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FACT 99-06

quick guide to multipurpose trees from around the world September 1999

Prosopis tamarugo: Uniquely adapted to the Atacama Desert of northern Chile

Prosopis tamarugo F. Philippi is a most remarkable tree, being able to survive in one of the most inhospitable deserts in the world. In the Atacama Desert of northern Chile, decades can pass without any rain at all, and layers of salt often several meters thick lie on the soil surface. The trees produce excellent quality fuelwood, timber from larger trunks, and nutritious pods and leaves. The edible pods were a valuable source of food for indigenous populations and supported Spanish armies as they crossed the vast desert during the conquest of South America. Deforestation on a massive scale during the following centuries decimated the once-great forests. A major reforestation scheme was undertaken in recent decades, and these new forests now support large flocks of sheep and a thriving local economy. However, attempts at introducing tamarugo to other and areas have not been successful.

Botany

Prosopis tamarugo is one of the 44 species of *Prosopis* recognized by Burkart (1976), being in the family Leguminosae, subfamily Mimosoideae, or family Mimosaceae. It is a deciduous tree with an open, irregular crown. In favorable conditions, trees are 8–20 m in height with roots reaching subterranean water at depths of 15 m. The trunk is usually short, up to 80 cm in diameter, with dark gray and fissured bark. Typical of common legume trees, the leaves are bipinnate, with one pair of pinnae, each 3–4 cm long, and with 10–15 pairs of small leaflets 4–8 mm long. The stems are thorny, with slightly curved, spiny stipules up to 1–4 cm long. The flowers are small, 8–9 mm long, yellowish, and in spike-like racemes 3–6 cm long. The pods are hard, curved, and red-brown, 2.5–4 cm long, containing 6–8 small, brown seeds.

Ecology

The range of mean annual minimum and maximum temperatures tolerated is 12°–36°C. The annual water deficit under cloudless skies is approximately 2000 mm per year. There is often a permanent water table lying 1–15 m deep. In the natural habitat, the soil is generally very saline sandy or clay loam with surface salt encrustation up to 60 cm thick. Soil pH is between 8.0 and 8.4. The tamarugo tree has evolved a two-fold root system, made up of one or more deep tap roots

Source: FAO 1985

and a dense, surface mat of lateral roots to exploit both deep ground water and atmospheric moisture for survival. It appears that atmospheric moisture condenses below the canopy and is taken up by the roots, rather than taken up directly by the leaves as was previously thought (e.g., Sudzuki 1969). This "reverse transpiration" process plays a negligible part in the water balance of *P. tamarugo* (Le Houérou 1999, pers. comm.). The tree grows very quickly in the early years of establishment, but annual increments decrease markedly after 20 years. Trees may live to be over 1000 years old. Unlike most *Prosopis* species, *P. tamarugo* shows less genetic variation and is thought to be at least partially self-compatible (Hunziker et al. 1975).

Distribution

The native range of the tamarugo tree is restricted to the unique environmental conditions of the Atacama Desert in northern Chile. The most extensive forests are found in the Pampa del Tarnarugal, with some 1000 km^2 now designated a national reserve (19°–22°S, 68°–70°W), at an elevation of 950–1500 m. This region is typified by an almost total absence of rainfall (0.2–1.0 mm annually), intense solar radiation, a very high diurnal range in temperature (24–35°C).

Uses

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Wood. The wood is very hard and difficult to work but extremely durable and resistant to decay, with a dry-weight density of 910 kg/m^3. The heartwood makes up over 80% of the stem volume, has a desirable dark brown to intense red color, and is very dimensionally stable (Cuevas et al. 1985). It is used for furniture, but the short, twisted, and often knotty stems are not very suitable as a source of timber. Other uses include tool handles and, more recently, for parquet flooring.

Fuelwood. The wood burns well, slowly, and with an even heat. It has a high calorific value of 5065 kcal/kg and produces an excellent-quality charcoal. It has been used extensively throughout history as the main source of fuel in the region, continuously for domestic use but also for industrial uses. Biomass production is 0.2–2.8 m^3/ha/yr from plantations at 25–188 trees/ha.

Fodder. The tree has palatable, nutritious foliage and fruit, and mature stands of 100 trees/ha are reported to support up to 26 sheep per hectare. Leaves have 50% total digestible nutrients and 14% protein and are rich in carbohydrates (Serra 1997). Leaf forage production is 20–70 kg/ha/yr from 14–22- year-old trees at 100 trees/ha. Flowering and fruiting begin when the trees are 8 years old (Stienen 1985) but then varies widely from year to year and even in the same year between individual trees (Serra 1997). The fruits have 55–65% digestibility, 10–20% protein, 20–30% carbohydrates, and are an excellent fodder source. The flowers are also a valuable bee forage.

Reforestation. Sustainable agro-ecological systems for the Atacama have been developed following large-scale reforestation, primarily with *P. tamarugo*. Beginning in 1965, the Chilean government initiated a plantation program that was responsible for the establishment of 20,000 ha of tamarugo forest by 1990. These now support extensive flocks of sheep, mainly Karakul and Suffolk Down, along with Angora goats. Hereford cattle are also raised.

Silviculture

There are 50,000–110,000 seeds per kg, which require pretreatment for rapid and synchronized germination. Untreated seeds give germination over 50%, but for >95% germination, soaking for 14 minutes in 95% sulfuric acid is required (Pasiecznik et al. 1998). Seed are sown in nursery bags and tended for 3-5 months before out-planting. Site preparation involves the digging of pits, normally at 10 x 10 m spacing (100 trees/ha), 80 cm in diameter and 40 cm deep, with another smaller pit dug into the bottom into which the tree is planted. This smaller pit is covered with a plastic sheet to maintain a saturated atmosphere. Pure sheep manure is used at planting, and superphosphate is applied at varying intervals during establishment. Trees are watered every 10 days initially, decreasing to every 30 days after the first year. Pruning improves tree vigor and increases foliage and fruit yields and is also required to allow stock to move freely between trees. Trees coppice readily when cut or lopped for fuel wood.

Symbiosis

The tamarugo tree is known to fix atmospheric nitrogen (Felker and Clark 1980), even under very saline conditions, up to salinity levels equal to sea water (Felker et al 1981), such as are found in the Atacama. Nodules appear 5–6 weeks after inoculation, generally in new secondary roots. Low growth rates have been correlated with low soil phosphorus, which has in turn been suggested as a factor limiting rates of nitrogen fixation in *P. tamarugo* under field conditions (Jarrel et al 1982).

Limitations

Following successful reforestation in the hyper-arid native range and research showing its ability to survive and grow in salinities equal to seawater (Felker et al 1981), the species was promoted as a promising multi-purpose tree for arid zones. However, after inclusion in many species trials the world over for the last 25 years, there are no records of any successful introductions. *Prosopis tamarugo*, if it survives the nursery stage, has suffered 100% mortality within the first year after planting in North America, India, and Africa (author's observation). Although reforestation in northern Chile should continue, it is not recommended for further introductions outside of its native range.

Related Species

Arboreal *Prosopis* species are dominant in many arid and semi-arid regions of the world. Several have been widely introduced, with mixed effects. While providing valuable fuelwood and animal fodder in areas where little else will grow, they have also become invasive weeds in some countries. The main introduced species are *P. juliflora* and *P. pallida* in tropical regions, and *P. glandulosa* and *P. velutina* in more subtropical climates. Other species such as *P. alba* and *P. chilensis* have been successfully introduced to several countries, and others have shown potential. *Prosopis africana*, *P. cineraria*, *P. pubescens*, and *P. tamarugo* have not been successfully introduced outside of their native range.

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A complete set of references is available from FACT Net

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