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WORLD SEED PROGRAM
TREE GROWING GUIDE

INTRODUCTION

This guide provides basic information on how to start a nursery, take care of the seeds and seedlings, transplant and take care of the young trees. The document includes a series of tables with specific information about the tree species provided by the World Seed Program, including species viability (Table 1), seed treatments (Table2), species characteristics (Table 3), advantages and disadvantages for each species (Table 4), species uses (Table 5) and biophysical limitations (Table 6).

HOW TO START A NURSERY

In order to raise young trees that will survive in the countryside, a great majority of tree species need to be sown[1] in a nursery. Once the seedlings[2] are big enough, they can be transplanted to their final location where they will be able to grow into mature trees.

To establish a nursery:

- Choose a location with a good **water supply**, to be able to water the seeds and seedlings as frequently as needed.
- Make sure the place is **protected** from the wind, direct sunlight, and animals.
- Choose a site that is **flat** and has **easy access**.

WHEN TO SOW THE SEEDS

To increase their survival rate, seedlings must be transplanted from the nursery to the field at the beginning of the rainy season. Seeds should be sown with enough time to germinate[3] and grow so that the seedlings are ready to transplant when the rains arrive. This time period will depend on how fast each type of species grows. The majority of the species provided by the New Forest Project are fast growing and sowing them three months before the rainy season is usually enough time. Grevillea is an exception and needs to be sowed 4-6 months in advance.

HOW TO STORE THE SEEDS

To maintain their viability before being sown, the seeds must be stored in a place that is:

[1] Definition: to put seeds in the ground so that plants will grow
[2] Definition: a very young plant which has grown from a seed.
[3] Definition: to cause a seed to start growing.

- cool,
- dry,
- dark, and
- well-ventilated.

Ideally, the seeds should be stored in a refrigerator at a temperature range of 0 to 5 degrees Celsius. If a refrigerator is not available, choose a cool place with constant temperatures. The seeds should be placed in containers that are clean, dry, and can be tightly sealed, and the air volume should be small compared to the seed volume.

Note: Be sure not to freeze the seeds because temperatures that are too low may kill them.

The species we provide are "orthodox", that is, under reasonable conditions, they remain viable for 1 to 2 years; and some for much longer periods of time.

Table 1. Species Viability

NAME OF SPECIE	LIVELIHOOD
Albizia lebbeck	Orthodox, 4-5 years, at room temperature
Acacia tortilis	Orthodox, many years at 10°C
Acacia nilotica	Orthodox, many years at 10°C
Acacia mearnsii	Orthodox, more than two years at room temperature
Acacia auriculiformis	Orthodox, many years
Acacia Senegal	Orthodox, many years at 10°C
Cajanus cajan	Orthodox, many years
Cassia siamea	Orthodox, 3 years at room temperature
Dalbergia sissoo	Orthodox, up to 4 years in a sealed tight container
Gleditsia triacanthos inermis	Orthodox, many years at 0-8°C
Gliricidia sepium	Orthodox, 1 to 4 years depending on container
Grevillea robusta	Orthodox, 2 years at 3-7°C
Leucaena leucocephala	Orthodox, up to 20 years in open container at room temp.
Moringa oleifera	Orthodox, many years at 3°C
Prosopis juliflora	Orthodox, many years at 10°C
Robinia pseudoacacia	Orthodox, 10 years from 0 to 5°C
Sesbania sesban	Orthodox, 2 years in open container at room temperature

HOW TO TREAT THE SEEDS

In order to increase germination rates, the seeds of many species need to be treated before being sown. The coat surrounding the seeds acts like a barrier that limits the absorption of water needed to germinate. Under natural conditions, this barrier allows the seeds to gradually germinate when exposed to different mechanisms (sun, rain, fire, etc.) that weaken and wear out the outer cover. In a nursery, it is convenient to treat the seeds before being sown to improve germination and guarantee uniform seedling size. Since the cover of each species is different, the treatment will vary depending on the species. Once the seeds have been treated, they should be sown immediately.

Most frequent seed treatments:

- **Cool water.** Soak seeds in a volume of water, at room temperature, that is 4 times the volume of the seeds. Seeds should be soaked for 12 to 48 hours, until they have expanded.

- **Hot water.** This mechanism is used for species with a thick coat. Boil a volume of water that is 4 to 10 times the volume of the seeds. Remove from the heat and cool down for 5 to 10 minutes. Pour the water into the container with the seeds and leave it for 6 to 24 hours until the seeds have expanded.
  Note: Do NOT place the seeds in boiling water, this will kill them!

- **Mechanical - Nick or Cut.** This mechanism can be used for all species, but because it is very time consuming, it is only recommended for small amounts of seeds. With a knife, needle, nail file or sandpaper, slightly scrape or cut the seed coat. To avoid harming the embryo, do it on the external layer only and on the side opposite to where the seed was formerly attached to the fruit. Soak in cool water.

- **Acid.** This treatment is used for seeds with a hard or thick coat. In a thick plastic or glass container, submerge the seeds in sulfuric acid for 10 to 30 minutes. Remove the seeds from the acid and wash them immediately under cold running water and then dry them.
  Note: We do not recommend this treatment due to the danger posed by the chemicals and their high costs. Use should be used only when other mechanisms have not yield results, and by people experienced and knowledgeable on the subject.

Table 2. Seed Treatments

NAME	TREATMENT(S)
Acacia auriculiformis	Soak in hot water for 1-2 minutes and in tepid or cold water for 24 hours.
Acacia nilotica	Pour hot water over the seeds and soak in cool water for 24 hours.
Acacia Senegal	Soak in water 12-24 hours or use mechanical treatment. Mature seeds might need acid treatment.
Acacia tortilis	Place hot water on seeds and soak for 24 hours.
Albizia lebbeck	Soak in hot water 2 minutes and place in cool water for 24 hours, or use mechanical treatment. May sometimes need acid treatment.
Cajanus cajan	Does not need treatment, but soaking for 24 hours is recommended.
Cassia siamea	Soak in hot water for 12-24 hours or in cold or tepid water for 48-72 hours. Soaking in sulphuric acid for 10-30 minutes may be necessary.
Dalbergia sissoo	Does not need treatment, but soaking in water at room temperature for 24-48 hours is advisable.
Gleditsia triacanthos	Soak in hot water during 24 hours or use mechanical treatment. Sulphuric acid for 60 to 120 minutes is also an option.
Gliricidia sepium	None, or soak in hot water for 12 hours.
Grevillea robusta	Does not need treatment.
Leucaena	Soak in hot water for 2 minutes or use mechanical treatment.

leucocephala	
Moringa oleifera	Does not need treatment.
Prosopis juliflora	Mechanical treatment or, if necessary, submerge in sulphuric acid for 15-20 min.
Robinia pseudoacacia	Soak in hot water during 2 minutes and leave in cool water overnight; or apply mechanical treatment.
Sesbania sesban	One minute in hot water or soak in cold or tepid water for 24 hours. Treatment with acid may be necessary.

Inoculation

Nitrogen is an essential nutrient for plant growth. Most of the trees provided by the New Forest Project fix nitrogen (see Table 3 to determine which do and which do not). Nitrogen-fixing trees are trees that can take nitrogen from the air (normally unavailable to plants) and incorporate it into their leaves and tissue thanks to the presence of specific bacteria in their roots. This nitrogen, through the cycling of organic matter, can have an important role in fertilizing the ground.

When using nitrogen fixing trees it is important to make sure that the soil contains the appropriate strain of bacteria needed by that species to fix nitrogen. In areas where trees are native or naturalized the soil will likely contain it. However, seeds should be treated or 'inoculated' with the appropriate strain of bacteria if the species is being newly introduced, there are no other nitrogen fixing plants in the area or a soil test shows less that 100 bacteria per gram of soil.

HOW TO SOW THE SEEDS

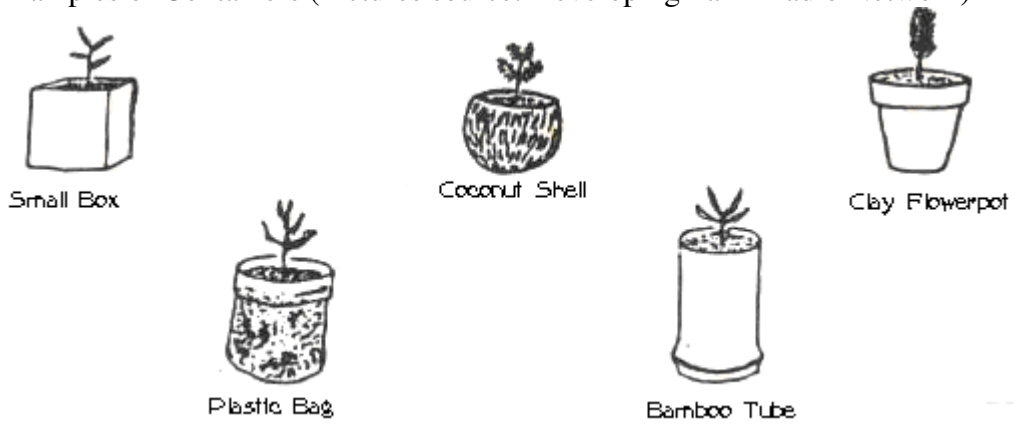
There are two basic ways to sow seeds:

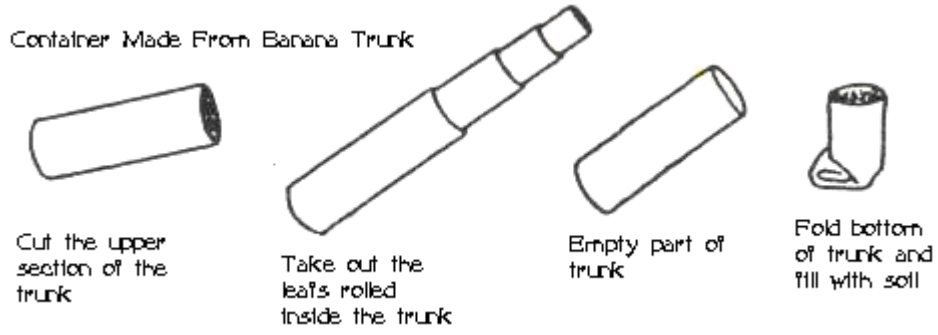
- In seedbeds
- In containers

To prepare a **seedbed**, plough the soil of approximately one square meter of land and mix in organic material, ashes, sand, etc. Sow the seeds in a row and cover them with a thin layer of soil (see next section for more information about the soil).

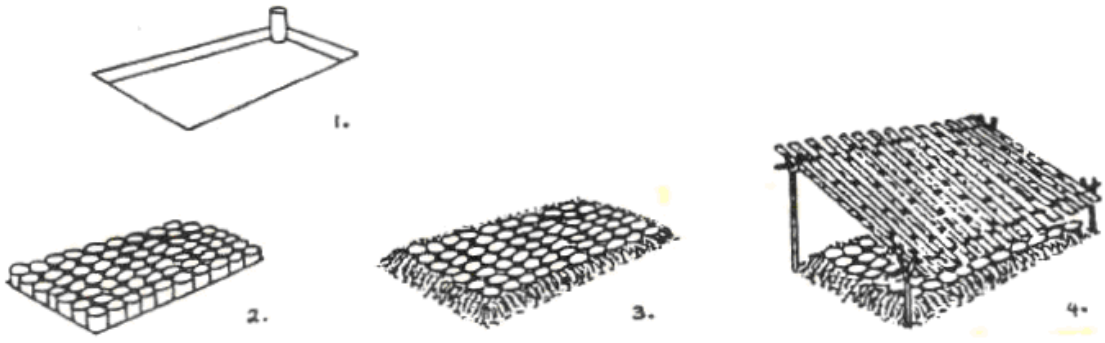
Flowerpots, plastic bags, cardboard boxes, cans and old pans can be used as **containers.** The trunks of banana trees can be used by cutting them into sections that are 20cm long, eliminating the interior layers and leaving the external leaves.

Examples of Containers (Pictures source: Developing Farm Radio Network)





- Sow the seedlings in containers that are **deep enough** in order to avoid the roots from getting tangled inside the container.
- Place **2 to 3 seeds** in each container.
- Place all the containers **close to each other** to protect them from the wind, and to maintain humidity.
- Sow **big seeds** in holes that have the same depth as the width of the seed.
- Sow **small seeds** in holes that are 3 to 4 times deeper than the width of the seed.
- Once the seeds are in place, cover with soil.



Place containers together to facilitate watering and to avoid damage by sun, wind or rain. To conserve humidity and reduce excessive heat dig a hole with a depth that is half the length of the containers (1), place the containers in it (2) and pile earth around the sides (3). See below for shading instructions (figure 4).

HOW TO PREPARE THE SOIL

Seeds should be sown in high-quality soil with good drainage. The right soil mix will provide the seedlings with the nutrients and humidity they need to grow well. A good combination is usually **3 portions of agriculturist soil, 1 portion of soil rich in humus, and 1 portion of sand**. The appropriate mix should be based on the characteristics of the soil. For example, heavy or clayey soils will need a higher percentage of sand, while sandy soils will need more organic matter.

HOW TO TAKE CARE OF THE SEEDLINGS

Watering

One of the advantages of growing seedlings in a nursery is that it is much easier to provide them with water. In general, watering should be done **two times a day during the first weeks and once a day after germination.** To avoid washing off the soil, hoses or cans with small holes at their mouths should be used. *Note: Never water during the hot hours of the day.*

Shade

Shading of the seedlings is necessary to conserve humidity and prevent damage from excessive heat and direct sunlight. To achieve this, a roof over the area where the seeds and/or seedlings are found should be built from bamboo leaves or branches, or any other material that will provide partial shade. Palm trees, for example, are easy to handle and provide the appropriate shade.
Note: Excessive shade over the nursery may prevent the seeds from emerging due to the lack of heat.

Competition between Seedlings and Pruning of Roots

If more than one seed germinates in a container, the best seedling has to be chosen and the remaining one(s) should be carefully pulled out. In addition to this, any weeds growing in the container should be eliminated. This will reduce competition for water, light and nutrients, enhancing the growth of the chosen plant. In addition to this, to make the plant grow stronger, all roots extending outside of the containers must be pruned by cutting them with scissors or a knife.

WHEN TO TRANSPLANT THE SEEDLINGS

The seedlings can be transplanted to their final place once they are big enough, which is usually when they are approximately 15 cm tall. If they are going to be transplanted to a place with tall grass and weeds, it is better to leave them in the nursery until they are about 30 cm tall. It is important to transplant the seedlings before the roots get to be too big and start growing in circles inside the flowerpot. This can cause the plant to loose its ability to develop a strong root system in the field, making it unable to maintain a vertical position.

Before transplanting the seedlings, it is crucial that the rainy season has started and that the soil has been wet completely. The soil will most likely be ready approximately two weeks after the rains arrive. If the project is in a temperate zone, it is recommended to transplant the seedlings at the beginning or the end of the growing season.

WHERE AND HOW TO TRANSPLANT THE SEEDLINGS

Choosing the right place

The place chosen to transplant the seedlings will depend on the objectives of the project. Each species has different soil requirements, so it is important to evaluate the characteristics of the soil at the site, making sure that it is appropriate for the species that will be planted (see Table 3 for species tolerance to certain soils). PH, salinity and humidity should all be taken into consideration when selecting a site. In addition to this, soils that are not deep enough should be avoided because they can dry out very fast and can have a layer of solid rock that will prevent the roots from growing. On the contrary, rocky soils are usually fine if they have cracks and fissures where the roots can grow.

Spacing of the trees

The spacing of the tress should be based on what they will be used for. For example:

- For fuelwood production, plants should be planted 60 cm apart.
- For wood production, or if bigger trees are desired, they should be planted one- and-a-half meters apart.
- If trees are planted to control land erosion, they should be planted next to each other forming a line approximately one meter apart.
- If the trees are going to be used for fodder production, it is recommended to plant them one meter apart, to stimulate leaf growth instead of branch growth.
- If trees are planted as wind breaks, 1 to 2 meters is an appropriate distance.

Preparing the site

Before transplanting the seedlings, all roots, weeds and grass should be cleared in a radius of one meter around the area where each seedling will be planted. This reduces competition for water, sunlight and food, allowing the tree to grow healthier and stronger. In addition, eliminating weeds also eliminates small animals and insects that may harm or eat the trees.

For each plant, dig a hole that is approximately 30 cm deep and 45 cm wide. When digging, place the superficial soil, which is rich in nutrients, on one side; and the subsoil on the other side. Loosen up the soil left within the hole. It is recommended to mix a bit of superficial soil with organic matter or compost (if available), and fill the hole half way. Make sure the soil is moist and add water if not. *Note: whenever you plant a tree the soil should be moist but not soaked.*

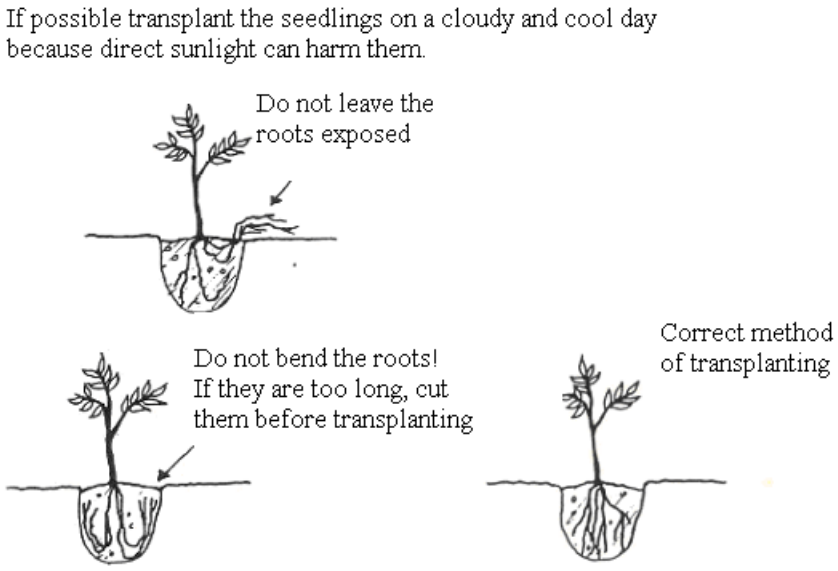
Transplanting the seedlings

The seedlings must be watered before being transplanted. They should be transported to the site where they will be sowed with caution and within their containers. If the containers are not easily degradable, such as a plastic bag, a bamboo tube, or a coconut they should be removed before being transplanted. At the site, remove the seedlings from their containers with much care and transplant them immediately before the roots dry out. To avoid damage, it is better to transplant the seedlings with the soil they were growing in. *Note: Take special care not to harm the roots or the soil adhered to them during the transfer from the containers to the hole in the ground.*

The seedling must be planted at the same depth it was growing in the container, not too deep and not too shallow. The remaining superficial soil should be used to fill up the spaces around the plant firmly pushing down the soil with the hands around the roots. Finally, the remaining subsoil should be used

to finish filling up the hole. If the area is arid, it is recommended to place a border of soil around the plant to capture and retain rainwater.

If the seedling was growing in a biodegradable container, cut the sides of the container with a knife from top to bottom, and then plant the seedling in its container.



Picture source: Developing Farm Radio Network

HOW TO TAKE CARE OF THE TREES

Weed control is absolutely essential during the establishment of the trees. Eliminate any plants that grow around it and can compete for water, light and nutrients. In addition to this the trees should be kept clear of animals that may eat the branches and bark. Goats, cattle or chickens can harm the young trees. If animals are present in the area, you should build fences around the young trees with sticks, branches with thorns or other materials.

It is recommended to trim the branches of the trees regularly and with caution. For example, in agroforestry plantations, branches should be trimmed to reduce shade on other plants and competition for soil nutrients. In addition to this, small branches can be trimmed and used as fuelwood, and the leaves can be used for fodder or green mulch. Trees planted for fodder or fuelwood will be trimmed more often than those planted for construction wood or other purposes.

Branches must be cut during the appropriate season and in the right way. Usually, the best season to trim trees is before the sowing period. While cutting the branches of the trees, it is important to maintain the original shape of the tree. Therefore, it is recommended to study the shape before cutting (for example: the tree can be extended as an umbrella, or can be long and cone-shaped, or compacted and round). To prevent the tree's outer layer from being damaged, cutting tools such as, axes, knifes, and machetes must be clean and sharp when used. The branches should be cut as close to the stem as possible but making sure only branch tissue is being removed. Cover the cut to protect it from insects and diseases.

Branches that are broken, dry or possibly infected must be cut off immediately. Those that show sign of possible diseases should be burnt as soon as they are cut. Branches that have been slightly damaged can be left on the plant because they can recover easily. However, those that are highly damaged should be eliminated to avoid insect attacks or spread of diseases.

A Note on Invasive Species

Some trees provided by the World Seed Program have the potential to become weeds or invasive in the new areas where they are being planted. Invasive species are species that have the potential to spread rampantly and can interfere with the growth of native species affecting entire ecoystems. Species that are being planted in different ecosystem from those where they evolved can lack natural competition or browsers to keep them at bay, making it easier for them to grow extensively. Also, invasive species usually have the capacity to grow and reproduce very fast; they are usually more efficient at gathering nutrients than native plants and have a tendency to shade out smaller plants. Some of the characteristics that make WSP species so useful, such as their fast growth and tolerance to difficult soil conditions, make them good invaders. Once a plant invades a site it can be very difficult to control and it can take over large areas of land. Species that have the potential of becoming invasive should be planted with extreme caution and monitored closely.

The following species provided by New Forests Project are potential invasive species:
Acacia nilotica
Acacia senegal
Leucaena leucocephala
Prosopis juliflora

For further information, please contact the New Forest Project or refer to the following links:

- http://www.agroforestry.net/overstory/overstory89.html-General information about woody invasives
- http://www.issg.org/database/welcome/-Global Invasive Species Database

Additional Tables:

Table 3. Species Characteristics

Species	Fixes nitrogen	Drought resistant	Tolerates saline soils	Tolerates water-logged soils	Tolerates alkaline soils	Tolerates acidic soils	Grows on poor soils
Acacia auriculiformis	X		X	X	X	X	X
Acacia senegal		X					
Acacia nilotica	X	X	X	X	X		X
Acacia tortilis	X	X					
Albizia lebbek	X			X	X	X	
Cajanus cajan	X				X	X	
Cassia siamea							
Dalbergia sissoo	X						
Gleditsia triacanthos		X	X				
Gliricidia sepium	X						
Grevillea robusta	X						
Leucaena leucocephala	X	X	X		X		
Moringa oleifera							
Prosopis juliflora	X	X	X	X			
Robinia pseudoacacia	X	X				X	
Sesbania sesban			X	X	X		

Table 4. Some Outstanding Advantages and Disadvantages of World Seed Program Species

SPECIES	ADVANTAGES	DISADVANTAGES
Acacia auriculiformis	Ability to tolerate a wide range of soil conditions	Crooked stems, susceptible to fires
Acacia nilotica	Good for dry areas of Africa; can withstand extreme temperatures	Weediness, thorniness, susceptible to pests and diseases
Acacia senegal	Mainly grown for gum arabic production	-no outstanding problem-
Acacia tortilis	Drought resistant; good for stabilizing sand dunes	Thorniness, susceptibility to browsing and insects
Albizia lebbek	Good fodder for semi-arid regions	Can be susceptible to insects and pests
Cajanus cajan	Best known as human food	Can be browsed by livestock
Cassia siamea	Produces quality fuelwood	Looses vigor after 2-3 coppices
Dalbergia sissoo	Produces fine timber and is a good soil stabilizer	Susceptible to fire and wind damages
Gleditsia triacanthos	Good in temperate and highland regions	Roots, bark and seeds are poisonous
Gliricidia sepium	Known for its use versatility	Weediness; toxicity to animals if overutilized
Grevillea robusta	Good for warm temperate sub-tropical areas and tropical highlands	Susceptible to fungal and insect attacks; flower, fruits and seeds are poisonous, not good for monocultures due to auto-toxic effects
Leucaena leucocephala	Rapid growth and excellent source of fodder and wood	Aggressive invader, extremely weedy; only for arid problem sites
Moringa oleifera	Extremely high nutritious value for humans; water purification	-no outstanding problem-
Prosopis juliflora	Extremely tolerant to droughts and marginal soils	Weediness, cattle should be kept out to avoid unwanted dispersal of seeds
Robinia pseudoacacia	Good for temperate frost-prone areas	Thorny; root bark and seed pods are poisonous; newly introduced trees need to be inoculated with its specific Rhyzobium.
Sesbania sesban	Good for subtropical areas and higher elevations and waterlogged conditions, rapid early growth rate	Newly introduced trees need to be inoculated with its specific Rhyzobium

Note: All of the above species can improve soils through the input of organic matter to the ground. In addition to this, many of them fix nitrogen (see table 2) and can incorporate this key nutrient into the ground.

Table 5. Species Common Uses

	Firewood	Ornamental	Fodder	Gum	Live fences	Construction	Medicinal	Erosion control	Apiculture	Food for humans	Shade	Pulp
Acacia auriculiformis	X	X				X		X			X	X
Acacia senegal	X		X	X		X	X	X	X	X		
Acacia nilotica	X	X	X	X		X	X		X	X		
Acacia tortilis			X			X						
Albizia lebbek	X	X				X	X	X	X		X	
Cajanus cajan	X		X					X		X		
Cassia siamea	X	X	X			X	X	X			X	
Dalbergia sissoo	X	X	X			X	X		X		X	
Gleditsia triacanthos	X	X	X			X	X	X	X		X	
Gliricidia sepium	X	X	X		X	X	X		X		X	
Grevillea robusta	X	X				X			X		X	X
Leucaena leucocephala	X	X	X		X	X		X	X		X	X
Moringa oleifera		X		X			X	X	X	X	X	
Prosopis juliflora	X		X			X	X	X	X	X		X
Robinia pseudoacacia	X	X	X	X		X		X	X			X
Sesbania sesban	X	X	X				X			X	X	

Table 6. Species Biophysical Limitations

Species	Altitude	Annual Average Temperature	Annual Average Rainfall
Acacia auriculiformis	0-500m	24-38° C	700-2000mm
Acacia nilotica	0-2000m	17-28° C	200-1500mm
Acacia senegal	100-1700m	16-28° C	300-1200mm
Acacia tortilis	0-1000m	23-31° C	100-1000mm
Albizia lebbek	0-1800m	19-35° C	500-2500mm
Cajanus cajan	0-2000m	18-38° C	400-2500mm
Cassia siamea	0-1200m	20-31° C	400-2800mm
Dalbergia sissoo	0-1500m	-4 a 45° C	500-4500mm
Gleditsia triacanthos	0-2500m	15-24° C	510-1520mm
Gliricidia sepium	0-1200m (1600m)	15-30° C	600-3500mm
Grevillea robusta	0-2300m	14-23 a 25-3° C	600-1700mm
Leucaena leucocephala	0-1500m	25-30° C	650-3000mm
Moringa oleifera	0-1000m	12.6-40° C	At least 500mm
Prosopis juliflora	0-1500m	De -35 a 40° C	1000-1500mm
Robinia pseudoacacia	Over 800m	De -35 a 40° C	1000-1500mm
Sesbania sesban	100-2300m	18-23° C	500-2000mm

If you take proper care of your trees, they will provide you with products and services for many years!!!

For more information on the World Seed Program:
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