

Their importance and care from environmental and ethical perspectives

#### **Qur'anic Botanic Garden**

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"In the Name of Allah, the Most Gracious, the Most Merciful"

{Indeed, in the creation of the heavens and the earth and the alternation of the night and the day are signs for those of understanding. Who remember Allah while standing or sitting or [lying] on their sides and give thought to the creation of the heavens and the earth, [saying], «Our Lord, You did not create this aimlessly; exalted are You [above such a thing]; then protect us from the punishment of the Fire}.

Sūratu Āl 'Imrān, verses (190 – 191)



# Foreword



### In the Name of Allah, the Most Gracious, the Most Merciful

Praise be to Allah, and may peace and grace be upon Prophet Mohammed, his family and all his companions.

The Qur'anic Botanic Garden, member of Qatar Foundation, is committed to promoting environmental awareness. In an effort to fulfill such mission, this booklet offers a brief scientific and technical introduction to tree planting and management.

Trees constitute a fundamental component of Qur'anic Botanic Garden, which specializes in the plants and trees mentioned in the Quran and Sunnah. Many Qur'anic verses and Prophetic Sayings make direct mention of trees, as in {"[More precisely], is He [not best] who created the heavens and the earth and sent down for you rain from the sky, causing to grow thereby gardens of joyful beauty which you could not [otherwise] have grown the trees thereof? Is there a deity with Allah? [No], but they are a people who ascribe equals [to Him]"} (An-Naml: 60). This verse indicates that trees form gardens whose beauty provides joy and comfort.

Trees constitute also an essential part of the ecosystem as indicated in the Quran, {"It is He who sends down rain from the sky; from it is drink and from it is foliage in which you pasture [animals.] He causes to grow for you thereby the crops, olives, palm trees, grapevines, and from all the fruits. Indeed in that is a sign for a people who give thought"} (An-Nahl:10-11). As the verse states, trees, which need water to grow, provide pasture for domesticated animals. The verse also notes the diversity of trees in terms of their types, shapes and colors and, as the verse concludes, trees also provide people with the opportunity to reflect upon the greatness of the Creator who bring to existence this ecosystem. The Quran also details the functions of trees as in {"[It is] He who made for you from the green tree, fire, and then from it you ignite"} (Yasin:80). This verse reminds people of the importance and uses of trees, which people often take for granted and rarely remember their duty to appreciate His creation and worship Him.



Trees are also often mentioned in the Prophet's sayings, as he often encouraged people to grow fruit trees for the benefit of people, birds and animals, as in the Hadith, {"If a Muslim plants a tree, and then a bird, a person or an animal eats from it, it is regarded as a charitable gift for him.»} Trees are also used metaphorically in the Sunnah as when the Prophet PBUH likened the believers to trees, {"The example of a believer is like a green tree whose leaves do not fall.»} (Sahih al-Bukhari, 8-73:143, narrated by Abdullah Ibn Omar). Also, one of the miracles performed by the Prophet Muhammad PBUH is when a tree told him about the jinn: {"I asked Masruq, 'Who informed the Prophet about the Jinns at the night when they heard the Quran?' He said, Your father Abdullah informed me that a tree informed the Prophet about them"} (Sahih al-Bukhari, 5-58:199, narrated by Abdullah Ibn Mas'ud).

May Allah accept this publication as an effort aimed to help people think about His creation through brief scientific presentations.

**Fatima bint Saleh Al-Khulaifi** Project Manager, Qur'anic Botanic Garden Doha, January 2015







# Trees: A definition perspective



# 1. Linguistic definitions of trees:

A tree in Classical Arabic is called *shajarah*, and the plural forms are *shajar, shajaraat* and *ashjaar*. A cluster of trees sharing a root is called *shajraa*'. A piece of land that has many trees is called *shajraa*', *shajirah or shajiirah*. Palm trees are not called trees, as Ibn Sayyiduh cites Abi Hanifah in his book "Plants."

Trees are defined as "every plant that stands on a trunk" or "every plant that feeds itself from the ground, whether it survives winter or not."

Arabs distinguish two kinds of trees, *jill al-shajar* and *duqq al-shajar*. The first category includes all trees that maintain their leaves in winter, which is equivalent to "conifers" in modern botany. The latter category has two sub-categories: trees with trunks and canopies that stay dormant in winter and grow new leaves in the spring, and plants that grow from seeds and end their lifecycles by going to seed at the end of the season, such as legumes. In other words, *duqq al-shajar* includes both plants that survive winter, and legumes that do not.

# 2. Scientific definition of trees

Trees are a type of plants distinguished by having roots, a trunk and branches. Size is also a defining feature of trees, as they tend to be much larger than other types of plants, such as grass, shrubs and algae. Trees can be ten meters tall, or more, and they vary considerably in size, as some tree are relatively small, while others are of medium height or massive. Trees, like all other living creatures, need water to survive, but the amounts of water needed vary depending on the tree's age, growth pattern and



Apple, fruit-bearing tree



environment. The characteristics and distinctive features of trees also vary depending on where they grow. For example, trees in our semi-arid environment, such as Christ's thorn and Umbrella Thorn, have adapted to grow and flourish despite the scarcity of water and summer heat.

Trees are not seen as seasonal or annual plants; they are stable ecological features that last for decades. The surrounding environment may change, but trees can stay stable. There are many different kinds of trees, but most trees fall under one of two categories: deciduous trees, which shed their foliage seasonally, and coniferous trees, which are mostly needle-leaved or scale-leaved evergreens.

Trees also include a wide array of fruit-bearing plants. In fact, most fruit-producing plants are classified as trees. Trees also produce large quantities of substances with medicinal properties that are vital for the pharmaceutical industry. These substances are collected from tree roots, leaves, trunks and even the bark, as in the case of willow trees.

# Trees in the Quran and Prophetic Tradition

In the Quran and Sunnah, the word "tree" and its derivatives prominently occur 11 times. In addition, several botanical terms related to trees also occur in the Quran, such as fruits, leaves, branches, roots and many more. In the Quran, many plants and trees are mentioned by name, such as figs, olives, pomegranates, grapes, date palms, bottle gourds, Christ's



thorns, tamarisk, ginger, camphor, Grape cluster and others.

The Quran also uses many botanical terms in different contexts. For example, such terms are sometimes used to clarify the meaning of a specific verse. The Quran repeatedly invites people to think about



the wisdom behind Allah's creation, including plants and trees. Allah says, {"Indeed, in the creation of the heavens and the earth and the alternation of the night and the day are signs for those of understanding. Who remember Allah while standing or sitting or [lying] on their sides and give thought to the creation of the heavens and the earth, [saying]. Our Lord, You did not create this aimlessly; exalted are You [above such a thing]; then protect us from the punishment of the Fire"} (Al-Imran: 191-192).

The Qur'anic verses that mention plants, trees and fruits are there to encourage people to think about Allah's creation and to help them reach a level of faith based on conviction. These verses also remind people of Allah's blessings and the need to thank Him for what He has offered them. Allah says, {"Then let mankind look at his food. How We poured down water in torrents, Then We broke open the earth, splitting [it with sprouts], And caused to grow within it grain And grapes and herbage, And olive and palm trees, And gardens of dense shrubbery, And fruit and grass [As] enjoyment for you and your grazing livestock"} (Aabasa: 25-32).

These verses also guide us to understand and reflect upon Allah's impeccable power. {"And We place the scales of justice for the Day of Resurrection, so no soul will be treated unjustly at all. And if there is [even] the weight of a mustard seed. We will bring it forth. And sufficient are We as accountant." (Al-Anbiyya: 47). Also, Allah says, {"And whoever does righteous deeds, whether male or female, while being a believer - those will enter Paradise and will not be wronged, [even as much as] the speck on a date seed" (Al-Nisaa:124).



Seeds of Mustard, (Qur'anic Botanic Garden's lab, in Qatar Foundation) Naqīr is the very small pore in the seed coat, through which the water enters during germination, Qur'anic Botanic Garden Lab. Qatar Foundation



Those who reflect upon the verses of the Quran find divine guidance for believers to love plants and trees, which remind them with the beauty of paradise. This brings us to the story of Adam and Eve when Allah gave them dwelling in Paradise. Allah forbade them to eat from the forbidden tree, and warned them that if they did, they would both be wrongdoers. When Adam disobeyed Allah and they ate from the tree, Allah removed them from Paradise to earth, and their last memory of Paradise was them using leaves to cover themselves. The faithful who follow the path of the Prophet PBUH will return to Paradise once again. This story encourages the faithful to love trees, which remind them of the gardens of Eden, where rivers flow, food is unlimited, and shade never goes away.

The contexts where trees are mentioned in the Quran are quite diverse. In some cases, trees are mentioned in contexts that describe punishment, as in the story of the dam, where people disobeyed Allah and refused to believe in Him. Allah punished them by sending a flash flood that destroyed them. After their life of comfort, Allah left them with only two gardens that bore nothing but bitter fruit, {"But they turned away [refusing], so We sent upon them the flood of the dam, and We replaced their two [fields of] gardens with gardens of bitter fruit, tamarisks and something of sparse Sidra trees"} (Sabaa: 16). Other plants, such as Zaqqum and Daria are created to be the food of those in Hell as a punishment for refusing to believe in Allah and denying his Prophet's message.

In other instances, trees are mentioned as a means of reward and everlasting pleasure in paradise for the faithful. Allah says, {"The companions of the right - what are the companions of the right? They will be among Sidra trees with thorns removed. And [banana] trees layered [with fruit] - And shade



Banana plants (Entebbe Botanic Gardens, Entebbe, Uganda)



extended – And water poured out - And fruit, abundant [and varied]"} (Al-Waqi'a:27-33).

In the Hadiths of the Prophet, trees and their products are mentioned in various contexts. For example, the Prophet PBUH compares different types of people to different types of trees, as he says, {"The likeness of the believer who recites the Quran is that of a citron, the taste and smell of which are good. The likeness of a believer who does not read the Quran is that of a date, the taste of which is good but it has no smell. The likeness of a hypocrite who reads the Quran is that of a sweet basil, the smell of which is good but its taste is bitter. And the likeness of a hypocrite who does not read the Quran is that of a colocynth (bitter apple), the taste of which is bitter and it has no smell."}

Many examples of trees and plants are presented in order to explain the meanings of verses and to clarify the intentions behind Hadiths. In the Quran and Hadiths, there are links between stories about people and trees and plants, as in the story of the two gardens. Allah says, {"And present to them an example of two men: We granted to one of them two gardens of grapevines, and We bordered them with palm trees and placed between them [fields of] crops"} (AI-Kahf: 32).

Islam urges people to care for trees and cultivate the land, which are deeds to be rewarded. This becomes very clear when Allah says, {"Do [as you will], for Allah will see your deeds, and [so, will] His Messenger and the believers. And you will be returned to the Knower of the unseen and the witnessed, and He will inform you of what you used to do"}. In addition, the Messenger of Allah, Muhammad (PBUH), has ordered us to plant trees even as the world comes to an end, {"If the end of the world approaches and one of you has a seedling (or plant) in his hand, if he can plant it before the end comes, let him do it."} He also says, {"If a Muslim plants a tree or sows seeds, and then a bird, a person or an animal eats from it, it is regarded as a charitable gift for him until the Day of Judgment."}





# Importance of trees in our daily lives

Trees play a vital role in human life, both directly and indirectly. For example, trees are used to decorate streets and urban roads where they serve as an aesthetic feature that provides comfort. Trees are also used to provide shade, and they have a cooling effect. Trees can also function as wind breakers, as tree belts can be planted around cities to reduce wind speed, especially during sand storms. Trees also help maintain the soil and protect it from erosion which leads to desertification (the spread of desert into urban areas)<sup>1</sup>.

In addition to being a valuable source of food, trees are the main resource for several human basic needs. Trees provide wood, which is the raw material used to make paper, charcoal, rubber, essential oils, dyes and other products. Trees are an essential resource that 7.44 billion people rely on every day (the world population, World Bank, 2014).

Trees are an essential component of agroforestry, an agricultural system that involves growing trees and crops together. In this system trees have several critical environmental functions " such as storing carbon, preserving biodiversity, enriching the soil and maintaining water and air quality.

Another crucial function of trees is that they serve as a critical host for the survival of many specifies of microorganisms and birds. In other words, trees play a critical role in preserving biodiversity<sup>2</sup> both directly and indirectly. Trees are also a main source of food for humans, as they provide nutritious substances such as sugar and spices in addition to many raw materials used in producing drinks and oils, among many useful products.



Tree is shelter and natural habitat for animals, Tanzania

## The lifecycle of plants in the Holly Quran: From green to dry

When discussing the lifecycle of trees and plants, it is important to define some of the relevant terms used in the Quran, which describes the lifecycle of plants in detail. This cycle starts when rain falls to the ground, which "quivers" and gets saturated. At that point, the appropriate conditions needed for seeds to germinate are met, and life begins in those seeds that have been dormant from previous years. Allah says, {"And you see the earth barren, but when We send down upon it rain, it quivers and swells and grows [something] of every beautiful kind"} (Al-Hajj: 5).



<sup>&</sup>lt;sup>1</sup> According to Article no. (1) of the United Nations Convention to Combat Desertification, desertification is defined as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climate variations and human activities, resulting in the degradation of agricultural 0 and viability. Desertification is a global phenomenon that has emerged strongly since the sixties, as severe droughts have been recorded across the world causing massive human, environmental and economic damages (Source: aljezeera. net).

<sup>&</sup>lt;sup>2</sup> Biodiversity is defined as the variation in all types of organisms in land and marine ecosystems, as well as variations among and within species. Perhaps the first lesson on biodiversity in human history is Noah's Ark, as God ordered Noah to take along a couple of each kind of creature to ensure that the flood does not cause the extinction of these specifies [25].»





The Quran also distinguishes between seeds and pits, which are the main types of seeds. Seeds come from grain plants that produce seeds on the heads of their stalks, as in wheat, corn and barley. Pits, on the other hand, have a wood-like shell and they grow inside fruit. Each pit has one seed inside, as in apricots, peaches, almonds, dates, grapes and others. In pits, the seed is covered by a hard shell, known as the coat,



Al-habb is used generically for grain or the like found inside the spike or the sheath. Nawā a term used to describe the date's stone.

which has a very small hole called the micropyle. Water goes into the seed through this hole to activate the embryo and initiate growth. The embryo develops a radicle, which turns into a root, and the cotyledons, which develop into the first leaves. Allah says, "Indeed, {Allah is the cleaver of grain and date seeds. He brings the living out of the dead and brings the dead out of the living. That is Allah; so how are you deluded?"} (Al-Anaam:95). The Prophet (PBUH) mentions layering as a method of tree reproduction, as he says, {"If the end of the world approaches and one of you has a seedling (or plant) in his hand, if he can plant it before the end comes, let him do it"}.

Once the seed germinates, the green leaves appear above the ground, as Allah says, {"Do you not see that Allah has sent down rain from the sky and the earth becomes green? Indeed, Allah is Subtle and Acquainted"} (Al-Hjj: 63). The root of the Arabic word for green, the color of leaves, occurs eight times in the Quran, five of which are in contexts that talk about plants. The green color of leaves is attributed to a pigment called chlorophyll, which is responsible for the production of food in plants through a process known as photosynthesis. This process is one of the main distinctive features of plants, as they are self-sustaining. In other words, they can make complex energy storing nutrients from simple elements such as water and carbon dioxide as Allah has created them. The leaves store energy from sunlight for the use of the plant, but also for the use of humans and animals when they consume the leaves. From a scientific perspective, we can think of photosynthesis, which takes place in the plastids in leaves, as a process of absorbing light from the sun and transforming it into energy that is stored in the substances that make up wood, such as cellulose and lignin, which is later released when we set dry wood on fire, as Allah says, {"[It is] He who made for you from the green tree, fire, and then from it you ignite"} (Yasin: 80).

The next stage is for the plants to turn yellow and dry up by losing their chlorophyll. This is when they become brittle and die. Allah uses this example to show how life ends quickly to no avail. He says, {"Know that the life of this world is but amusement and diversion and adornment and boasting to one another and competition in increase of wealth and children - like the example of a rain whose [resulting] plant growth pleases the tillers; then it dries and you see it turned yellow; then it becomes [scattered] debris. And in the Hereafter is severe punishment and forgiveness from Allah and approval. And what is the worldly life except the enjoyment of delusion"} (Al-Hdid: 20).



Mountains filled all by green plantations in nature, (Morogoro, Tanzania)



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# The Morphological structure of trees

The morphological structure of trees helps distinguish them from other plant types. As illustrated in, trees are made up of three parts:



Tree structure and its parts functions, Illustratation "Source: maarefa.org"



### The root system

The root system is comprised of the roots which grow under the ground. Roots look like long branches, and they have the same kind of tissues that form the trunk. The main functions of the roots are: (a) anchoring the tree to the ground and (b) absorbing water and minerals from the soil. Roots are divided into three types: (a) primary roots, (b) secondary roots and (c) hairy roots. At the depth of 30 to 60 centimeters, primary roots branch into secondary roots, which in turn branch into hairy roots. In some tree types, the main root is known as a taproot, which is bigger than other roots, and it grows straight down into the ground for five meters or more.

During the lifetime of a tree, it develops a very large number of roots that grow and get renewed constantly. These roots penetrate the soil to anchor the tree into the ground and absorb water and nutrients, which make their way to the trunk, the branches and the leaves through the root tissue and vessels. Different types of fungi grow on most tree roots in a symbiotic relation, as these fungi help the roots absorb water and nutrients while protecting the tree from disease.



A tree grows on cement foundation at zero point of Nile River, Jinja, Uganda

The functions of the root system can be summarized as follows:

- The roots anchor the tree to the ground.
- The roots absorb water and nutrients and send them to the rest of the tree through the trunk. The nutrients produced in the leaves through photosynthesis are transported to growth areas in the roots or for storage in specialized roots.



- The root system stores nutrients for a while, and some root types are specialized in storing food, such as the roots of radishes, beets and turnips.
- Some root types secrete organic acids and minerals that microorganisms feed on. The area surrounding the root system is called the Rhizosphere.

#### Stem/Trunk

The stem is the main component of the shoot system, which carries leaves, buds, flowers and fruits. In most plants, the stem grows above the ground, but some stems have adapted to do additional functions, such as storing nutrients, and these trunks grow, at least partially, under the ground. The stem consists of two parts: (a) the nodes, where leaves and buds grow out, (b) the internodes, the distances between every two nodes.

The stem serves some valuable functions for plants. These are:

- Support: supports the leaves, buds, flowers and fruit. It is also important for the leaves to receive enough lights for photosynthesis.
- Transportation and Conduction: transports the water and minerals absorbed by the roots to the rest of the plant. It also moves the nutrients produced in the leaves during photosynthesis to the areas where they are either consumed for growth or stored.
- Storage: stores food, while others have adapted to do other functions, such as climbing, reducing transpiration or making nutrients through photosynthesis.

Moreover, stem can perform additional functions to help the plant in optimum growth. There are many examples in plants about that e.g. Sugarcane plant; sugar is stored in the stem, and in Willow tree; the bark contains medicinal substance that used as inputs of Aspirin medicine, and Aloes-wood/ agar-wood tree; when infected by kind of mold, the tree produces a dark aromatic resin in response to the attack, which results in a very dense, dark, resin embedded heartwood, the wood use in Bukhour and fragrance, and Toothbrush tree; stem and root are using as natural brush for tooth hygiene because of medicinal components in it.

## Stem forms:

It's branched or non-branched, each kind have a specific role in the tree/plant. Branching in general aiming to exposing leaves into sunrays as major as possible, in order to functioning photosynthesis optimally.

- Non-branched stem is obvious in Date palm and other crop plants e.g. Sugarcane and Maize.
- There are two forms of branched stem; Apical and lateral branching, while lateral branching has two forms as following:
- Indefinite branching: the apical bud is proceeding in growth in constantly through adding new branches over the stem, as the newest branches is the closer on to shoot top.
- Definite branching: the apical bud is active in growth for limited period of time, and then it became flower, spine or tendrils (as in Grapes).

# Stem modification

The stem of plants can be modified into different forms in order to provide the plant/tree with additional important functions, as below:

## 1- Aerial stem:

- a. Into leaf-like Stem: stem is modified for functioning photosynthesis as in Asparagus plant.
- b. Into fleshy stem: to store large amounts of water as common in desert plants e.g. Opuntia *ficus-indica*.



Opuntia ficus-indica plantations in Rawdet al-Faras Research station farm, Shammal Road, Qatar





- c. Into spiny stem modified stems that protect plants from grazing animals, as in wild plants e.g. Camel thorn (*Alhagi maurorum*) undershrub, Desert thorn (*Astragalus spinosus*) and Spiny zilla plant (*Zilla spinosa*)
- d. Into tendrils: A slender stem that is used by Grapes and some climbing plants to wrap around or to hook a support.

#### 2- Subterranean stem:

- a. Rhizomes, which grow horizontally under the ground, thus making it possible for the plant to spread and reproduce. This is the main spreading strategy in many grass species, such as common grass, bamboo, ginger, crêpe ginger, and European yew
- b. Bulbs, which are stems that grow under the ground to store nutrients or help with plant reproduction. There are different kinds of bulbs, including true bulbs, such as onions and bulb offsets (or cloves), as in garlic. In both garlic and onion, the bulb has the roots growing from the bottom to form a thick outer layer. Other examples of bulbs include tulips and narcissus;
- c. Tubers, which are stem that carry buds and serve as storage areas for food. Each tuber has several eyes with buds that sprout into new plants, as in potatoes.



Red-Onion bulbs, (Wholesale market, Doha, Qatar)



Stolon, a propagation type as in Strawberry plant (picture taken from private garden, AlNasr area, Doha, Qatar)

Also, there are other forms of stem modifications, one of it is Stolons, which grow horizontally over the ground, thus helping the plant to spread and grow additional roots at the nodes, as in strawberries.



# Shoot system/Canopy

The shoot system, or canopy, is made up of the leaves, which are simply the plant's food factory. To produce nutrients, the leaves need to take in three essential components: (a) water and minerals from the soil, (b) carbon dioxide from the air, and (c) energy from the sun. These components are the input of a complex process known as photosynthesis as can be seen in the equation below:

#### 6CO2 + H2O + light + chloroplasts = C6H12O2 + 6H2O

The output of this process includes food and energy for the plant and oxygen, which is released into the air. Chlorophyll plays a critical role in photosynthesis, as it helps the plant use light to produce different kinds of sugar. Chlorophyll is also the reason why leaves are green for most of the year. Photosynthesis occurs over two stages depending on the pants need for light.

The first stage involves light-dependent reactions where light energy is absorbed by chlorophyll molecules known as thylakoids<sup>3</sup> and transformed into a chemical energy that is temporarily stored in energyrich molecules. The second stage, which is light-independent, takes place at night. This stage, which is known as the Calvin Cycle, is where energy-rich molecules and carbon dioxide are used to produce trioxide glucose compounds. During this stage, energy is stored in the glucose compounds along with other bio-products of the process.

The structure of leaves is far from simple. A leaf has layers of tissue made up of pigment cells that have chlorophyll. Photosynthesis occurs in these cells. Leaves also have vascular bundles that serve two functions: (a) they bring water and nutrient to the pigment cells for use in photosynthesis, and (b) they take in the sugars produced through photosynthesis to release energy. The gas exchange processes take place through small openings called pores or stomata, through which carbon dioxide goes into the leaf and oxygen is released into the air. Water also comes out of these pores during transpiration. Most leaves are covered with a waxy layer called epidermis which preserves water inside the leaves and prevents evaporation during heat periods.

<sup>3</sup> A thylakoid is a membrane-bound compartment inside green chloroplasts and blue cyanobacteria, and it is where the light-dependent reactions of photosynthesis take place.



# Growth and Development of Trees



Seed propagation is the most common and most important way for trees to reproduce. Once a seed germinates, the seedling starts to grow until it becomes a sapling that is 1.2 to 1.5 meters tall. At this stage, the trunk is 2.5 to 5 centimeters in diameter, and it can be planted in a permanent place.

The amount of water trees need varies considerably depending on the geography and climate in their immediate environment. However, most trees require large quantities of water in their early stages of development until they are anchored well into the ground and have enough roots to absorb ground water.

In order to understand how trees grow, we need to know the processes involved in their development.

# Germination:

Seeds have a unique structure that allows them to grow. A seed has enough food stored in it that allows it to germinate. Each seed has one or two cotyledons that become the first leaves of the seedling. Seeds germinate once the environmental factors needed, such as water, air and sunlight, are available. Once water is absorbed into the seed in the right soil, the root radicle emerges to form the main root which gradually grows into the ground. During this stage, the seedling uses the nutrients stored within the seed until the new root starts absorbing water from the soil. The shoot starts to grow upward forming leaves which would later form the canopy and the trunk.

# Photosynthesis:

As leaves grow, they get xylem sap<sup>1</sup> from the root system while absorbing carbon dioxide from the air. Leaves use energy from sunlight

<sup>&</sup>lt;sup>1</sup> Plant sap is a water-based fluid that goes through plant roots and shoots. There are two types of plant sap. The first is a raw sap known as xylem sap, which is made up of water saturated with minerals, and it goes from the roots to the leaves through a trunk layer known as sapwood. The other type is called phloem sap and it is made up of water saturated with nutrients, and it goes from the leaves to the plant parts that store or consume it for growth. Xylem is stickier because it is mostly sugar.



to transform sap and carbon dioxide into sugars in a process known as photosynthesis, which provides nutrients for the different parts of the tree. Leaves also produce oxygen and release it into the air.

#### Vertical growth:

Trees continue to grow from the top of the trunk and the tips of the branches. One bud develops at the tip of the stem, while others develop at the end of every branch within a year. A bud, which is an embryonic shoot that grows at the axils of leaves or stem nodes, is the beginning of a new shoot and it is typically covered by modified leaves called scales. After a dormant period, buds grow and open up, which co-occurs with the growth of the shoot resulting in the extension of the stem and the branches. This type of buds is known as terminal buds. Another type is axillary buds, which grow at the tip of the stem and the branches. Axillary buds develop into new branches. Some tree buds known as flowering buds grow into flowers, while others develop into branches that carry leaves and flowers at the same time. There are other kinds of buds as well, as they can be classified according to their functions (vegetative and reproductive) or according to the types of leaflets they grow. A leaflet is a small leaf, and a cluster of leaflets in one growth can be considered a leaf, as in prosopis, acacia tortilis and acacia ehrenbergiana. Buds can also be classified according to their level of activity into dormant and active buds. Trees in warm climates grow buds year round, and some even continue to grow without buds.

Trees that have no branches, such as gymnosperms<sup>2</sup> and most palm trees, grow in slightly different ways. For example, palm trees grow upwards slowly while the trunk gets wider and the fronds increase and get larger. Once the trunk and crown mature, the palm tree starts to grow upwards at a faster rate.



#### Width of the trunk and branches:

The trunk and the branches continue to grow thicker throughout the lifetime of a tree. The cambium, which is the layer of tissue under the inner bark, is responsible for this growth, as it uses the sugar produced by the leaves to make new phloem toward the outside bark and new wood tissue toward the inside.

Generally speaking, wood is made up of cellulose, which is a hard substance made of sugar. There are two types of wood: sapwood and heartwood. Sapwood is made up of active living cells that transport sap between the roots and the crown of the tree, and it is closer to the bark. In tropical climates, sapwood continues to grow all year long, whereas in colder climates, new layers of sapwood are formed in the beginning of the summer only. As a tree grows older, sapwood that is closer to the center of the trunk stops growing and turns into heartwood, which functions to further support the tree.

In regions where trees form a new layer of sapwood only once a year, each layer forms a ring. These rings can be used to identify the age of a tree once it is cut down, as every ring represents one year of growth. Scientists have discovered that slight changes in the cellulose content in a tree can help understand the changes in weather it endured.



<sup>&</sup>lt;sup>2</sup> Gymnosperms are bare-seed producing trees that are similar to palm trees, but many of them have smooth and thick straight trunks with wide feathery leaves. Gymnosperms are common in the tropical and semi-tropical regions in Africa, Australia, North American and South America (kids.jo – Next.jo)



# **Trees Reproduction**



# a. Sexual reproduction

A relatively large number of trees reproduce sexually, i.e., through seeds, which are produced through the exchange of pollen between male and female reproductive systems. The flowers of many flowering trees (known as angiosperms<sup>1</sup>) have both male and female reproductive parts, and this is why they are considered bisexual, as pollen can simply be transported from the male parts to the female parts within the same flower.

Other angiosperms and all gymnosperms have separate male and female flowers or conifer cones. Male and female flowers and cones can grow on the same tree or different trees. Pollen from these trees is transported by insects, the wind or other means. Once male pollen is unified with an ovule a seed, or more, is formed inside the fruit or cone, which separates from the tree once matured.

# b. Vegetative Propagation

As the name suggests, a part of a tree, which can be part of a root, trunk or leaf, is cut out to clone a new tree. There are many easy methods of tree reproduction that involve cuttings, and they are usually used for tree whose seeds do not germinate easily, either because they are too small or because it is difficult to separate the seed from its coat (the layer that covers the seed and the embryo), as in the case of Christ's thorn trees.

<sup>&</sup>lt;sup>1</sup> Angiosperms are a class of seed producing flowering land plants (also known as Magnoliophyta). Angiosperms are distinguished from other plants by having the flowers that carry the reproductive organs later become fruit containing the seeds. There are two categories of angiosperms: monocotyledons and dicotyledons (See the webpage of Dr. Gamil Jabr, Department of Biology, Umm Al-Qura University, http://uqu.edu.sa/page/ar/88630).





In natural settings, propagation involves the growth of new trees after the separation of parts of the tree trunk, and over time one, or more, or these cuttings grow into new trees. Tree branches can also be grown, as they come from roots, which is the case with apple trees. In other cases, branches develop roots, as in the case of spruce trees that grow in marshes. This propagation method is called air layering.

In commercial settings, propagation by cuttings is one of the most common propagation methods used in nurseries, where a branch is cut out form a tree, treated with fungicides and root hormones, and then planted in a special soil in a controlled environment. The cuttings develop roots and new buds form branches, and later they become saplings.

Another method involves making a cut into the tree bark, covering it with wet soil and sealing it using special polyethylene tape. Primary roots would then develop in the sealed area, and later on the branch is cut out and planted to grow as a new tree. There are many other propagation methods



Unique vegetative propagation phenomena, Entebbe Botanic Gardens, Entebbe, Uganda



Proper part of fig stem as cutting, (QBG pilot nursery, QF, Doha Qatar)



Layering, a method of vegetative propagation (Entebbe Botanic Gardens, Entebbe, Uganda)

that include air layering, mound layering, bulbs and corm separation, and many others<sup>xi</sup>.

Modern technology has introduced new propagation methods that are more efficient in terms of time, effort and cost, such as propagating by tissue cultures. This method is now commonly used in propagating palm dates, bananas, and other plants to develop strong and resistant new trees that have similar characteristics to the source trees.



# **Values of Trees**



# Environmental value of trees

Trees are an essential element of the ecosystem, and they are very useful to us. The environmental benefits of trees can be summarized as follows:

- Trees contribute to the environment by providing oxygen and improving air quality, trees purify the air. They remove dust and absorb pollutant particles, such as carbon dioxide, sulfur dioxide and nitrogen dioxide. Tree leaves collect unhealthy particles, which are later washed down by the rain.
- Trees contribute to climate control, it protect against greenhouse gasses by maintaining low levels of carbon dioxide. Trees absorb heat and purify sunrays. They also provide shade and cool spaces in the summer. In winter, trees help with the climate, as they serve as windbreakers that redirect the wind and slow it down. Trees also protect against heavy rain and hail. They help keep the temperature down in hot seasons.
- Trees provide a natural habitat for many species, such as birds, fish and microorganisms, both above and below the ground, and even in the sea.
   Some birds and animals use trees as habitats that protect them from predators. Trees reinforce the ecosystem and serve it especially in areas that suffer ecological deterioration. Perhaps the growth of mangrove trees along sea



Mangrove plantation on the seashore, (al-Thakhiera area, Al-Khor City, Qatar)

shores is a perfect example of how trees support the ecosystem, as trees offer a natural habitat for some rare kinds of fish and preserve carbon in the soil. Many animals depend on trees for food while many birds and insects depend on their nectar for survival



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- The strong roots of trees help preserve the soil by protecting it against erosion.
- Trees reduce water runoff by breaking rainfall, thus allowing water to flow into the ground and replenish ground water naturally. They also reduce the dangers of floods and landslides.
- Fallen tree leaves and branches can be recycled to produce a natural fertilizer that provides balanced nutrients for use in seed germination and growing saplings. They can also be used in compost mixes that sever as natural fertilizers, which are essential for organic agriculture.

According to the United States Department of Agriculture One acre of forest annually sequesters or absorbs six tons of carbon dioxide and produces four tons on oxygen, which is enough for 18 people for a whole year.

## Aesthetic value of trees

- Trees inspire people to work and think about Allah's creation, as they marvel at their beauty, where trees with similar and dissimilar

color are produce its leaves, flowers and fruits in harsh climate conditions, and this could promote us to work and produce.

- Trees major sources of aesthetic pleasure, trees are shelter from harsh sunrays in summer and it complete the aesthetical feature in gardens



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Trees of Conocarpus and Date palm are landscaping roads, Al-Madīnah Al-Munawwarah, KSA.

and promote recreation. Trees used in landscaping main and side streets to add aesthetic feature in.

**Ibn Al-Qayyim Al-Juzeih** says, "With love and for love, the earth and heavens were created. Love is the essence of nature and the power that moves all beings to their destinations. Only with love can souls achieve their goals, get rid of their evil traits and find their path to Allah. Love is all beings' ultimate goal, and with love they taste the joys of faith and lead a happy life."

- Green areas and public parks have a high recreational value that can improve and promotes physical activity, also children growing in an environment with adequate playgrounds and green areas are given equal development opportunities regardless of their social or economic classes, while green open spaces can promote a more active lifestyle for more senior adults. Green areas can be used in promoting the issues of nature, climate change and tree plantations. (FAO)

There is a famous quote by **Professor Wangari Maathai**, Nobel Peace laureate and founder of the Green Belt Movement, where she says, "When we plant trees, we sow the seeds of hope and peace." Professor Maathai received this highly esteemed prize for her contribution to planting millions of trees in Africa across national borders in an attempt to spread goodwill and peace among the peoples of Africa.



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Trees are a rich and diverse source of natural resources that provide many valuable services to the ecosystem. Some scientists have attempted to develop calculations that estimate the monetary value of trees, but these calculations vary considerably. Nevertheless, we thought it is worth drawing attention to efforts by international organizations to encourage people to preserve trees. According to one unofficial estimate, a 50-year old tree is worth the following:

<ul> <li>Oxygen released into the air</li> </ul>	USD 31,250
<ul> <li>Controlling air pollution</li> </ul>	USD 62,000
• Fertilizing the soil and protecting it against erosion	USD 31,250

- Recycled water
- Providing a natural habitat for animals

These calculations do not include the value of the fruit, the wood or the aesthetic value of trees.

As a way to encourage city dwellers to promote a culture of tree planting and preservation, the illustration in the picture above is found in some botanic gardens and public parks abroad, including a park in the Philippines. This picture presents the above mentioned numbers to increase awareness about the value of trees among those who are interested in monetary figures.



USD 37.500

USD 31.250

Roll-up shows in one of parks in Philippines about tree's monetary value (Photo sourced from Internet)



# Economic value of trees

- A source of food: Trees provide substantial amounts of fruits, vegetables and legumes that people consume on a daily basis. The nutritional values of tree products vary considerably, as does their taste, color and smell. Yet, they are all very valuable.
- A source of sugar: sugar-cane plant produce sugar in its stem, beet plants is also produce sugar in roots, and Stevia plants is producing natural sugar in their leave.



Resin secretion by one of coniferous trees (Entebbe city, Uganda, East Africa).

• A source of starches: in

Casava trees a high content of starches in roots, also plants like potato, Maize, Wheat and Rice.

- A source of natural drinks: tea comes from tea plantations; also coffee is fruits of coffee tree, and drinks made by roots of Liquorice plants, etc.
- A source of spices: as many plants and trees produce spices from leaves, flowers and fruits and roots
- drinks
- A source of medicine row materials: as in Senna plants, there are medicinal substances use in anti-constipation medicines, also leaves of Artichoke plants use in Laver medicines, and bulbs of (Urginea maritime) plants is uses in cardiac medicines.







- A source of essential oils: Basil plant and Mint plants are containing high-content essential oils in their leaves, fragrance row materials comes from Citrus tree fruit, also Anise, Fennel have those oils in their seeds and inflorescences of Chamomile plants contain high-content of.
- A source of oils and fat: Oil palm trees is producing oil in their fruits, also many plants produce vegetative fats like Shea butter tree.
- A source of wax: Waxes extracted from plants are highly valued. For example, Copernican palm leaves (Carnauba tree), which grow in large numbers in South America and Brazil in particular, produce a type of wax that has many different uses.
- A source of fodder: Beet plants produce rich fodder root and many trees of Acacia genus are rich fodder for wild animals, as well as Ficus rasemora tree.
- A source of Bio-fuels: Jatropha trees are produce seeds that produce oil used as bio-fuel, also Jujoba tree and Castor tree is producing castor oil which use in same purposes.
- A source of fertilizer: leaves and all byproducts come from trees and plants could be used in making compost, which is environmental friendly product and use in increase soil fertility.
- A source of wood: trees of pine are producing large amounts of woods, also mahogany woods.
- A source of paper: in ancient history papers came by Cyperus papyrus plant, nowadays trees are main source to produce high quality paper sheets.



Qur'anic Botanic Garden



# **Facts about Trees**



- Trees receive an estimated 90% of their nitrogen nutrition from the atmosphere and only 10% from the soil, which mean trees, contribute in increasing soil quality in terms of nutritious content.
- Trees grow from the top, not from the bottom as is commonly believed, because of bud growth which occurs annually.
- There are 20,000 species of trees in the world. India has the largest number of tree species followed by the United States.
- Arbor Day was first celebrated in Nebraska, USA in 1872. The State of Nebraska is home to one of the largest forests planted by people. The forest has more than 200,000 acres of trees.
- Half of the world's tropical forests are deteriorating or disappearing rapidly. At least 4,500 hectares of forests are cleared every hour either by being burned or cut down. The main causes of deforestation are overpopulation, unequal access to land and poverty (United Nations Food and Agriculture Organization, Forestry Department).
- The annual net loss of forests across the world is 7.3 million hectares, which is equivalent to 18 million acres (United Nations Food and Agriculture Organization, Forestry Department).
- Across the world, there are 1.6 billion people who depend on forest products for their daily living, either partially or completely (World Resources Institute and the United Nations).
- Firewood is consumed in sub-Saharan Africa at a rate that is 30-200% more than the annual growth rate of trees, which results in a significant deficit in wood resources and natural habitats for animals, insects and microorganisms (United Nations Environment Program).
- Trees play a major role in the ecosystem by storing carbon in the tree mass (wood, leaves and roots), which helps control the climate. Currently, the world forests store about 283 million tons of carbon, which is equivalent to the weight of 40.1 billion elephants (United Nations Food and Agriculture Organization, Forestry Department).
- Forest products provide materials used to house 1.3 billion people around the world, i.e., 18% of the world population.[50]



# **Preserving Trees**



We always recommends protecting and caring for trees. We present a series of simple steps that you can take in your daily life. These steps protect trees indirectly, but they are effective in protecting the environment.

These suggestions include:

- Recycle paper in smart ways, such as collecting paper and cardboard in a bag separately from cans, glass and plastics. These materials can be recycled and reused, thus reducing the number of trees that would have to be cut down to produce new raw materials for these products.
- Buy less newspapers and magazines. You can browse them online. If you have to buy newspapers and magazines, share them with others to reduce the number of copies needed. As for store catalogs, you can return the unwanted ones after reading them. This way someone else can reuse the catalogs. Also, the number of copies needed would go down and so will the number of trees that would have to be cut down.
- Reduce your consumption of tissue paper in your car and office or at restaurants as much as you can. You can use sterile cloth napkins and handkerchiefs instead. This also cuts down on paper consumption.
- Always try to print double-sided documents and set your printer default to double-sided printing.





# Our responsibilities toward Trees



The noblest thing we can do to preserve trees is to follow the teachings of our religion, which orders us to plant trees and take care of them. The prophet PBUH says, "If a Muslim plants a tree or sows seeds, and then a bird, a person or an animal eats from it, it is regarded as a charitable gift for him." To fulfill our duties toward trees, we need to familiarize ourselves with the correct steps for planting them, which are as follows:

# 1. Identify the purpose for planting a tree.

Evergreens with dense canopies are some of the best shade trees, such as Christ's thorn (Sidra) tree. Trees that produce flowers with contrasting colors are perfect if our goal is to have decorative trees. If we are planting trees for privacy hedges or as windbreaks, we are better off with evergreens, such as eucalyptus and casuarinas, this will help decide the kind of tree to plant. Remember that climate plays a critical role in the growth of trees. When choosing a tree to plant, we have to indentify the optimal climate conditions for its development to decide whether it is suitable for the area where we want to plant it. Some trees require periods of very cold conditions, and therefore, they will not grow successfully in hot climates, and vice versa. We should also bear in mind the distinctive features of the trees we want to plant. For example, we should avoid planting trees with dense roots that spread horizontally near homes because these roots can damage the foundations of buildings and break underground water pipes. They can even block sewage pipes.





# 2. Get the seed or sapling.

The best samplings are 90-120 centimeters tall, with well developed shoots and proportionate canopies. Make sure the leaves are healthy and free from visible fungi. The roots should also be strong, well developed and free from parasites such as nematodes<sup>1</sup>.

If you are a specialist or you have experience with trees, you can use seeds, but they take a very long time to germinate. Sometimes, tree seeds need special care and controlled conditions for very long periods of time to germinate.



Citron Seedlings, developed by direct seed sowing, Qur'anic Botanic Garden Lab, QF

# 3. Space the saplings

When planting trees, it is important to space them out. Trees should be spaced four to seven meters apart. Shrubs can be spaced two or three meters away from each other. Annual plants can be planted close to each other, only 30-40 centimeters apart for aesthetic effects.

# 4. Learn the correct steps for planting trees:

## a. Dig a hole large enough for the root ball.

When planting a tree, dig a hole that is large enough for the entire root ball of the sapling. Make sure you keep the dirt you dig out because you can use it later to fill in the hole around the root ball. While digging, make sure to dig straight down and please be safe. The best tool to dig a hole for a root ball is the shovel.





Proper way on how to remove plant from a pot

#### b. Planting the tree

Once the hole is ready, take the plant out of its planter following the correct procedure. Hold the stem and turn the planter upside down. Tap on the bottom of the planter until the plant comes out with the root and dirt intact. Plant the sapling immediately to avoid exposing the roots to the sun, which can damage them.

#### c. Put the plant into the hole.

Make sure to put one third of the mixed soil in the bottom of the hole. Then put the plant in the middle of the hole, and add the other two thirds of the soil mix around it. Press the soil gently until it is lightly packed. This allows the air to get out of the soil. This air can disrupt the water column that connects the plant and the soil.

#### d. Fill the hole with dirt.

You can use the dirt you dug out at the beginning. Add some organic fertilizer according to the instructions. Fill the hole all the way while making sure the plant is standing straight in the middle. Pack the dirt and water the plant to make sure all air pockets are gone.

<sup>&</sup>lt;sup>1</sup> Nematodes are worm-like parasites, but they are a different species altogether. The nematodes that are harmful to plants are about 300-1000 micrometers (A micrometer is one of a millionth of a meter), and they can be four millimeters long. This makes them almost invisible, but you can see them easily through a microscope.





## e. Space the saplings

When planting trees, it is important to space them out. Trees should be spaced four to seven meters apart. Shrubs can be spaced two or three meters away from each other. Annual plants can be planted close to each other, only 30-40 centimeters apart for aesthetic effects.



Date-Palm landscaping (Education City, Qatar Foundation, Doha, Qatar)

## f. Fertilization

Add some fertilizer to the topsoil after filling in the hole and then water the sapling. Use a hose to distribute water evenly over the fresh dirt. You can add some mulch or compost on top to reduce water evaporation.

#### g. Support

If the tree you are planting is 60 centimeters tall, or more, you need to support it with stakes. Support helps newly planted trees resist strong winds until their roots are sufficiently established. Stakes should be tall enough and secured well enough in the ground. It is better to use round stakes with pointed bottoms (similar to an upside down pencil) that are at least two inches in diameter. The recommended number of stakes for a single trunk tree is two to four, and three or four for a tree with multiple trunks.

#### h. Pruning

It is important to constantly care for young trees by clipping side branches, cancers and unwanted new growths, which shoot up from the roots. Pruning should be done with the right tools, such as sharp clippers, and they have to be used property for safety purposes.



Resin secretion by one of coniferous trees (Entebbe city, Uganda, East Africa).

## i. Annual fertilization

Adding fertilizers is important for young and mature trees alike, and it needs to be done at consistent intervals. It is also important to use a well balanced fertilizer mix that includes nitrogen, phosphorus and potassium (NPK mix). Slow degrading fertilizers should be added to trees every six months, and the amounts used have to be appropriate for the size of the trees. Please, always follow instructions when adding fertilizers.

#### **Remember:**

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We recommend planting local evergreens in order to promote the development of a comprehensive and sustainable ecosystem. To do this, it is most practical to plant fast growing trees that can tolerate the local climate. This will help increase the number of trees and help save our environment.

#### j. Pest control

Pests, fungi and viruses attacks plants and trees throughout their growth periods, and therefore, it is very important to protect them constantly, so that we can intervene at the right time to reduce the negative consequences of these attacks.

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We recommend using environment friendly pest control methods, such as:

- **Biological Control:** is basically using the natural predators of the pests that attack plants to eliminate the threat naturally and without chemical intervention. This method helps reduce the negative impact of pests while protecting the environment. Biological control can be done using natural materials such as repellants extracted from plants and the use of mycorrhiza fungi, among others.
- **Cultural Control:** is a pest control method that relies on adopting an administrative protocol in gardening which aims to secure safe disposal of agricultural waste to prevent the spread of infection. It also involves regulating irrigation and excess water discharge because most pests continue their lifecycles in the soil. Cultural control also involves the use of organic fertilizers to reduce the chances of nematode attacks and other infections, in addition to the planting of pest-resistant plants and eliminating weeds that serve as the main host for pests.
- **Mechanical Control:** is the use of manual or mechanical methods to reduce pest infection. It involves the use of insect traps that attract pests away from the trees as well as cutting and burning infected branches.
- **Chemical Control:** Make Chemical Control your last resort strategy to help protect the environment, as this type control is the use of poisonous pesticides to eliminate pests directly and quickly. However, it is a fairly dangerous method because it can harm human health and the environment. There are many chemical compounds that are used in this control method for different kinds of pests, but they should be used only when the above mentioned methods fail.

Control needs to be done regularly to all plants to protect them against pests, and always remember that an ounce of prevention is worth a pound of cure.





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