### **Use of microbial inoculants for growth and conservation of Moringa in KSA**

High quality seedlings are essential to develop good quality plantations. The quality seedlings may be raised under nursery conditions by inoculating microbial inoculants for rapid growth in the nursery and for survival of seedlings after plantation. This is because microbial inoculants like Arbuscular mycorrhizal fungi and other beneficial microorganisms are an imperative component of soil microbial biomass influencing essential processes at the plant-soil interface. It has been observed that roots of Moringa are colonized by AMF and are considered as a mycorrhizal dependent tree species.

*M. peregrina* is a highly endangered multipurpose tree species in Saudi Arabia and the plant serves as source of food and fodder in desert environment (e, g. Robiansyah *et al.*,<sup>[15]</sup>) It helps in sand stabilization and acts as a source of shade also. But the plants suffer from stresses imposed by arid environment and lack of water and mineral nutrients<sup>[50]</sup>. Arbuscular mycorrhizal (AM) fungi are known to help plants in nutrient uptake and disease resistance<sup>[51]</sup> and offer drought tolerance<sup>[52]</sup>. The capacity of AM fungi to act as biofertilizers, bioregulators and bioprotectors<sup>[53]</sup> has repeatedly been demonstrated. Thus, they play a key role in sustainable conservation of tropical gene pool and diversity<sup>[54]</sup>. AM fungi are well known to bring about biochemical changes in plants by increasing various enzymatic activities<sup>[55]</sup>. Use of AM fungi along with other beneficial soil microorganisms as fertilizer helps in the establishment of plants in arid and semiarid regions and also in the increase of soil fertility by making available phosphorus and nitrogen to the plant. Use of AM fungi as a biofertilizer is a low-cost technique, but results are surprisingly better than the use of chemical fertilizers. So, these results open new prospects on the utilization of AM fungi. Thus, they play a key role in sustainable conservation of tropical gene pool and diversity. This technology may be implied in Moringa cultivation in KSA.

#### **Mitigation of climate change through Moringa cultivation in KSA**

Moringa may be planted in Saudi Arabia to mitigate the climate change situation. Climate change is an important global threat and long-term challenge that may aggravate a further increase in average global surface temperature, atmospheric carbon dioxide concentrations and changes in precipitation as well as altered disturbance regimes. Forest ecosystems can play a significant role in reducing greenhouse gas emissions, capturing carbon in soil and biomass, and reducing the vulnerability of people and ecosystems to the detrimental impacts of climate change. Forest management strategies with Moringa can prove to be promising tools to achieve this stabilization with social, economic and environmental goals in the Kingdom.

## CONCLUSION

Moringa is regarded as a miracle plant having numerous benefits for human being by providing food and nutrition and thus should be taken as a high quality gift of nature. The plant is the most inexpensive and credible alternative to not only providing good nutrition, but also the cure and prevention of a lot of diseases.

Moringa can be cultivated in Saudi Arabia as a drought tolerant plant to save water (need less water for growth) in Date palm, olive and other plantation crops as cover crops and green manure crop to replace the existing cover crops like Alfalfa and others which needs lots of water for their growth.

Moringa may be planted in Saudi Arabia as a forest plant to mitigate the major global threat and long-term challenge for the climate change situation, which is playing a significant role in aggravating surface temperature, atmospheric carbon dioxide concentrations, changes in precipitation etc.

By cultivating Moringa under Saudi conditions, a maximum yield of its different usable parts could be achieved to derive the maximal amount of commodities of a multifarious nature for the welfare of mankind. More research work can be done on humans so that a drug with multifarious effects will be available in the future market.

Saudi Arabia as a signatory to the UN Convention on Biodiversity, needs to have research on population ecology and genetic variation for conservation and further sustainable utilization of the species and to help protect this valuable tree in Saudi Arabia. In this point, also *M. oleifera* a promising species of Moringa cultivated in arid and semi-arid regions throughout the world may be cultivated along with *M. peregrina* (a native species of Saudi Arabia) in Saudi Arabia immediately to improve environmental conditions and preserve ecological balance of the country.

## ACKNOWLEDGEMENTS

This research was financially supported by King Saud University, Deanship of Scientific Research and College of Food and Agriculture Sciences, Research Centre.

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