THE USE OF SHRUBS IN LIVESTOCK FEEDING IN LOW RAINFALL AREAS

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Summary

Fodder trees and shrubs can be useful to improve grazing lands where the plant cover is poor. They can act as (a) a standing fodder bank to buffer seasonal fluctuations that occur in arid and semi-arid areas, (b) a protein supplement for livestock on poor native rangelands or consuming low quality roughages, (c) a mean of soil erosion control, and (d) a fuel source for low income farmers. For these reasons, fodder trees and shrubs plantations are expanding.

By the end of the twentieth century, about one million ha have been planted with native and exotic fodder species in the Mediterranean basin, mainly in eastern and southern countries. In Europe, plantations of fodder shrubs are a relatively recent phenomenon. Many scientists from southern Europe have, however, realized that shrubs and trees could be selected for desirable ecological, agronomic and nutritional traits, and be planted to meet specific needs in Mediterranean production systems.

The available literature shows that the bulk of the work on browse is essentially agronomic, in which the main focus was on types and availability of browse, rates of productivity, and biomass structure. In this contribution, more consideration will be given to the relatively limited work on chemical composition, nutritional value and intake, as well as on palatability, use and animal performance. Examples have been limited to the most commonly used species.

1. Introduction

The use of plantations of fodder trees and shrubs (*trubs*) in arid and semi-arid zones expanded greatly and diversified from the 1950s, but it did not reach regional significance until the 1970s. At the end of the twentieth century, about one million ha were planted with native and exotic fodder trubs in West Asia and North Africa. The dominating species are saltbushes (*Atriplex sp*.), wattles (phyllodinous *Acacias*) and cacti (*Opuntia ficus indica*). Since then, planted areas have been increasing and genetic material is diversifying.

In Europe, plantations of fodder shrubs are a relatively recent phenomenon. With the exception of southern Spain where they cover sizable areas, they are still at the experimental or the demonstration level. The main reason for this slow development is the abundance of natural shrublands for livestock feeding. Many scientists from southern Europe have however realized since the 1970s that shrubs and trees could be selected for ecological, agronomic and nutritional traits, and be planted to meet specific needs in Mediterranean production systems. Since then, they have focused on the selection and cultivation of fodder shrubs and trees by studying the most promising spontaneous or introduced multi-purpose species in each country. The most important species in arid and semi-arid zones are: *Medicago arborea* L. (see Figure 1), *Atriplex sp*. and *Chamaecytisus proliferus* L.

Figure 1. Foliage and flowers of *Medicago arborea*.

Natural shrublands in Europe cover about 200 000 km², and range from semi-arid to humid climatic regions. They are mainly distributed along the coasts of countries bordering the Mediterranean Sea. They may be classified according to height and cover into three height classes: high (> 2 m), middle (0.60 to 2 m) and low (< 0.60 m), and in three cover classes: dense (> 75%), discontinuous (50 to 75%), and scattered matorral (25 to 50%).

From a range management point of view, shrublands are subdivided into three categories by using the French terms *maquis* and *garrigue* and the Greek term *phrygana*. These categories are roughly equivalent to tall and dense, middle and discontinuous, and low and scattered matorral, respectively. The dominating species are:

- for maquis: (*Arbutus unedo* L., *Erica arborea* L., *Myrtus communis* L., *Quercus ilex* L., *Phillyrea media* L., *Pistacia lentiscus* L., *Cistus monspeliensis* L., etc.;
- for garrigue: (*Quercus coccifera*, *Carpinus orientalis* Miller and *Fraxinus ornus* L); and
- for phrygana (*Sarcopoterium spinosum* L., *Phlomis fruticosa* L. *Coridothymus capitatus* L., *Salvia officinalis* L., and *Cistus spp.*).

Shrubs are used for several purposes:

- to improve grazing lands and thus reduce grazing pressure on degraded areas where the plant cover is poor;
- as a standing fodder bank to buffer seasonal fluctuations that occur in arid and semi-arid areas;
- as a protein supplement for livestock on poor native rangelands or consuming low quality roughages;
- as a forage source in arid and salt-affected areas;
- as a fuel source for low income farmers;
- as a mean of soil erosion control; and
- as an emergency feed during drought years.

Shrubs can, thus, be planted on rangeland areas and on marginal lands. They can also be used at the farm level in alley cropping: a system where annual crops, such as barley, are grown in alleys formed by hedgerows of shrubs such as *Atriplex sp.* This kind of system provides on-farm forage during critical periods, improves grain yields through its wind shield effect, and provide a protein-rich supplement for cereal stubble grazing and low quality roughages feeding after crop harvest.

2. Establishment Method and Planting Density

There are two methods of establishing shrubs: (a) by pit planting (planting in equidistant pits surrounded by impluviums), mostly used in flat terrain; or (b) by furrow planting along contours, the most common technique. The advantage of the latter resides in its ability to capture rainfall which benefits both the native vegetation and the shrubs. The use of containerized seedlings or rooted cuttings for this purpose is the most widespread method. Direct seeding was tried in many places, but was unsuccessful or gave lower establishment performance compared to planting.

Favorable rainfall conditions (good distribution of spring rain and some summer showers) are critical for establishment by seeding. Better results are obtained on humid soils with pre-soaked seeds, where the survival rate is improved by 60 to 70%. However, interesting field observations in several plantation sites in Morocco have shown that *Atriplex* also has the potential to self-regenerate from seeds. This finding should be a stimulus for research to investigate the feasibility of *Atriplex* seeding to reduce establishment cost.

In early *Atriplex* planting operations, the average plant density was generally around 1000 plants/ha. In plantings undertaken after 1990, the density was lowered to between 850 and 500 plants/ha. This reduction is justified by the lower establishment cost and improved growth of herbaceous vegetation. Work conducted in semi-arid Morocco confirmed that shrub spacing of 2 m x 5 m (1000 plants/ha) gave optimal biomass production and plant vigor.

If the objective of the plantation is to provide protein during the dry season, then the total shrub biomass is increased with a higher shrub density. However, if the plantation is to be used also for spring grazing, then the shrub density should be decreased to allow for more biomass production. It is, therefore, imperative that studies be conducted to understand the relationship between shrub density and total biomass output from both shrub and herbaceous vegetation per unit area. This will obviously vary with soil and weather conditions.

3. Productivity of Browse Foliage

Browse is a term referring to the tender shoots, twigs, and leaves of shrubs and trees that are eaten by livestock. Browse productivity of cultivated shrubs varies widely depending on species, cultivar, environmental conditions, planting density, and management.

Research conducted in north-east Morocco showed an average production of 920 kg DM/ ha (1000 plants/ha density), with variations from 406 to 2140 kg DM/ha depending on the species studied. *Atriplex vesicaria*, *A. semibaccata*, *A. nummularia* and *A. paludosa* scored the highest levels of production. In the same trial, *A. nummularia* (see Figure 2) produced on average 374 g DM per plant and varied from 36 to 1100 g DM per plant depending on the site and the age of the plantation.

Other reports indicate that forage production from a 2-year old *Atriplex* plantation was 625 and 1125 kg DM/ha under 150 and 200 mm rainfall, respectively. Edible biomass of *Atriplex nummularia* varied from 200 to 1500 kg/ha/year. *Medicago arborea* in Sicily produced about 500 g/plant of browse. It was about half that amount in southwest Spain, where *Atriplex halimus* produced 430-500 g/plant and *Chamaecytisus proliferus* had production intermediate between the two species.

Figure 2. Foliage of *Atriplex nummularia*.

4. Integration of Shrubs into Production Systems

Because of their multiple roles, shrub plantations require careful management to maximize the potential of both shrubs and land. This implies that shrub plantations should be well integrated into production systems. In a given system, shrubs can be planted alone on rangeland or marginal land, or can be associated with other crops (mainly forages) on land of low to medium potential. In both situations, fodder shrubs may be directly grazed or cut and carried to the animals out of the plantation. Thus, the shrubs may be used when feed resources are scarce or when the feed requirements are high. They can be kept as a standing feed reserve for unusual periods of drought. They may also be used in combination, with a first part of the shrub resource used on a regular or seasonal basis, and a second part kept as a standing reserve to be used whenever needed.

In southern Europe, West Asia and North Africa grazing of cereal stubble in the summer (e.g. after the grain harvest), and subsequent straw feeding are widespread practices. Because of the low feeding quality of stubble and straw, cereal fields may be improved by introducing shrubs in widely spaced rows. In such mixed systems, single or double lines of hedgerows of shrubs are established in widely spaced patterns to allow for mechanical cultivation and harvesting of the associated crop, when appropriate (alley-cropping system). This technique was initiated in Libya in the early 1980s, and was applied in Spain, Morocco and Syria in the 1990s. It offers two interesting advantages:

- The associated crop benefits from the improvement of microclimatic and soil conditions provided by the shrub, such as reduction in wind speed and potential evapotranspiration, better water budget, increased organic matter in the soil, etc., leading to higher crop productivity
- Protection of the shrubs from grazing during the crop growing cycle allows them to recover from previous defoliation.

After harvest of the associated crop, generally a cereal, the combination of shrub foliage, cereal stubble or straw in the diet of ruminants is ideal. In fact, stubble and straw (which is poor in nitrogen) provide the energy, while shrubs (poor in energy) provide the nitrogen, minerals and carotene. The additional nitrogen from shrubs causes an increase of straw intake of up to 40% and enhances digestibility of the straw by 5 to7%. Such a combination may provide a balanced diet for sheep allowing better long-term maintenance and production of the flock.

When the cut and carry system is applied, the wood remaining after the browse consumption by the animals is used as fuel wood. The latter is badly needed, especially in countries lacking other sources of fuel.

5. Browse as Supplement to Low Quality Roughages

Establishment of pastures containing herbaceous legumes was seldom successful in the tropics, but tree and shrub legumes were shown to be ecologically more appropriate. The foliage of fast-growing browse species has a lot in common with herbaceous legumes and can be expected to have a similar supplementary role. The slow-growing types of browse species are expected to have a lower fiber digestibility, but since they tend to retain their nutritive value when mature—in most cases a nitrogen (N) concentration of more than 20 g N/kg DM—they may possibly have a supplementary role for poor quality roughages.

"To many shrubs are food—and sometimes even the only food—for animals". In fact, in many parts of the world, fodder trees and fodder shrubs play a significant role in feeding domestic animals, particularly as protein suppliers and especially in harsh environmental conditions and in poor rural areas. For instance, in extensive animal production systems in the drier parts of Africa, it is estimated that ligneous materials contribute up to 90% of rangeland production and account for 40 to 50% of the total available feed. In Northern Africa, browse forms 60 to 70% of rangeland production and 40% of the total availability of animal feeds in the region.

Even though trees and shrubs are commonly used as browse, and the cutting of leaves or branches for animal feed was recorded as long ago as Roman times, their importance as browse plants was only recognized much later. Observations, trial and error tests, and scientific investigations have gradually produced information about shrubs in terms of their nutritive value, palatability to livestock and big game, use for wildlife habitat, chemical and physical characteristics, and other biological functions in arid ecosystems. In fact, in recent decades, there has been a growing trend in many regions throughout the developing world to identify potentially important feed sources among shrubs and tree leaves and to explore possibilities of including them in a beneficial way in ruminant diets. Other reasons that have contributed to this development might in particular relate to the recurrent severe feed shortages, the severe and prolonged drought periods over recent decades, the continuing low per-animal performance, and poor production levels.

6. Nutritive Value of Tree and Shrub Foliage

6.1. Intake and Palatability

Generally, crude protein concentration, intake, and digestibility are the primary factors to be considered when evaluating forage quality. It has been shown that neither intake nor digestibility alone will reliably evaluate differences in feeding value between forages. In fact, intake depends upon the structural volume or cell wall content, while digestibility is affected by both the concentration of the cell wall and its availability to digestion, as determined by lignification and other factors. These factors usually determine the amount of energy and N that can be obtained by animals.

Voluntary intake is affected by palatability in a rather unpredictable way. This is especially true in tree and shrub foliage, and is usually a result of the plant's defense strategies. In some cases, high ash or oil content may also affect intake quality. In fact, oil and other unpalatable substances are common in trees and shrubs and these may reduce the intake by animals. Some research in Western Australia for example noted that mulga (*Acacia aneura* Muell.) foliage became more acceptable as trees became older, and that this was associated with a decrease in the ether content (more specifically the resin content) of the foliage. In Queensland, it is commonly observed that the foliage of vigorous "sappy" trees is not readily eaten, and that wilting increases palatability. Seasonal variation plays a minor part in determining browse quality.

It is widely admitted that feeding value of cultivated fodder trubs varies depending on species, cultivar, phenological stage, plant part, and environmental conditions, and that it is generally higher than that of most spontaneous species of natural shrublands.

The fodder value of the leaves and fruits of browse shrubs is often superior to herbaceous plants, particularly in the case of legumes. Compared with dry grass and forbs at the maturity stage, browse species have the highest content of crude protein (CP), where CP =% N * 6.25), and P and carotene are just marginally below the digestible energy requirement of the ewe.

6.2. Ecological Background to Variations in Nutritive Value

Present-day trees and shrubs have co-evolved with herbivores such as arthropods and mammals, and have developed mechanisms to defend themselves. In turn, herbivores have learned a behavior allowing them to obtain a maximum amount of nutrients in a situation where nutritive value, aversive factors and toxins vary from species to species and sometimes from plant to plant. Plants tend to evolve and develop in a way that maximizes the benefit-cost ratio of defenses. Resource limitation (e.g. of light, water or nutrients) favors inherently slow-growing plants whose parts are long-lived; species tend to naturally and gradually develop the production of long-term chemical defenses of the "quantitative" type such as tannins and fibrousness.

The synthesis of tannin is metabolically costly, so that leaf numbers of a rainforest tree were decreased by one in 10 for each 13 mg condensed tannin produced per g DM. Tannin-containing foliage tends to be low in N and lignin. Resource-richness favors plants capable of fast growth of virtually disposable foliage and either minimal defense or "qualitative" defenses such as alkaloids and similar toxins, which are often confined to immature foliage. Such toxins are relatively inexpensive to synthesize and highly effective per gram, but have short biological half-lives and would be relatively costly to maintain in long-lived foliage.

These mechanisms can have direct and indirect effects on the nutritive value of plants. Slow-growing, persistent tree species typically have characteristics which depress nutrient availability such as resistance to mastication, fibrousness and phenolic compounds including tannins. Even within individuals there may be changes in defense strategy with age; as their leaves mature they become physically tougher and have lower nutritive values for herbivores, and tannin concentration may decrease. Tannin and fiber levels sometimes increase for up to three years in response to repeated defoliation. Plants have also evolved other strategies to deter herbivores which include unpleasant aromas, tastes and appearances, and structures such as thorns and hairs.

Plants also have to contend with fungi and invertebrate herbivores, and to do this their leaves may contain high levels of phenolics, waxes, cutin, volatile oils, and other protective compounds. Besides defenses against herbivory, trees and shrubs have adaptations to the physical environment which also affect their nutritive value. In arid and semi-arid areas they have developed thick cuticles to control transpiration; these are indigestible and may contain a high concentration of salts in response to salinity and moisture stress. Some shrubs and trees synthesize oxalic acid to minimize the effects of high cation concentrations on metabolism. All of these adaptations affect the nutritive value for ruminants, usually adversely.

Fast growing species tend to invest less in defense and thus may provide abundant nutritious foliage. However, their ecological roles are as pioneers or successional species; they make little contribution to natural climaxes. Forage legumes and N-fixing trees and shrubs such as *Acacia*, *Leucaena*, and *Gliricidia sp.* fall into this category. Consequently they require an appropriate management if their role in farming systems is to be optimized.

Apparently on the favorable side, naturally-occurring tropical trees and shrubs do not have as great a concentration of cell wall constituents as do grasses, and in many cases their foliage is high in N, while P is rather lower and crude fiber somewhat higher. Many of them produce energy-rich pods.

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He has been an active researcher for twenty-two years, including six years as an Experiment Station Manager, and the remaining years as a researcher in the evaluation and utilization of shrubs and by-products for sheep feeding. He has been very active in coordinating and implementing research/development activities in the field of crop-livestock integration in low rainfall areas in collaboration with ICARDA and regional and local agricultural development agencies.