Grassland and Pasture Crops

Country Pasture / Forage Resource Profiles

TUNISIA

by

Chedly Kayouli

---

1. INTRODUCTION:

The Tunisian Republic is bordered by the Mediterranean to the North and the East, to the South by Libya, and to the West by Algeria (see Figure 1). It covers 162 155 km^2 with a population of 10 000 000, and is an ancient political entity of the Maghreb. It's capital is Tunis. Tunisia has a privileged geographic position at the cross-roads of the Eastern and Western basins of the Mediterranean, between Europe and Africa. The country's history

dates to the founding of Carthage by the Phoenicians in 814 BC which soon became an important centre of trade, reigning over the region until 146 BC when it was conquered by Rome and became part of the Roman province of Africa. In its 3 000-year history, Tunisia has seen numerous invaders and civilisations: Punic, Roman, Berber, Byzantine, Arab and Ottoman. The Arab conquest came in 647; numerous Arab dynasties reigned over the country: the Aghlabites, the Fatimids. In the sixteenth century, Tunisia became a province of the Ottoman Empire and, in 1881, a French protectorate. Tunisia gained its independence in March 1956, and was proclaimed a republic on July 25, 1957.

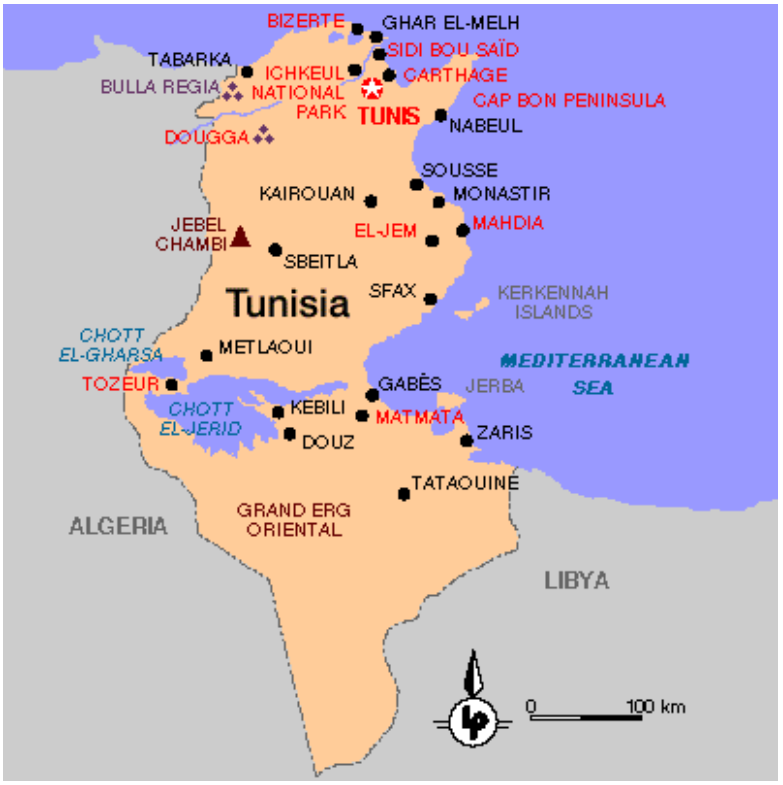


Figure 1. Map of Tunisia

---

2. SOILS AND TOPOGRAPHY

The mountain chain of Kroumerie Mogods which runs along the north of the country is a continuation of the Tell Atlas. To the south are the fertile plains of the valley of the Mejerda, Tunisia's only perennial river. The High Tell or Dorsale is a continuation of the Saharan Atlas; the highest mountain in the country is Jebel Chambi (1 544 m). Most of the central region is a plateau at about 500 m; further south there is an area of internal drainage, shotts, and the south is the Sahara, much of it part of the Great Eastern Erg. There are large plains on the east coast, the Sahel plain south of Sousse and the Gefara plain south of Gabes.

SOILS

There are four distinct physiographic zones with considerable diversity of soils:

The North: is characterized by two regions, the North-East and the North-West. The former is a mosaic of hills and plains where there are fertile soils and important underground water resources permitting intensive and extensive agriculture. The latter is marked by hills and valleys where underground water resources are limited.

The North-West is formed in its southern part (the Tell) by "calci-magnesic" soils and vertisols on limestone and marls, while its northern sector called "Mogods-Kroumirie" is characterized by brown-dark soils developed on sandstone and on non-calcareous clays. The Mogods-Kroumiries have steeper and irregular slopes. Because of their poor soils, 'Mogod-Khroumirie' have low agricultural potential. During forage trials in these regions the soil was analyzed (see Table1); results showed that soils are very acidic (pH KCL = 4 – 4.3) and low in nitrogen (0.06 - 0.07 percent), with a very low phosphorus content (1 mg / 100 g) and a marginal humus concentration (1.5 - 1.9 percent).

Table 1: Analysis of soils in two horizons: 0-20 cm and 20-40 cm in the Northwest of Tunisia (Mogod-Khroumiries)

Soil horiz	pH KCl	Humus (%)	P(mg/100g)	P water soluble (mg/100g)		
(0 - 20 cm)	4.3	1.9	1	0.1		
(20 - 40 cm)	4	1.5	1	0.1		
soil horiz	K(mg/100g)	Mg(mg/100g)	Na(mg/100g)	Ca (mg/100g)	Mn(mg/100g)	Fe(mg/100g)
(0 - 20 cm)	5	2	2	8	7	116
(20 - 40 cm)	4	2	2	3	4	132
Soil horiz	N(total)(%)	C/N	Chlorine(mg/100g)	Saline Conc.(microsiemens)		
(0 - 20 cm)	0.07	14.0	5.27	46		
(20 - 40 cm)	0.06	13.6	6.20	43		

Granulometry percent						
soil horiz	Clay	Fine Alluvial	Coarse Alluvial	Fine Sand	Coarse Sand	
(0 - 20 cm)	7.59	2.89	2.17	13.47	73.88	
(20 - 40 cm)	7.57	2.88	3.60	13.98	71.98	

Source: SEDENOT: 1999

Although the Tell is dominated by marly slopes, it is a fertile region because of its alluvial plains with deep soils. There are different soil types:

- alluvial soils: these soils, basically confined to alluvial sediments, do not cover a large area and are in the valley of the Medjerda. They are characterized by a relatively high organic matter content (2%) in the superficial horizon, but this decreases gradually with depth. Considering their inorganic matter content, their low lime content and especially their favourable permeable structure, they suit all crops and especially fruit trees very well.

- young or recent alluvial soils : developed in recent alluvia of river plains; generally different sediments appear in the profile in the form of strata. These soils characterize all alluvial plains. In well watered plains with defective drainage, they can give way to swamps that may be saline (valley of the Medjerda, plain of Mateur).

- vertisols : dark and brown soils appear on soft limestone rocks, marls and clay, that by alteration give a clayish swelling material. Usually they appear in flat areas and shrink in summer and develop a deep cracks in a distinctive polygonal pattern. They have a high clay content, causing problems during land preparation: dry soils are hard and difficult to work and when wet are vey sticky. However, experience has shown that the vertisols give the best cereal yields and suit all annual crops very well. Nevertheless, they are unsuitable for rainfed arboriculture, because of risks of root damage due to soil movements and deep seasonal cracking.

- calci-magnesic, rendzinas and brown limestone soils: two types of soils are clearly distinguished: Rendziniform and brown limestone soils. The former develop directly, without transition on a hard limestone material. The latter are deeper, having in addition to the organic horizon a structural horizon overlying a limestone material that is generally soft marl or a calcareous hardpan.

The Dorsale

The Dorsale is characterized by its hilly relief and plains with fragile soils. The eastern Dorsale is dominated by large mountains separated by plains. The plains have irrigation schemes and mountains covered with forests and *Stipa tenacissima* ('alfa or esparto). At the base of the large mountains there are calci-magnesic soils, which are crusted, limestone brown and degraded on hardpan. These soils formed under more arid climatical conditions, are low in organic matter, stony and often eroded. They suit grazing and in some places olive plantations. In alluvial plains they are recently evolved, often slightly saline ; these soils suit many crops, notably under irrigation.

The Centre

The centre is characterized by its aridity. The eastern part is notable for the absence of relief, making a flat space broken by many saline depressions called "sebkhas" collecting flowing water; the soils are deep and light. The western part has large mountains connected by vast glacis to alluvial plains containing extensive water resources.

The South

Southern Tunisia is characterized by:

(1) Mountainous areas (Matmatas) where agriculture is based on spate irrigation. In the mountains there are limestone and calcic-marly soils on which are developed lithosols characterized by a very shallow surface horizon (10 to 15 cm) with the rock breaking the surface here and there ; they have no agricultural potential. There are also significant areas of fluvisols in the major river valleys and in alluvial fans below escarpment slopes. The fluvisols are usually fertile because they receive regular silt from flooding.

(2) Coastal plains (called the Jeffara): Soils in arid areas undergo a low soil genesis. The most visible processes are the scouring and sedimentation under the action of the water and the wind. Thus in the High Jeffara, one can observe crusted glacis where the soil is formed in one horizon with light texture (calcic paleorthid). In the Low Jeffara, soils are more or less crusted, but with the appearance of the crystalline basement rocks consisting of gypsum at the surroundings of the "sebkhats" and the large depressions that are formed of salty soils (salorthids). These crusted soils (paleorthids, calciorthids, cypsiorthids) can be deep and serve as a water reservoir. When they are well protected from the wind

erosion, they constitute the most fertile soils of the region for irrigated cropping (oases and irrigated areas).

(3) Large Depressions or "Chotts" where underground water resources are the origin of some oases. The soils of the zone of "Chotts" are influenced by the presence of salty materials. They are very susceptible to wind erosion of their sandy surface horizon from the soils surrounding the oases. There are two types of soils:

- sandy soils in Southern Chott Jerid: the surface is a succession of micro dunes more or less invaded by a vegetation called "nebkas".

- the very salty soils of Chotts: the surface of these soils is covered with salt lying over sediments engorged with salty water. Those soils are completely sterile. No vegetation can grow; it is the true desert.

(4) The Desert zone, the "Erg", formed of dunes of sand separated by small sandy depressions where develop a very sparse vegetation.

---

3. CLIMATE AND AGRO-ECOLOGICAL ZONES:

The Tunisian climate is Mediterranean, characterised by hot dry summers and cool moist winters that limit the growing period; precipitation is very irregular and the rainfall varies considerably from the North to South. Tunisia is divided into four large geographical units: Northern, Eastern, Central and Southern regions (Figure 2). According to Emberger (1960) there are five bioclimatic

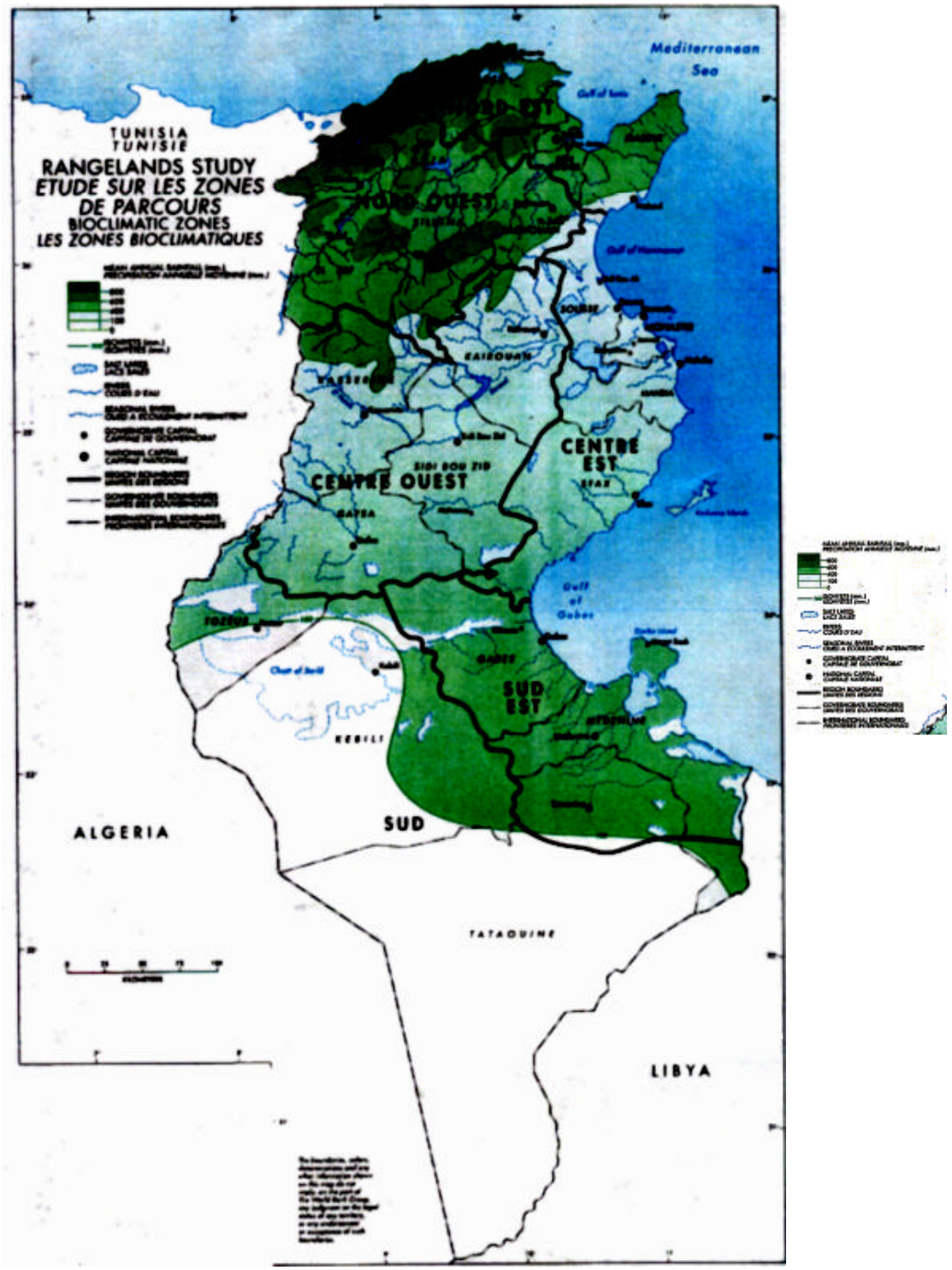


Figure 2. Bioclimatic Zones of Tunisia

Legend for Figure 2.

zones in going from the most arid to the most humid based on rainfall (Table 2). Rainfall is not the only bioclimatic determinant; temperature and especially winter temperature is

from the buffering effects of the sea. Bioclimatically, therefore, the country is also divided into areas of warm, cool and cold winters.

Table 2: The five bioclimatic zones in Tunisia:

Annual rainfall (mm)	Bio-climatical strata
800 - 1200	Humid
600 - 800	Sub-humid
400 - 600	Semi-arid
100 - 400	Arid
20 - 100	Desert (Saharan)

Depending on the annual rainfall, there are four main agricultural regions which can be summarised as follows (Table 3):

Table 3: The agro-ecological zones:

Zone	Annual rainfall (mm)	Agriculture and land use
North	500 <Rain <1000	Natural forest, maquis and grazing areas; possibility of rainfed crops: annual crops and horticulture
Dorsal	400 <Rain <500	Forest, maquis and rangelands but fragile; possibility of cropping but with risky annual crops and tree crops adapted to edaphic and topographic conditions
Centre	200 <Rain <400	Forest and maquis very fragile in favourable edaphic and topographic conditions. Rangelands are fragile. Possibility of cropping but with risky annual crops and tree crops,
South	Rain < 200	Very fragile steppe in favourable edaphic and topographic sites. Rangelands very easily degraded. Rainfed agriculture is locally possible with good management of run-off.

Meteorological data from representative stations are given in Appendix 1: Tabarka on the northern littoral in the wettest part of the country, Jendouba in an inland part of the Mejerda valley, Kairouan in the central plain, Skanes and Sfax at the northern and southern ends of the Sahel and Tozeur far inland on the desert edge.

---

4. LIVESTOCK PRODUCTION SYSTEMS

Tunisian agriculture, has like other African countries been marked by colonisation, which has determined the structure and, partially, types of production. Of a total area of 125 000 km^2 some 76 000 km^2 are considered as agricultural land, of which 47 000 km^2 are arable, 28 000 km^2 grazing and forests lands and 6 000 km^2 fallow.

Livestock has an important share of agricultural production; it contributes approximately 40 percent of the total agricultural product, but this is clearly inferior to cereals and olive that dominates traditional Tunisian agriculture. However, in recent years, the governmental has been encouraging animal production to increase national self-sufficiency in animal products (meat and milk). There are 380 000 farms in Tunisia and 65 percent keep livestock, mainly smallholders, with an average agricultural area under 20 ha. who represent 80 percent of the livestock statistics for 1998 (see Table 2). Sixty five percent of the cattle are in the North, 60 percent of sheep and goats are in the Centre, and 80 percent of camels in the Centre and the South.

The bulk of the cattle are local and grade cattle owned by small farmers with little or no

land. Although described as "Atlas Brown", more than half the local cattle show characteristics of successively imported breeds, e.g. Normandy, Eastern Red and White [Eastern Red Pied], Brown Swiss and Tarentaise. After increasing between 1970 and 1975 (they represented 95 percent of the total), the local and cross cattle population has now ceased to show a serious decline after decreasing by 32 percent in the 15 year period 1975 - 1990. This was mainly due to Friesians increasing in the dairy sector.

Table 2: Ruminant numbers, meat and milk production, 1986, 1994 & 1999 (Ministry of Agriculture)

Item	1986	1994	1999
Friesian cattle ('000)	83	124	185
Local & cross Breed Cattle ('000)	265	250	240
Sheep ('000)	3000	3500	3800
Goats ('000)	500	700	800
Camels ('000)	70	40	55
Beef & veal ('000 tonnes)	30	42	52
Sheep & Goat meat ('000 tonnes)	40	50	58
Milk ('000 tonnes)	330	520	1000

As shown in Table 2, pure breed cattle rose rapidly from 83 000 in 1986 (they represented only 24 percent of all cattle) to 185 000 cows at present. Almost all pure dairy cattle are Friesian-Holstein; their increase is mainly due to massive imports of pregnant heifers. Since 1975, Tunisia has imported more than 100 000 pregnant dairy heifers. In the past decade, the dairy sector has had a remarkable evolution thanks to encouragement by the State, especially advantageous loans and subsidies as well as the organization of milk collection (disengagement of public sector from milk collection and transfer of milk centres to private and co-operative organizations). Dairy production has tripled since 1986, Tunisia has recently (1999) reached self-sufficiency in milk (78 kg / capita / year); it was only 60 percent self-sufficient in 1987. Dairying has been traditionally concentrated in the north where climatic conditions are favourable. However, in recent years dairying is appearing in new regions, in the Sahel, which had no such tradition and that, according to the last statistics, contribute half of the collected milk nationally.

Ruminant meat production has also increased considerably, from 70 000 to 110 000 tons between 1986 and 1999. Meat from cattle, sheep and goats form 95 percent of national production, while 5 percent are from camels and horses. The total meat consumption is 30 kg per capita per year: poultry (15), beef (7) and sheep and goat (8). Because of the high price of ruminant meat, Tunisia is almost self-sufficient with national production covering 95 percent of consumption.

Ruminant production systems vary according to the variety of feed resources which decrease with aridity. Farm income in most of the subhumid and semi-arid areas is based on cereals, vineyards, orchards and livestock, whereas small ruminants are the basic source of income in arid areas. As in other Mediterranean countries, livestock production systems, especially intensive systems, are generally fragile. There are two long periods of forage shortage: 3 - 4 months in winter where growth is inhibited by low temperatures, while in summer the dry season lasts at least three months when herbage dries out due to high temperatures and the lack of rain. According to the type of management and feed, there are three main dairy systems as summarised in Table 3.

4. 1. Extensive or traditional systems

These have limited productivity and are based largely on marginal lands, and on less productive breeds of livestock, mainly local sheep, goats and cattle. The main problem is low fertility due to poor seasonal feeding and high mortality. These problems are often linked to overstocking, and seasonal feed scarcity. These systems have low economic efficiency but are very well adapted to the environment and have a high ecological efficiency.

Table 3: Simplification of the main systems of dairy production

	EXTENSIVE	INTEGRATED	"LANDLESS"
Main location	North	North	Sahel (Centre Coast)
Forage area	>1 ha/cow	0.25 ha – 0.75 ha/c	0 – 0.20 ha
Cattle breed	Local / Crossbreed	Holstein Friesian	Holstein Friesian
Herd size	1- 20 cows	100 -1600 cows (companies) 1-40 cows (farmers)	1- 20 cows
Milk yield (l/cow/year)	<2000	3000 - 6500	3000 - 6500
Basic feed	rangelands	forage/concentrates	concentrates
Origin of forage	grazing	farm/market	market
Origin of straw&hay	farm	farm/market	market
Origin of concentrates	(market)	market	market
Investment level	nothing	high	limited
Origin of funds	own	credit	own
Main income	agriculture	livestock/crops	other jobs
Labour type	family	paid	paid/family
In charge	family	paid	family
Strength	limited cost	forage availability	high flexibility high demand of milk
Weakness	• Seasonal production • lack of technical supervision	• High investment • main activity • poor forage quality	• high price of forage • dependence on market (fragility)
Tendency	decreasing	high use of concentrates	organization of the profession

Extensive systems for cattle are mainly in the North, and in the Centre and South for small ruminants. Milk production is seasonal, linked to availability of forages with a modest herd size (1 to 5), labour is family. Two thirds of sheep and goats are in Central Tunisia; they play a very important role, besides their production they are kept by small farmers as savings. Traditional livestock production in arid and semi-arid areas is based on adaptation to low and variable rainfall, poor fragile soils and extensive grazing similar to the Sahel of Sub-Saharan Africa (Speirs and Olsen, 1992). Traditionally, sheep were managed under transhumance but, over the past decades, recurrent drought, modern technology and new economic rules have dramatically changed sheep production systems and socio-economic conditions. Increasing settlement of nomads, increase in sheep numbers in marginal zones, expansion of cultivation and reduction of fallow have greatly increased pressure on available land and reduced soil fertility. Grazing land is becoming scarcer and meagre as more and more land is put under crops. Sheep and goats traditionally grazed on hillsides and steppes in winter in the Centre, and stubble in summer in the North during transhumance. This continues, but is much reduced. Increased purchasing power has raised the demand for livestock products so farmers are changing to intensive sheep rearing with feed supplements, based on imported cereals.

4. 2. The integrated intensive system

This is related mainly to dairy and fattening cattle integrated in an agricultural area meant partly or exclusively for growing forage. Farm sizes are very variable, this system includes family farms from 1 to 40 cows as well as the large farms with often more than 100 cows. Forages are rainfed in the North or grown under irrigation. An important part of forage is grown on the farm whereas concentrates are purchased. Some hay and straw are often bought. However, green forage and silage are generally by far the greatest part of the ration, meaning that hay and concentrates occupy an important place. Despite the availability of land for forage production, integrated farms use large quantities of concentrate. This is partly due the poor quality of locally produced forage. (Kayouli et al., 1988).

4. 3. Semi-integrated and "landless" intensive systems:

This is mainly a family dairy enterprise concentrated in irrigated and peri-urban zones. The arable area is often limited compared to the number of animals, consisting of 0 to 0.3 ha / cow (Kayouli, 1995). Almost all feed (forage and concentrates) is bought. The labour is often family, and farmers have often another source of income. Investments are minimal with limited external funds. The number of animals is very variable but is generally from 1 to 20 cows. This system has shown a spectacular development in the Sahel (Sfax, Mahdia, Monastir, Sousse) and is commonly met in other regions, mainly in peri-urban areas of Tunis and in horticultural zones (Bizerte, Cap Bon).

The feeding system in the Sahel and Sfax is based on an intensive small irrigated holding and external feed, it can be qualified in many places as "landless" stock keeping and has shown a considerable expansion during recent years because of the increase in milk prices and the strong demand from urban and tourist zones as well as to good infrastructure (roads, collection centres). The most surprising example is the spectacular development of dairying in the Sahel (Sfax, Mahdia and Monastir) where it was not traditional. Fresh milk collected in Sfax was only 237 250 to 365 000 litres in 1976; it was more than 100 millions litres in 1999. The Sahel has today 40 000 pure breed dairy cows, the majority on family holdings with an area for forage production of only 0.12 to 0.5 ha/cow. Cultivated forages mainly grown in these regions are: annual crops: winter (barley, oats, rye grass and berseem); summer (*Sorghum* ,); perennial forages (essentially lucerne) and fodder carrots are frequently grown. Farmers buy straw and hay from the North, lucerne pellets and commercial concentrates. By-products, particularly from olive plantations, cake, leaves and twigs, and horticultural residues are frequently fed.

In irrigated areas (coastal zone of Bizerte, Ariana and Nabeul), integrated farming is scarce and feed is mainly bought. Fodder areas are small and have developed little compared to horticulture and tree crops. In the irrigated public lands of Ariana the forage area is only 3 000 ha (of a total of 38 000 ha). Cultivated forage is often used: sorghum, lucerne, berseem and cereals (barley, oats). The forage deficit is covered by purchasing hay, straw and concentrates. Farmers use some by-products such as tomato pulp and horticultural residues. The integrated livestock production around urban zones is insignificant. The capital Tunis has 6 000 cows which are 85 percent pure breed; they are mainly kept on "landless" farms and fed with hay, straw, concentrate and by-products such as the leftover bread gathered from public institutions and restaurants, as well as brewers' grains.

4. 4. Constraints in ruminant livestock systems:

Although intensification of livestock in Tunisia is increasing, its integration with crops is

limited. Integration of forage into rainfed farming has not really succeeded. Cultivated forage area has remained constant during the last 15 years and its contribution to animal feeding is limited (Colson et al, 1995), whilst livestock numbers have significantly increased, mainly dairy cattle. Irrigated forage has met with little enthusiasm, there are some summer forages (sorghum, maize); for economic reasons farmers opted for vegetables and tree crops. On the other hand and at the national level, statistics indicate that the contribution of natural pasture and range in the feed calendar is decreasing dramatically because of frequent droughts and over-grazing. In order to cover animal requirements, therefore, increasing amounts of feedstuffs (maize, barley, soya bean meal, ...) are imported which puts pressure on the national balance of payments. Apart from the extensive system, ruminant feeding is characterised by high use of cereals and concentrates to such point that concentrate not forage, is the basis of the ration. There are several reasons for this:

The limitation of areas for growing forages: as shown in Table 4, the area of forage crops has changed little despite the large increase in livestock numbers. The factors that limit forage development are as follows:

- Fodder cereals (oats, barley) pure or mixed with vetch (*Vicia sativa*) are the dominant forages, as hay, occupying at least two thirds of the total area. However this lack of diversity influences forage quality enormously. Oat hay is usually poorly made, farmers go for bulk, not quality, as there is no market premium for hay of superior feeding quality; it has a low nutritional value (5-8 percent crude protein and 45 - 55 percent dry matter digestibility). In most cases, rations based on cereal hay hardly cover the maintenance requirement of animals managed under intensive systems (Kayouli et al., 1988). Growing mixed oat-vetch for silage is common especially on large farms in the North, where it was developed by the project FAO/GCP/TN/010/SWE (1975 - 1980). However, there has been little expansion of the area since the project closed.

- The limited size of smallholdings makes mechanisation difficult. Furthermore, smallholders do not like forages that occupy land for more than a year. They prefer short cycle crops(e.g. vegetables).

- Ruminant feeding, mainly dairy cattle, is based essentially on imported concentrate which competes with local forage and has influenced the development of fodder production negatively.

- Research on forage is limited, consequently Tunisia frequently uses imported seeds which often are not adapted to local conditions.

Table 4 : Evolution of cultivated forage areas in Tunisia ('000 ha).

Years	1991 - 1992	1998- 1999
Winter forages:	263	258
Oat/Oat-Vetch Hay	162	156
Oat/Oat-Vetch Silage	20	15
Cut-and-Carry forage	50	66
Forage Seed production	31	21
irrigated forage	23	39
Summer forages (irrigated)	7.5	18

Total	270.5	276

The rising price of forage: Because of the rainfall situation, Tunisia regularly has a fodder deficit; frequent droughts have caused a fall in cereal and forage production with a spectacular rise in the price of hay and straw. Hay (even if grown locally) is generally the most expensive feed source expressed in energy units. The average price of a bale (18-22 kg) is 4 - 5 dinars in the North and more in the Centre and the South. In practice, as indicated below, an energy unit of oat hay is the dearest when compared to concentrates and green forage.

Table 5: Some indicators on cost of animal feed in Tunisia

PRODUCT	market price	cost of production	Price millimes[1]/kg	MFU[2]/kg	millimes /MFU
Oat hay	0		200-250	0.50	400-500
Oat hay		0	150	0.50	300
Barley	0		210	1.0	210
Concentrate	0		280	0.90	311
Wheat bran	0		140	0.75	187
Berseem, ryegrass		0	25	0.12	208

[1]1 Dollar U$ = 1350 millimes (August 2000)

[2] MFU = Milk Feed Unity (expression of the French energy system for the ration formulation of the ruminants, 1 MFU = 1750 Net enery Kcal)

Finally, the national feed scarcity seems to be more structural than circumstantial. In the past decade livestock numbers have increased strongly while forage production areas stagnated as shown in Table 4. Moreover, there is separation between producers and consumers of hay and many farms (especially small and landless farmers) systematically purchase it. Large farms in the subhumid zones find it more convenient to sell hay than to keep livestock.

4. 5. Concentrate use:

The consequence of forage shortage and its poor quality is the widespread use of large quantities of concentrates for ruminants, particularly for dairy cattle. Subsidies on imported raw materials for concentrates explain the strong growth of feed mill factories in Tunisia (more than 300). This has created a tradition of concentrate use and, probably, has reduced interest in forage production. These subsidies have been discontinued for some years. Concentrate manufacture has increased continually since 1973; between 1972 and 1994, it increased tenfold. Until 1987, the main progress was for poultry which have benefited much from Government encouragement. Between 1987 and 1999, concentrate manufacture increased greatly, especially for ruminants; mainly due to importing pure bred dairy cattle, to the shortage of forage and especially its poor nutritive value.

Because of the inadequacy and or lack of local raw materials, concentrate is heavily based on imported ingredients (Figure 3). Maize and soybean cake are all imported. Barley imports vary a lot with climatic events; during droughts they rise and the country imports hay and lucerne. Tunisia has a cereal shortfall for human food and 30-50 percent of wheat

is imported (Figure 3).

---

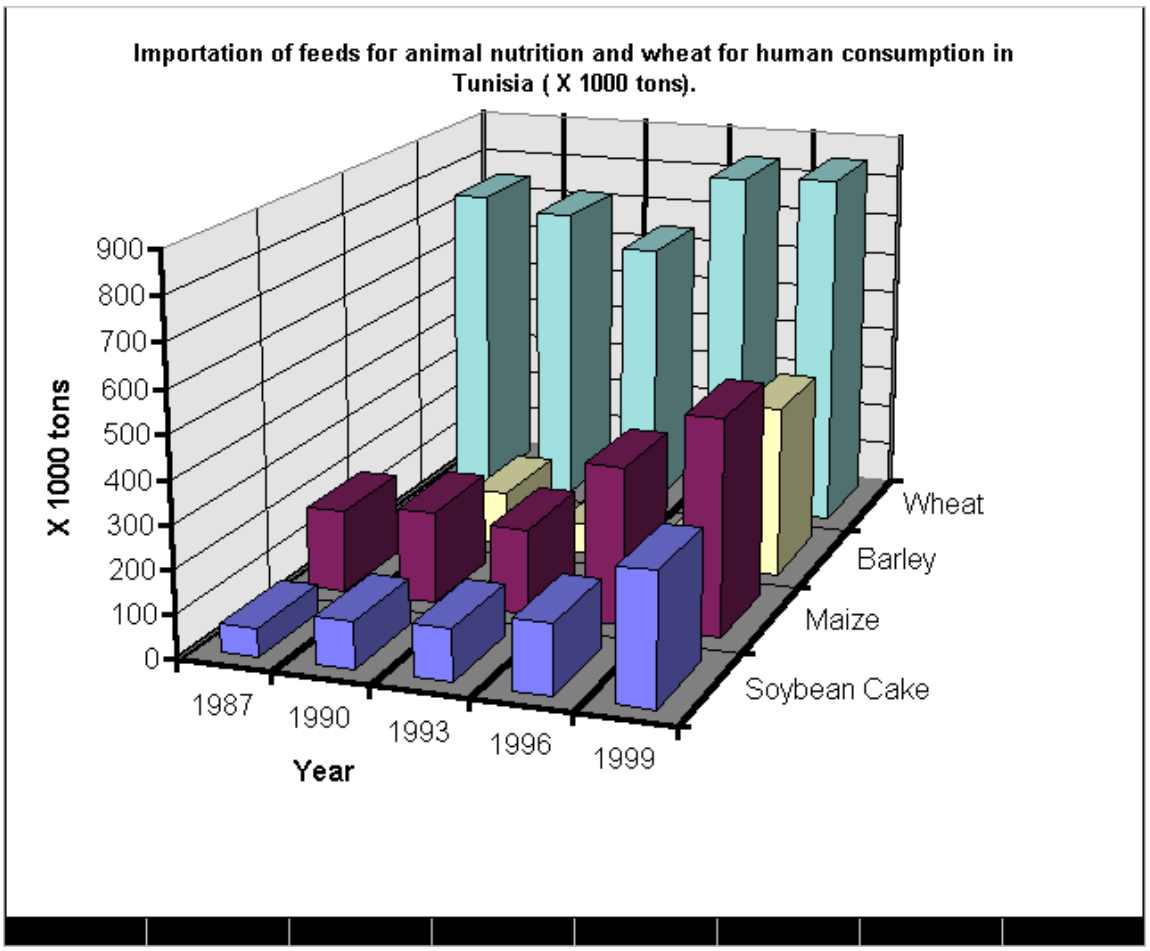
5. THE PASTURE RESOURCE:

There are four main forage sources in Tunisia: natural pasture, fallows and stubbles, sown fodder and crop residues.

5. 1. Natural pasture

The pastoral flora of Tunisia is very rich, especially in the humid, subhumid and semi arid zones. Unfortunately in the better-watered areas, most has been turned into crop land and that marginal land left for grazing is so overgrazed that the better species are often barely visible, they soon return, however, with improved management, especially if grazing pressure is reduced and/or the pasture is closed rotationally for the start of the growing season Many of Tunisia's pasture plants belong to species which have been domesticated and brought into cultivation elsewhere; the annual legumes and *Lolium rigidum* have become notably important in Australia.

Figure 3:



Important pasture grasses include: *Ampelodesma mauritanica* ("diss" its large clumps are a salient feature of many hillsides), *Aristida* spp. (common on degraded hillsides and in the steppe; (*Avena bromoides, Cynodon dactylon, Dactylis glomerata, Festuca arundinacea, Hyparrhenia hirta, Imperata cylindrica, Koeleria* spp., *Lolium multiflorum, Lolium perenne, Lolium rigidum* (an important component of fallows), *Lygeum spartum* ('alfa, an important steppe grass gathered as a fibre), *Oryzopsis miliacea, Phalaris aquatica, Phalaris coerulescens, Phalaris truncata* (the phalaris are important on heavy clays "marnes" often in association with *Hedysarum*), *Phleum pratense, Sorghum halepense* and *Stipa* spp. (which are very important in the steppe).

Forage legumes are as rich as are the grasses, as is common under Mediterranean conditions. *Anthyllis tetraphylla, Anthyllis vulneraria (*where winters are mild), *Astragalus hamosus, Astragalus caprinus, Hedysarum coronarium (*very widespread on marl), *Hedysarum spinosissimum, Lotus* spp., *Medicago sativa, Medicago falcata, Medicago* spp. (many annuals but most important in fallows q. v.), *Trifolium fragiferum (*on sites with permanent moisture, often in association with *Festuca arundinacea), Trifolium isthmocarpum, Trifolium resupinatum* and *Trifolium subterraneum.*

Other important herbaceous forages include *Bupleurum balansae, Moricanda arvensis,* and *Sanguisorba minor.* Many trees and shrubs provide browse; *Artemisia herba alba* (a major component of steppe grazing), *Fumana* spp*., Globularia alypum, Olea europea (*which may be browsed into a cushion*), Phillyrea angustifolia, Quercus* spp. *(*notably *Q. coccifera* which is usually seen in the form of a low, browsed shrub), *Rosmarinus officinalis* and *Thymus* spp.

Despite their net decline, natural pastures play an important role in livestock feeding. During the last twenty years, natural grazing areas have decreased by 20 percent. The area of natural grazing varies according to climatic zones (Table 6). The humid, subhumid and semi-arid zones represent only 2, 2 and 9 percent respectively of the total natural grazing. Natural pasture is mainly in arid zones (45 percent) and Saharan zones (42 percent). In the Central and Southern regions (arid and semi-arid ecological zones) the vegetation is a steppe which is composed mainly of: *Stipa tenacissima, Artemisia herba-alba, Artemisia campestris*, *Aristida pungens* and *Cynodon dactyl*on.

Table 6: Ordinary pastures and grazing forest areas (ha) according to climatic zones in Tunisia (Sarniguet J. et al., 1995).

		humid	subhumid	semi-arid	arid	Saharan
Total rangelands (ha)	3,989,986	79,391	89,155	347,731	1,791,429	1,682,280
%	100	2	2	9	45	42

Use of the "maquis" in north-western Tunisia:

In mountainous zones, the forest and maquis, with their different strata, constitute the principal sylvo - pastoral resources grazed by livestock. Woodlands in humid and subhumid zones are often composed of various associations: *Quercus suber, Myrtus communis, Smilax aspera, Erica arborea, Quercus coccifera, Pinus halepensis, Pistacia lentiscus, Phillyrea angustifolia, Calicotome villosa* and *Arbutus unedo.* Annual fodder production varies between 865 and 650 ME Mcal / ha respectively for dense and eroded woodland. The relative utilization of the different species varies with season and stocking rate (Mill-E;

Steinbach-J, 1984 and SEDENOT Project, 1999). In a field study carried out in a cork oak forest (*Quercus suber*) in the North West area (humid climate with annual rainfall 850 mm) it was observed that the nutritive value of the most browsed species (Table 7) are more valuable than the traditional oat hay grown in Tunisia.

Table 7: Chemical composition and in vivo dry matter digestibility of the most browsed forest species by goats in the North West area of Tunisia:

Species	Crude Protein (g/kg DM)	Acid Detergent Fibre (g/kg DM)	in vivo Organic matter digestibility (%)
Oat hay	53	420	52
Quercus suber	87	415	60
Pistacia lentiscus	76	295	43
Phillyrea angustifolia	79	348	52
Viburnum tinus	66	284	62

Pasture and shrubs in desert areas: There are many salt tolerant fodder species in the Saharan parts which are grazed by camels and goats. The most common: 1) trees are *Tamarix*, 2) shrubs *Salicornia, Salsola, Suaeda* and *Atriplex*, 3) perennials are *Aeluropus*, *Sporobolus*, *Puccinellia* and 4) annual species are *Hordeum maritimum*, *Lepturus cylindricus, Frankenia* and *Melilotus*. The halophytic vegetation was studied by Houerou-HN-le et al. (1995), its primary productivity was determined (above ground biomass of *Atriplex halimus* was 10-15 t DM/ha and annual productivity 2-5 t DM/ha); grazing and nutritive value (digestible DM 40-70 percent, digestible OM 50 percent and CP content 10-12 percent); and cultivation (*Atriplex nummularia, A. semibaccata, A. canescens and A. lentiformis).*

5. 2. Fallows

Fallow has been a very important part of rainfed cereal rotations, originally one year in two or three lay fallow (bour) and furnished excellent grazing from autumn through spring; intensification of crop production in some areas is reducing the fallow acreage but it is still an important source of high quality seasonal grazing for small ruminants. Many of the fallow plants of the Mediterranean zone have been domesticated in Australia and incorporated into cereal-fallow rotations in their areas of Mediterranean climate; there have been many attempts to re-import these plants and its associated technology into North Africa but with very limited success; more phosphatic fertiliser in the rotation, probably ion the cereal, and careful grazing management would greatly improve the natural fallow grazing - but large cereal farmers are not livestock owners and fallows are often let to passing transhumant herds which graze them to bare ground. The rich pastoral flora of the fallows includes: *Avena sterilis, Lolium rigidum, Hippocrepis* spp., *Lathyrus aphaca, Lotus* spp., *Medicago ciliaris* (particularly well adapted to heavy soils), *Medicago littoralis, Medicago orbicularis, Medicago polymorpha* (the commonest with many highly productive forms) *Medicago rugosa, Medicago scutellata, Medicago truncatula, Melilotus* spp., *Scorpiurus* spp. and *Trifolium cherleri.*

5. 3. Stubbles

These are an important source of summer grazing for small ruminants; where weed control

has not been intense there may be considerable herbage other than the bases of wheat stems on offer. There are frequent cases of toxicity due to *Hypericum* spp. which causes photosensitive symptoms in sheep.

5. 4. Crop residues and by-products:

As noted above, feed supply is a serious constraint on animal production in Tunisia. Imported feeds, which lead to a trade deficit, have been used traditionally. There is renewed interest in all local feed resources. Large quantities of crop residues, by-products and animal wastes are produced and better utilization of these products has been studied (Table 8). The crops residues and by-products studied and which are frequently used by farmers in Tunisia are: cereal straws, olive cake and fresh olive leaves and twigs, grape seeds, sugar beet pulp, tomato pulp, brewers' grain, wheat bran, date palm residues, fruits and poultry litter.

Table 8 : Chemical composition, DM In Sacco digestibility and energetic value of crop residues and by-products in Tunisia.

By-product	Dry matter (%)	Ash (% DM)	NC6.25 (% DM)	ADF (% DM)	DM In Sacco digestibility (48 hours)	MFU
Wheat Straw	89.0	7.4	3.7	40.7	40.1	0.38
Olive cakes	45.5	11.5	4.0	46.5	36.3	0.34
Olive leaves	56.8	3.6	10.5	29.9	60.3	0.65
Raisin kernels	37.1	9.2	13.8	45.7	52.2	0.35
Sugar beet pulp	17.2	6.2	9.1	31.6	86.2	0.85
Tomato pulp	25.5	4.5	21.5	35.0	59.9	0.61
Brewery grains	24.3	4.0	28.5	22.1	75.4	0.80
Wheat bran	89.1	7.0	16	13.7	71.9	0.73
Date residues	87.6	2.5	3.2	7.8	93.8	1.11
Poultry litter	70.6	15.4	23.5	24.9	65.9	0.68

OM : Organic matter; DM: Dry matter; ADF: Acid Detergent Fibre; MFU = Milk Feed Unity (expression of the French energy system for the ration formulation of ruminants, 1 MFU = 1750 Net energy Kcal); N : Kjeldahl Nitrogen

About 1 500 000 tons of straw are produced yearly from wheat, barley, oats and triticale. Straw has been a traditional feed-stuff for sheep and cattle during winter. A huge amount of research was done on the use of straws in ruminant feeding and on methods to improve their nutritive value, using NaOH in the beginning and later ammonia gas and urea. Some years ago, straw ammoniation using 3 percent anhydrous ammoniac was widely used on large scale farms as well as on smallholdings. This technique fell out of use because of the increasing price of anhydrous ammonia and its danger when handling; it was efficiently replaced with application of 5 percent urea. Urea treatment of straw is well adapted to smallholders where access to mechanisation is limited. Trials have been carried out on the effect of wheat straw treatment with urea fed to sheep during 4 dry season months (Nyarko-Badolu et al, 1993) Results in Table 9 show that ammoniation with 5 percent urea has significantly increased nitrogen content, in sacco digestibility and straw intake. Results on liveweight variation show that ewes lose weight when fed untreated straw whereas ewes fed treated straw gain.

Table 9 : Nitrogen content, in sacco digestibility, feed intake and liveweight variation of ewes fed untreated, treated wheat straw and multinutritient blocks (30 animals per treatment ; 120 days trial) (Nyarko-Badolu et al., 1993)

Forage	NC6.25	72 h In Sacco digestibility	Intake (g DM / kg $P^{0.75}$)	Liveweight variation (kg)
Untreated wheat straw	5.0 a	45.0 a	43.0 a	- 2.8 a
Urea treated straw (5%)	11.0 b	55.0 b	56.0 b	+ 4.0 b
Anhydrous ammonia treated straw (3.5%)	12.0 b	57.0 b	58.0 b	+ 5.7 c
Untreated straw supplemented with feedblocks*			60.0 c	+ 6.4 c

a, b, c : averages in the same column with different letters are significantly different (P < 0.05) * multinutrient blocks are composed of (Raw ingredient in percent) : molasses (10), urea (8), poultry litter (20), wheat bran (20), olive cakes (15), cement (15), salt (6), minerals (6).

To make better use of local crop residues and by-products, a strategy was adopted based on combining them so as to make low cost and nutritionally balanced feed supplements or basal rations. This has now acquired increasing relevance and importance with several Tunisian farmers. Some by-products, mainly those with high nitrogen content, are considered as good strategic supplements allowing better use of crop residues and other feed-stuffs low in nitrogen and / or high in cellulose. So olive cake, wheat straw, grape pips and olive leaves and twigs are similar to tomato pulp, brewery grain and poultry litter; sugar beet pulp and dates are interesting energy sources.

Olive cake has been successfully ensiled with poultry litter and wheat bran (45 :45 :10 percent w/w/w, dry matter). Results indicated that ensiling for six weeks is efficient for conserving poultry litter at low cost and eliminates health hazards. The silage was substituted for commercial concentrate and soybean meal and fed to lambs for 66 days (Kayouli et al., 1993). Results in Table 10 indicate that daily gain and feed intake are higher on concentrate but feed cost was 50 percent lower with poultry litter silage.

In a beef fattening trial (Kayouli, 1988) a ration containing sugar beet pulp and poultry litter was compared to a control (sugar beet pulp and concentrate with high content of soybean meal) fed to fattening steers over 150 days; animal performance (growth rate, feed conversion and carcass quality) was similar while ration cost was reduced by 20 percent with the experimental formulation.

Table 10 : Feed intake and performance of growing lambs fed an ensiled poultry diet or concentrate diet (12 animals per treatment ; 66 days trial) (Kayouli et al., 1993)

	Ensiled poultry litter diet[1]	Concentrate diet
in vivo OM digestibility (%)	61.4	74.9
Retained nitrogen (g / day)	33.0	37.2
Feed intake (g DM / day)	1520.0	1098.0

Daily gain (g / day)	252.8	221.2
Feed conversion (kg DM / day)	6.1	5.4
Carcass yield (%)	47.5	45.1
Feed cost (U.S.$ / kg gain)	0.4	0.8

(1): Poultry litter was ensiled with olive cakes and wheat bran in the following proportion on a dry matter basis: 45:45:10 w/w/w for the three ingredients respectively. water was added to obtain 50 percent DM in the silage, based on DM contents of the ingredients.

6. OPPORTUNITIES FOR IMPROVEMENT OF PASTURE RESOURCES

6. 1. Cultivated Forages.

Annual forages are mainly grown in the northern rainfed zones and, to a lesser degree, under irrigation. The major crops are:

Oats (*Avena sativa*): grown in pure stand or mixed with vetch; is a crop well rooted in the tradition of smallholders. It is the dominant forage in Tunisia and occupies about 172 000 ha (60 - 70 percent of all annual forage). Farmers prefer oats for the following reasons: 1) seeds are generally locally produced; 2) seeds being larger than those others, they are easy to establish on generally badly prepared fields; 3) the equipment for wheat and other cereals can be used for cultivation and sowing; 4) oats offer the possibility of a high forage yield; 5) oats has two important advantages: its adaptation to deep, moist soil and its resistance to drought. Oats are mainly grown for hay, which is partly destined for sale, especially to the Centre and the coastal regions, in variable quantity according to weather; this generates heavy speculation on the price of hay.

The FAO/GCP/TUN-10/SWE project developed semi-intensive fattening schemes in North Tunisia (450 - 650 mm) based on cereal silage (mainly oat and oat-vetch). The most successful achievement of this project was the introduction of silage-making techniques which are still well established there. Compared to hay, silage is harvested earlier, freeing the land and consequently facilitating sowing of summer crops. On the other hand, the forage being less mature, the nutritional value of silage is higher and animal performance better with less concentrates. In a fattening trial with local cattle using oat silage or hay *ad libitum* with 3 kg of concentrate daily, Sansoucy et al. (1984) found an average daily gain and feed conversion rate 20 and 35 percent higher with a silage based ration than with hay.

Tunisia currently grows 15 000 ha of silage, allowing a better integration of livestock and crops. The association cereal-silage, on which the system is based, is a very clear improvement on specialised cereal systems or those associated with hay. Most farmers and technicians are well aware of the practical advantage of silage which contributes to more efficient forage use.

Barley (fodder), *Hordeum vulgare*: Barley is a well-known crop in Tunisia and North Africa, often grown on small farms in irrigated zones as well as rainfed areas. It is interesting for its early maturity, usually it is sown in September and provides green forage in autumn. Because of its precocity, the "barley-based" feeding system is interesting in drier areas (Centre and South), it escapes the early drought that often occurs there. In the semi- arid zones, barley is often used as dual purpose for green-feed and grain.

Italian ryegrass *(Lolium multiflorum)*: is particularly cultivated in rainfed humid zones as well as in irrigated areas. It is not only more productive than oats but has a high nutritive value (Ben Jeddi et al., 1992, SEDENOT Project, 1999). It gives several cuts and thereby it is very suitable for supplying green feed for dairy cows. In a trial in North-western Tunisia (SEDENOT Project, 1999) the application of 50 units of P_2O_5 and 50 units K_2O prior to sowing and 50 units of N after each cutting on a sandy acidic soil, has shown that ryegrass is far more productive than berseem (*Trifolium alexandrinum*) and oats. It has produced 7.3 tons of dry matter/ha in five successive cuts at the vegetative growth stage 20 - 25 cm. This yield is 2.2 times higher than berseem and 1.6 times superior to oat forage.

Berseem (*Trifolium alexandrinum)*: is widespread in the Mediterranean zones. In Tunisia, it is a traditional winter forage on small irrigated farms. It is sensitive to frost and prefers deep clayish or calcareous soils. Some small farmers cultivate berseem for its high yield and its advantage in crop rotations because it is a good precursor for cereals. As a legume, berseem provides a large quantity of nitrogen to the soil. Yields vary between 4 to 8 tons dry matter/ha at small farm level. The development of berseem growing in Tunisia is mainly explained by its important role in the dairy feeding system in winter and by the availability of seeds, largely home-produced by farmers. Observations by Jaritz (1982), in the humid north-west on 25 exotic cultivars of berseem indicated that local cultivars were more productive: 6.8 tons DM/ha and 8.3 t DM/ha respectively in clayish sandy soils. In the pilot farm of Frétissa the average seed production obtained over six years without weeding was 439 kg/ha (Jaritz et al., 1976). However the yields are influenced by sowing time. The best sowing time is the beginning of October and according to Jaritz et al. (1976) delay in sowing delays the first cuts and yields are seriously affected. Optimal cutting frequency is to cut when the vegetation reaches 20 to 25 cm. With this practice good results are obtained, with the first cut 60 days after sowing and a frequency of cuts of 30-40 days.

Fodder Sorghum, *Sorghum sudanense,* and hybrids: irrigated forages, especially for summer, were developed thanks to new water resources made available through numerous dams. Forage sorghum is of great nutritional interest in areas which are relatively dry in summer (Ben-Taamallah-S, 1989). Sorghum is an intensive fodder for dairy cattle. It is grown in summer with imported varieties (super graze II, sweet sorghum, piper). The area under sorghum is about 8 000 ha, more than the double all other summer forages.

Farmers like sorghum because it tolerates high salinity (up to 7 g/l), grows on a wide variety of soils (pH varying between 4.5 and 8.5) in areas with 500-900 mm of rain annually and is drought resistant. It is valued in areas with hot dry summers for ease of establishment and its ability to recover after grazing or cutting. In field trials in the humid north-west, sorghum sown in May on sandy soil was cut five times, the first cut was 55 days after sowing then cuts every 25 - 30 days at 50 - 70 cm. Total yields were 18 and 19.5 ton DM/ha respectively with the application of 100 units of phosphorus and 30 tons of manure prior to establishment. For both treatments, 60 units of nitrogen were applied after each cutting (SEDENOT Project, 1999)

Perennial forages. These are now little grown but some have been widely used in the past. Lucerne, *Medicago sativa*, was a traditional fodder of the oases and grows well on the better-drained soils where rainfall is over 450 mm; it also grows very well in irrigated areas. Sulla, *Hedysarum coronarium*, in addition to being an important component of natural pasture on marls, has been widely used, especially with encouragement by the Forest Department; when sown on soils where it does not occur naturally inoculation with its specific bacteria is necessary; the cultivated types of sulla (usually Italian cultivar)

usually behave as biennials. While it can produce a large quantity of forage, sulla has the disadvantage of having most of its growth in a peak in spring; its thick stems make it difficult to conserve as hay.

6. 2. Sown pasture

As noted above many of the common cultivated pasture species occur naturally in Tunisia. Considerable research was carried on these in the past; much of the work is summarised by le Houerou (1977). Hardly any pasture is sown nowadays because large cereal farms are not generally interested in livestock and small farms are not suited to grazed pasture which requires relatively large areas, fencing and preferably water reticulation. A development of co-operatively managed artificial pastures in the Sedjenane area in the north-west at the eastern end of the Mogods had reasonable success and much research and extension resulted in a commercially viable milk cooperative. The project received continued and intensive support from GTZ. It is situated near the coast in a zone of mild winters and relatively high rainfall; the area is not particularly well suited to cereal growing and the population were quite keen to try another way of gaining a livelihood. The pastures were largely based on subterranean clover and ryegrass.

The success of the Sedjenane project raised hopes that cooperative dairying could be spread to other smallholder areas of the Northwest with the double objective of raising family incomes and re-vegetating steep land then under annual crops. A large programme was designed, without prior experimentation, in areas which are climatically and socially quite different. It was executed by L'Office de Développement sylvo-pastoral du Nord-Ouest (FAO 1984) as part of an overall rural development plan. This intervention was not a success; firstly the smallholders were in no way interested in having their land turned into cooperative pastures and secondly the assumed "available technology" based on imported Australian cultivars said to be adapted to the various agro-ecological zones of the project area, failed. The Office's zone of intervention ranged from the sub-humid to semi-arid with cold winters; imported cultivars germinated well enough but did not overwinter and perennate. All with a good level of technical supervision as well as inputs from the World Bank (the financing agency) and FAO. Sulla (*Hedysarum coronarium*), a familiar biennial fodder and important component of the pastoral vegetation of the marl soils, was included as an alternative for smallholders - no community opted for cooperative pastures. It was highly popular so far as acceptance of seed and claiming food aid went but there were difficulties in reconciling the claims with the areas seen in the field.

6. 3. Improvement of grazing lands in Central Tunisia:

During many years under different development projects, improvement of the pasture and the grasslands of Central Tunisia was widely investigated, basically the areas which produce low yields of arable crops (Houerou-H-N-le, 1977). The establishment of sown pastures proved very difficult in areas with annual rainfall <350 mm and in these areas extension of irrigated fodder crops, Cactus (*Opuntia)*, *Atriplex* and *Acacia* plantations was suggested.

As noted previously, Central Tunisia is the main area for sheep. In order to optimise the balance between grazing and browsing to meet the dietary needs of livestock, thousands of hectares of fodder shrubs have been established, particularly spineless cactus [*Opuntia ficus-indica* var. *inermis*], *Atriplex nummularia* and *Acacia cyanophylla*. Nowadays, those fodder trees and shrubs play a key role as feed reserves (particularly in periods of drought). Their productivity varies. Where the rain is below 350 mm, yields oscillate between 1 600 to 5 000 kg dry matter/ha and from 600 to 3 700 kg dry matter/ha

respectively for *Atriplex* and Cactus (Sarniguet J. et al., 1995). There are many hectares in Southern Tunisia of artificially established saltbushes, both native and exotic, on large-scale plantations. These include species, introduced from Australia, and South and North America, that have successfully undergone field trials. Over the past four decades, large plantations of *Atriplex* spp. appear to be one of the best ways to rehabilitate desertified and eroded areas. This agro-sylvopastoral system of production is well adapted to arid lands and to the needs of their populations, increasing the potential of fodder availability.

6. 4. Cereal - forage legume rotations

Although many Tunisian fallows have a rich natural pastoral flora with a high proportion of self-regenerating legumes, it has often been suggested that the critical feed shortage in the rainfed, cereal-growing areas might be alleviated if the fallow period was used for forage crops or self-regenerating pastures. Legumes not only provide nutritious feed for livestock but also fix atmospheric nitrogen for use by subsequent cereal crops. Therefore the use of forage crops and pastures is likely to substantially increase farm profitability. To be effective such a rotation should use shallow tillage, adequate phosphatic fertiliser and have controlled grazing of the legume.

Tunisian fallows are already very rich in forage legumes, appropriate management would greatly increase their productivity without recourse to seeding but: farmers invariably plough very deeply without obvious agronomic reasons, relatively little phosphate is used in comparison to nitrogen and, most seriously, large cereal farmers are not generally stock-owners and when the grazing of a fallow is sold to nomads the field is usually grazed to the root in a few days. The cereal rotation was greatly pushed by the Office de Développement sylvo-pastoral du Nord-Ouest in the early eighties, using Australian seed, but with no success - any good growth of medic reported turned out to be indigenous plants encouraged by the fertiliser and cultural techniques used. In some of the drier areas *Melilotus* spp. took over, being encouraged by the same cultural techniques as the annual *Medicago* but much less palatable and seeding very freely.

An Australian sheep-cereal system was successfully tested in the arid and semi arid areas of Central Tunisia with various annual *Medicago* (*Medicago truncatula, Medicago littoralis, Medicago rugosa*, and *Medicago scutellata*) and pulse crops (Huss, 1978, Zoghlami et al, 1996, Bakhtri, 1977, Cocks, 1988). The introduction of a grain legume to replace the fallow period in the traditional rotation has increased crop and animal production in many Arab countries. Huss (1978) reported the following results: In Libya, wheat yield increased from 0.4 tons grain/ha using traditional methods to 1.6 tons/ha with medic [*Medicago* spp.]/wheat rotation and grazing capacity was 3 sheep/ha. Common vetch, lucerne or sainfoin have also increased forage yields in areas with cold winters and av. rainfall of >350 mm. In Turkey, wheat, sainfoin and fallow rotations yielded 0.5 t/ha more wheat and gave an additional 5 t/ha of herbage. Rangeland was improved by controlled grazing in Jordan, Tunisia and Libya from 7-10 ha/ewe annually to 2-3 ha/ewe after a few years. A 4-pasture rotation system in Tunisia increased grazing capacity from 7 ha/ewe to 2 ha/ewe annually in a 175-mm rainfall area, and in a higher-rainfall area yielded 3 tons more lamb from 200 ewes than under traditional methods. Results of ICARDA (1986) on-farm trials, carried out over three years in the drier areas of Tunisia to replace fallow with a productive crop other than barley, concluded that farmers can profit by sowing forage legumes, especially common vetch, *Vicia sativa*, and chickling vetch, *Lathyrus sativus* in the year between barley crops.

7. ORGANIZATIONS AND PERSONNEL INVOLVED IN PASTURE RESEARCH - KEY INSTITUTIONS AND PERSONNEL

INSTITUT NATIONAL AGRONOMIQUE DE TUNISIE, 43 AV. CHARLES NICOLE, 1002 TUNIS-TUNISIA

Professor Chedly Kayouli: A ruminant nutritionist with research interest in the following fields: 1) Strategies for better use of local feed resources, 2) Forage utilization and evaluation of their nutritive value, 3) Improvement of sylvo-pastoral systems in maquis and cork-oak forest areas (*Quercus suber*) in North-western Tunisia: a) Pasture value of the most common types of maquis foliage browsed by goats; b) Potential of subterranean clover pastures and *Lolium* spp. sown on cleared shrublands.

Prof. Mongi Zouaghi and Mr. Ben Jeddi Fayçal: Biological characters of the grassland and forage species in relation to their utilization, involved also in forage seed production.

INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE DE TUNISIE, LABORATOIRE DE NUTRITION ANIMALE, RUE HEDI KARRAY, 2049 ARIANA, TUNISIA.

Drs. Nefaoui Ali, Chermiti Amor and Ben Salem Hichem: Animal nutrition and nutritional evaluation of shrubs and fodder trees in arid and semi-arid zones of Tunisia.

Dr. Chakroun, M. and MM. Zoghlami, A., Hassen, H. And Mansouri, M. : Forage specialists with special interest in genetic resources, research and extension of forage crops.

OFFICE DE L'ELEVAGE ET DES PATURAGES, 30, RUE ALAIN SAVARY, TUNIS, TUNISIA.

MM: Souissi, M., Ben Rhouma, H., Gouhis, F., Ben Arif, T. And Chouki: Improvement and development of pasture and range in marginal zones in Central Tunisia.

ECOLE SUPÉRIEURE D'AGRICULTURE DE MATEUR.

MM. Ben Taamallah Salem and Tibaoui: Research on irrigated summer forage.

8. REFERENCES

Bakhtri M.N. (1977). Wheat/forage legume rotation and integration of crop and sheep husbandry in the Near East and North Africa. *Proceedings of an International Symposium on Rainfed Agriculture in Semi-Arid Regions*, April 17-22, 1977, Pasadena, California. 1977, pp. 520-538.

Ben Jeddi F., Zouaghi M. et Moujahed N. (1992). Qualité et productivité de 9 variétés de ray-grass. *Revue de l'INAT*, Tunisie, p : 59-72.

Ben-Taamallah-S. (1989). Behaviour and pastoral interest of forage sorghum grown under irrigation in a Tunisian bio-climatic environment. CA: 16. *International grassland congress. 16. Congres international des herbages. Nice (France).* 4-11 Oct 1989.

Cocks,P.S. (1988). The need for seed production of pasture and forage species. *Seed Production in and for Mediterranean Countries. Cairo (Egypt)*. 16-18 Dec 1988. ICARDA, Aleppo (Syria). Pasture, Forage and Livestock Programme.

Colson, F., C. Kayouli, J.C., Belloin, R. Nardello (1995). Study of Dairy Cattle Sector in

Tunisia. TSS1-TUN/94/01T-001/AGAM-FAO (April-May, 1995).

Emberger, L. (1960). In: L'exploitation traditionnelle du maquis du nord de la Tunisie: Possibilite d'une meilleure utilisation. OEP-Ministere de l'Agriculture Tunisienne; GTZ, Eschborn, Reublique Federale d'Allemagne

FAO (1984). *Rapport de fin de mission de l'expert en aménagement agropastoral - TUN/ 81/004* Rome/Béja

Houerou, H.N. le, (1977). *Principles, methods and techniques for range management and fodder production in the Mediterranean. Tunisia.* FAO Publication, Ed. 2, FAO; Rome; Italy.

Houerou-HN-le; Le-Houerou-HN; Choukr-Allah-R (ed.); Malcolm-CV (ed.) and Hamdy-A, (1995). *Forage halophytes in the Mediterranean basin. Halophytes-and-biosaline-agriculture*. 1995, 115-136.

Huss, DL. (1978). Importance of range development in dryland systems of farming for integration of crops and livestock husbandries in the Near East. *Technology-for-increasing-food-production*-Holmes,-J.C.-Editor*. 1978*, 188-192. FAO.; Rome; Italy.

ICARDA, (1986). International Center for Agricultural Research in the Dry Areas, Aleppo (Syria). *ICARDA Annual Report 1986*. Aleppo (Syria). ICARDA. 1987. p. 23-26.

Jaritz G. (1982). *Amélioration des herbages et cultures fourragères dans le Nord - Ouest de la Tunisie : étude particulière des prairies de trèfle-graminées avec Trifolium subterraneum,* 340 p GTZ. Schriftenreihe 119, Eschborn.

Jaritz G., Gachet J.P., Seklani H., Rondia G., Rondia A., Mathlouhi M., Dachet P., Khaiem H. and Baccouche H. (1976). *Adaptation of forage production systems without irrigation in different climatic regions in northern Tunisia.* 1976, No. 67, 105-133.

Kayouli C. (1988). *A strategy for animal nutrition in the dry subtropics. International Symposium on the constraints and possibilities of ruminant production in the Sub-Tropics (MOA of Egypt, ESAP, EAAP, FAO, ICAMS, WAAP),* Cairo, Egypt, November 1988. Published in by Purod Wageningen, 1989, pp. : 201 - 206.

Kayouli C., Jemmali M. et Bel Hadj T. (1988). Situation de la Production Laitiére Bovine Intensive en Tunisie. Seminaire Mediterraneen, le Lait dans la Région Mediterraneenne, Rabat: 25-27 Oct 1988. In: *Options méditerranéennes* CIHEAM, n° 6, pp. : 97 - 100.

Kayouli C., Demeyer D.and Accacha M. (1993). Evaluation of poultry litter and olive cakes as an alternative feed for ruminant production in Tunisia. *In the proceeding of the International Conference on Increasing Livestock Production Through Utilisation of Local Resources*; October 18-22, 1993 Beijing, China. pp. : 420 - 440

Kayouli, C. (1995). *Study of Dairy Cattle Sector in Tunisia*. TSS1-TUN/94/01T-001/AGAM-FAO (April-May, 1995).

Mill-E; Steinbach-J. (1984) and SEDENOT Project, (1999). Utilization of the Tunisian maquis by goats: forage value and carrying capacity. Rangelands: a resource under siege. *Proceedings of the 2nd International Rangeland Congress, Adelaide, Australia,* 13-18 May 1984. Pb: Australian Academy of Science; Canberra; Australia 1986 pp 135-136.

Nyarko-Badolu D.K., Kayouli C., Ba A.A. and Aziza G. (1993). Valorization of cereal straw in the feeding of sheep in the North of Tunisia:-Treatment with ammonia or urea,-complementation with urea molasses blocks. *Proceeding of the International Conference on Increasing Livestock Production Through Utilisation of Local Resources;* October 18-22, 1993 Beijing, China. pp. : 172 - 184.

Sansoucy R., Ben Dhia M. and Soltane C. (1984). Supplementation of diets based on cereal forage silage for fattening of local Tunisian bulls. *Fourrages*. 1984, No. 97, 85-104.

Sarniguet J., Bruzon V. and Makhlouf E. (1995). Une stratégie pour le développement des parcours en zones arides et semi-arides (rapport technique: Tunisie). W*ord bank Document N° 14927* MNA

SEDENOT, 1999-2000. *" Sustainable feeding systems through local resources in small farms in the North West of Tunisia."* Inter-University Belgium and Tunisia Co-operation Project

Speirs, M. and Olsen, O. (1992). Indigenous integrated farming systems in the Sahe*l. Word Bank Technical Paper Number 179*, Africa Technical Department Series.

Zoghlami,A., Hassen, H., Seklani, H., Robertson, L. and Salkini,A.K. (1996). Distribution of annual medics in Central Tunisia in relation to edaphic and climatic factors. *Fourrages*. 1996, No. 145.

9. CONTACTS.

This profile was prepared by Chedly Kayouli who is Professor of Animal Nutrition and an International Feed Resource Consultant. Periodic updating of this profile will be done by the author. For further information on forage resources in Tunisia contact the author at the following address:

Chedly Kayouli

Institut National Agronomique de Tunisie

43. Av. Charles Nicole, 1082 Tunis-Tunisia

Tel: 00 216 1 883 265

E-mail: chedly.kayouli@gnet.tn

[With additions by J.M. Suttie who also edited the profile – October, 2000]

APPENDIX 1

Meteorological data from selected stations

Station Tabarka	Latitude 37^0 14 N	Longitude 9^0 49 E	Altitude 4 m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max C	15.0	15.5	17.1	20.0	23.2	27.7	30.5	31.0	29.3	25.0	21.0	16.0
Min C	7.7	7.7	9.3	10.5	13.2	17.7	20.0	20.5	19.3	16.0	11.6	8.8
Precip	165	132	88	69	38	22	4	10	54	125	137	178
Annual precipitation 1 022 mm												

Station Jendouba				Latitude 36^0 29N			Longitude 8^0 48 E			Altitude 144 m		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max C	15.0	16.0	19.0	22.0	26.0	33.0	37.0	37.0	33.0	26.0	20.0	16.0
Min C	5.0	5.0	6.0	8.0	12.0	16.0	18.0	19.0	17.0	13.0	9.0	6.0
Precip	65	49	47	45	33	16	3	10	33	56	47	73
Annual precipitation 477 mm												

Station Kairouan				Latitude 35^0 40 N			Longitude 10^0 06 E			Altitude 70 m		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max C	16.0	18.2	20.5	24.3	28.2	33.8	37.7	37.1	33.2	27.7	22.1	17.1
Min C	4.3	5.5	7.1	9.3	12.7	16.6	19.3	20.0	18.2	14.3	9.3	5.5
Precip	28	25	36	25	23	13	5	8	38	31	31	25
Annual precipitation 288 mm												

Station Skanes				Latitude 35^0 40 N			Longitude 10^0 45 E			Altitude 3 m		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max C	16.0	15.5	16.8	19.0	22.7	26.3	30.7	30.5	29.3	24.5	20.2	16.7
Min C	7.6	7.2	8.8	10.5	14.0	17.5	20.0	20.7	20.2	16.2	11.6	8.6
Precip	40	32	30	30	17	7	10	7	41	45	37	35
Annual precipitation 331 mm												

Station Sfax				Latitude 34^0 43 N			Longitude 10^0 41 E			Altitude 23 m		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max C	16.0	18.0	19.0	21.0	24.0	28.0	30.0	31.0	29.0	26.0	22.0	18.0
Min C	6.0	7.0	9.0	12.0	15.0	19.0	20.0	21.0	20.0	17.0	12.0	8.0
Precip	18	18	25	21	12	5	1	5	26	38	26	15
Annual precipitation 210 mm.												

Station Tozeur				Latitude 33^0 55 N			Longitude 8^0 10 E			Altitude 51 m		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max C	15.8	19.0	22.0	25.7	31.1	34.8	39.1	38.3	32.8	27.6	21.2	15.6
Min C	4.5	6.8	9.3	12.7	17.6	21.7	24.3	24.6	20.7	15.7	10.0	5.0
Precip	14	8	6	2	15	0	0	0	22	4	8	10
Annual precipitation 89 mm.												