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# Multi-purpose Tree Crops for Dry Lands

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## Prelude:

In August, 1983 the farmers from Karnataka, South India marched to the government nursery at Holatalli, pulled out all the eucalyptus seedlings, and replaced them with tamarind seeds. Five days later farmers from Neginahalla village moved into the government nursery at Buddigavi and pulled out the Eucalyptus saplings. From these first isolated protests against single purpose trees the Apiko movement has grown to become a ________ factor in forestry programs in India.

Similar protests have taken place in other areas of the World where top-down forestry schemes have ignored the ecological and sociological impacts of forestry projects. International aid in agriculture, after many years of equal insensitivity, has become more enlightened about these issues but forestry lags behind. It is time for change.

## Introduction:

The need for improved management of dry land agricultural systems has become increasingly critical as the result of population growth and the cumulative effects of past mismanagement (Karrar and Stiles, 1985, Dregne, 1984). Most aid programs and consultants have ignored multi-purpose tree crops for use in these difficult and degraded lands. Multi-purpose tree crops (food, fodder, and fuel are most common) can be valuable elements in the design of sustainable agricultural systems (Grainger, 1980; Bainbridge, 1985c; Smith, 1953; Sholto Douglas and de Hart, 1984). Many of the multipurpose trees (Prosopis, Acacia, Leucaena, Robinia) may also fix nitrogen and thereby provide even greater benefits (Felker, 1981). Better understanding of the ecological interactions, effects, and benefits of multi-purpose tree crops must be developed for their optimal use.

The dry lands of the world are one of the most difficult challenges for the agroecologist (Speth, 1985). The use of perennial crops and particularly deep rooted trees is often one of the best methods to maximize resource use efficiency, both above and below ground (Cannel and Jackson, 1985). Trees can collect nutrients and water from a much greater depth and can thereby provide increased security for subsistence farmers. Yet, despite their potential importance tree crops and agroforestry systems have been sadly neglected.

Interest in agroforestry and tree crops has been increasing and several meetings have been convened recently, most notably a 1984 conference at the Institute for Terrestrial Ecology in England (Cannell and Jackson, 1985). Much of this work has emphasized tree crops for fuel alone and made enemies of the people the trees were supposed to help (Fernando, 1984; Anon, 1984). If real progress is to be made toward slowing and eventually halting the desertification and desertization of the world's dry lands (Dregne, 1985; Le Houerou, 1976) and meeting the needs of the dry lands dwellers the design and development of agroecosystems must include the use of the multi-purpose trees. These trees will not be used more regularly and wisely until they are more widely known and appreciated and the ecological interactions between individual trees, other crop and weed species, and the ecosystem are better understood.

Two of the many important multipurpose tree species for use in these dry lands are the oaks (Quercus) and mesquites (Prosopis).

## THE OAKS (QUERCUS spp)

The oaks are perhaps the most neglected multiuse tree. They produce food, oil, fodder, timber, fuel, insulation (cork), tannin, dyes, and serve as a food source for insects that produce silk and sugar (Bainbridge, 1986). They are adapted to a wide range of soils and climates and include species that can grow in sea water, survive very cold temperatures, endure drought, and contrary to common belief, many are fast growing. Yet, despite centuries of use and acceptance from the MidEast to Asia the oaks have been ignored by Western foresters, and by virtue of their impact, foresters throughout the World.

### Acorn Use as Food

The oak seeds, acorns, have been used as food by homo sapiens for thousands of years virtually everywhere oaks are found. The destruction of the acorn resource may well have led to the development of annual based agriculture and to civilization as we know it today, (Bohrer, 1972; Bainbridge, 1985b). In Europe, Asia, North Africa, the Mid-East, and North America, acorns were once a staple food, (Bainbridge, 1985a). For example, the Ch'i Min Yao Shu, a Chinese agriucltural text from the sixth century recommends Q. mongolica as a nut tree (Sheng Han, 1982) and in Spain and Italy as recently as 1900, acorns provided 20% of the diet of some people (Memmo, 1894). For many of the Native Americans in California, acorns made up half of the diet (Heizer and Elsasser, 1978). Acorn foods remain on the market not only in Korea and North Africa, but are available in most major American cities, at Korean food stores (Bainbridge, 1985a).

The acorns of all the species of oaks (500 + world wide) are apparently edible and should be evaluated. Although the acorns of some oaks are too small or hard to open for widespread use , there are many species that could and should be planted for use as food. The relatively few studies of acorn composition that have been done show that the structure of acorn starch falls between that of corn and potatoes. Acorns also contain up to 55 mg of Vitamin C per 100g in the raw acorn. Acorns also include Vitamin A, with 180 IU per gm in Q. phellos. Twenty-seven grams, or less than a tenth of a pound of these acorns, would meet the suggested daily Vitamin A requirement of 5,000 IU. This could be of considerable importance in very poor areas of the world where vitamin A deficiencies are common. Thorough testing of the full range of oak species may well discover other standouts for these and other vitamins, trace elements, and amino acids. Acorn composition is shown in Table 1.

Table 1: Acorn Composition 18 Species. (Bainbridge, 1985a)

| | Range % |
|---|---|
| Protein | 2.3 - 8.6 |
| Fat | 1.1 - 31.3 |
| Carbohydrate | 32.7 - 89.7 |
| Tannin | 0.1 - 8.8 |
| KCAL/100 gms | 265 - 577 |

## Acorn Oil

Acorn oil, can be separated by boiling, crushing, or pressing. It has been used as a cooking oil in Algeria, Morocco, and parts of the U.S. This oil was also used by the Native Americans of the eastern U.S. as a salve for burns and injuries. Some species contain up to 30% oil, comparable to or better than the best olive varieties, and the oil itself is very similar to olive oil. (Bainbridge, 1985a; Wolf, 1945).

## Oak Leaves

Oak leaves are or have been used in Mexico and China (Bainbridge, 1985a) and used as wrappers for cooking, like corn husks. I have been unable to locate any information on the composition of these leaves but it is an intriquing area for research.

## Fodder

Acorns have been used to feed domesticated animals for thousands of years. Most varieties can be fed to 20% of the diet of chickens and other animals with no difficulty. Leached, acorns can be used in higher percentage as part of a properly balanced diet (Bainbridge, 1986). Acorns are also an essential food for many species of wildlife. Oak leaves are an important fodder in many regions of the world. *Q. infectoria* is favored in Iraq for this purpose (Blakelock, 1950). Oak trees may be pollarded for ease of harvest and higher productivity.

## Timber

Many of the oaks have very high quality wood. For several hundred years, oak was the preferred material for shipbuilders. Oak wood is still prized because the wood from many species is hard, tough, durable, and resilient. It is widely used for flooring, veneer, furniture, boats, barrels, and many other products. It is favored for use by timber frame house builders. More countries should have the wisdom to adopt the 120-210 year oak rotation practiced in France (Oswald, 1982). By the time today's planting mature the world hardwood market will be drastically changed and the flood of low cost hardwoods from the devastation of tropical forests will be past.

Oak and other temperate hardwoods will become important as the tropical hardwoods are exhausted. The United States and other countries where oak forests were once predominant should begin extensive oak planting programs to restore the oak forests.

Selection and widespread distribution of a number of high quality timber and acorn cultivars would do much to repair the damage that has been done to these forests by hundreds of years of neglect and abuse.

Firewood

Many of the oaks produce excellent fuelwood and this has been a contributing cause of oak decline. Oak wood was a primary fuel in the beginning of the industrial revolution. For example, two English iron smelters at Sheffield and Worth were consuming 15,000 tons of oak per year in the middle of the 18th Century. (Sweeting, 1943). In developing and developed countries where oak forests remain, oak is still a preferred fuel wood. In California, for example fuel wood is the major use of oak, with as many as 160,000 cords sold each year, with a retail value of more than $20 million dollars cord (Tuazon, 1986).

Oak is well adapted to coppice and will yield 5 tons/ha/yr in a 30 year rotation (Beckely, 1982). Coppice with standards adds continued acorn production and an eventual timber harvest.

Cork

The bark of some oaks is used for insulation, flooring, wine stoppers and a variety of other purposes (Preston, 1983; Cooke, 1961). Quercus suber, the preferred cork tree, is a major commercial crop in the Mediterranean region. Cork oaks have prospered in California and survived as far north as Puget Sound.

Other products

Oak leaves are used to feed silkworms in China. The "manna" from heaven described in the Bible, was probably the sugar produced by scale insects feeding on oak leaves. This sugar has been collected and eaten in the Mideast for thousands of years (Thompson, 1949). It is either collected from rocks beneath the oaks or from tarps spread for the purpose.

Oaks are intimately related with many fungi (Singer, 1961). The very valuable truffle ($300 US/per pound) grows on oak roots and oaks have been planted in Europe for truffle production (Cohen, 1984). In both Japan and the United States shitake mushrooms are grown on oak logs.

Tannin-rich acorns and bark were once used industrially for tanning hides. Insect galls on oaks have been used to make dye and ink and were once an important international trade item.

Summary - Oaks:

The evaluation of oaks for fuelwood, timber, and other purposes should be begun. Testing of salinity, drought, and cold tolerance should be started on the more promising species.

Management practices for oak must also be refined, with particular concern for their use in polycultural systems. The importance of the symbiotic ectomycorrhyzae has only recently been appreciated (Mitchell et al, 1984) and inoculums tailored for oak planting in specific settings should be developed and evaluated. Multi-strain inoculums may offer the best performance.

THE MESQUITES (PROSOPIS spp)

Nitrogen fixing trees are especially valuable for agroforestry use. These trees can produce well without expensive and energy intensive inputs of manufactured nitrogen. One of the most promising goups of nitrogen fixing trees is the mesquite family, Prosopis, a group of 44 species extremely well adapted to the dry lands.

The mesquites are able to produce effectively in the dry lands because they are adapted to heat, drought, and salinity (Nilsen et al, 1986; Virginia et al, 1984; Felker et al, 1981a; Anon, 1985; and Kaul, 1982). Mesquite roots are fast growing and will reach very deep for ground water, 50 meters or more. Seedlings may send roots down as quickly as the water table drops after the wet season. Recent research has shown that the nitrogen fixing symbionts are effective in the deep soil, with active nodules at 5 meters (Virginia et al, 1986). The mesquites also exhibit salt tolerance with some species aable to tolerate 36,000 ppm of sodium chloride (Felker et al, 1981b). This remarkable rooting ability and salt tolerance, combined with drought tolerance and nitrogen fixing allows a useful crop to be grown in areas where few plants of any kind will grow. Pitcher irrigation has proved useful in establishing mesquite in difficult environments (Sheik and Shah, 1983).

The mesquites have been utilized for hundreds of years by people in many of the World's dry lands (Pedersen and Grainger 1981). They produce edible pods that are high in sugar (Meyer, 1984; Felker, 1981; Esbenshade 1980; Nabhan, 1986). These pods are used by people and as fodder for livestock. The mesquite also produces excellent fuelwood and is suited for other purposes as well.

Mesquite pods were once a staple for the Native inhabitants of many drylands of the Americas. This use continues to a limited extent today (Meyer, 1984). Mesquite pods are also eaten in some areas of India.

The use of mesquite pods for food was as important to the people where they grew as acorns were in the colder zones where oaks were predominant. The high productivity of the tree, 146kg for a 30 year old tree (Felker, 1979), made it possible for collecters to harvest 80 kilos of pods per day (Meyer, 1984). The harvester had to be quick because mesquite pods are as avidly consumed by wildlife as acorns.

The development of mesquite foods for modern times is very promising and a mesquite and peanut candy is now being developed for sale in Northern Mexico (Becker, 1986). The production and taste testing conducted by Meyer (1984) suggests that mesquite pods could be competitive on the market. Mesquite/corn chips were judged as better than pure corn chips for all organoleptic criteria.

Table 3: Mesquite Composition (Meyer, 1984; Gupta et al, 1984)

| | Exo and Meso Carp Range | Pod Range |
|---|---|---|
| Protein | 6 - 11% | 8.0 - 15.0% |
| Fat | 0.8 - 4 | n.a. |
| Sugars | 25 - 58 | 6.8 - 15.8 |

One of the advantages of the mesquite pods is the edibility of the raw pods. The feeding value decreases slightly with cooking. The pods could also probably be fermented to make tempe like leucaena pods (Wirfodarmodjo et al., 1983) or like soybeans to make tofu.

## Mesquite as Fodder

Mesquite pods are widely used as fodder. Feeding tests have shown that it is a better fodder when it is ground. Mesquite leaves are also edible. Sheep are well adapted to whole pods and a remarkable mesquite plantation in the salt flats of Chile supports a large sheep ranching operation (Jarrell, 1986). A very high percentage of pods causes trouble for cows because the sugar disrupts normal cellulose digestion (Felker, 1979).

## Mesquite Timber

Most of the mesquite trees are small statured but the hardwood is used for tiles, tools, and furniture on a limited basis.

## Mesquite as Fuel

The most valuable product from the mesquites is likely to be fuel. Plantings of mesquite for fuelwood have been evaluated in many drylands of the world, including Pakistan, India, South America, Africa, and the U.S. (Ayensu, 1981; Felker, 1981). Much of the recent research has been completed in California and the results have been encouraging (Felker et al, 1981a; Felker et al, 1983a,b).

Mesquite trees may produce more than 14,000 kg/ha/yr but more commonly will yield less (Felker , 1979; Felker et al., 1981a; Felker et al, 1983a,b; Sharifi et al, 1982). These levels of productivity are particularly impressive in the difficult conditions of the dry lands. The ability of mesquite to stump sprout makes it well suited for fuelwood coppice (Clark, 1981).

The development of a coppice with standard managment system for mesquite should recieve priority. A rotation with inter-cropping of corn, grains, and vegetables should maximize use of the biologically fixed nitrogen. To increase nitrogen availability for other crops the leaves (up to 4% N) and stems of the mesquite could be composted when the fuel trees are harvested.

## Other uses

The mesquites are also used for living fences. The thornier species are effective for this if grown in a hedge.

## Summary: Mesquites

The mesquites are outstanding multi-use tree crops and their use can be expected to increase in the future. Yet, mesquites are not without their faults, which should be considered when using mesquite. First, the mesquite trees are not very cold hardy (Felker et al, 1982). Second, mesquite can become a weed if used on overgrazed range. Third, the features that make mesquite useful for fencing can make it hard to work with, as some species have thorns up to four inches long; but thornless cultivars are available (Clark, 1986) and tissue culture techniques have been developed to propagate mesquite (Kurian et al, 1983). And finally, mesquite is not a particularly efficient user of water. It will produce well only if sufficient water is available, though it may survive in very difficult conditions (Nilsen et al, 1986; Felker et al, 1983b). Fortunately this water can be provided by deep groundwater or saline water.

## Conclusions

Multi-purpose tree crops are extremely valuable in the dry lands. Agroforestry systems including multi-purpose trees can increase resource utilization above and below ground and increase productivity. These deeply rooted perennials can minimize the risk of crop failure and provide a wider range of products for use and for sale by the dry land farmer or rancher.

Two of the more promising trees for this type of use are the oaks and mesquites. The oaks are a larger group and will fit a wider range of environments but where the mesquites can be grown they should be included in agroforestry planning. Although much research is needed on establishment, management, and use of these trees enough is already known to begin using them. Research and development of managment systems should emphasize ecological considerations including; symbiont effects and interactions in polyculture assemblages. Native species should recieve emphasis in this research and the wisdom of indigenous people and traditional farmers should be sought and used so that ecological and sociological benefits are both realized.

Dedication: To Winifred Hermann

"How long should we stand around and talk....... Let's get out and plant a tree."

from her writings.

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