Forage Production and Management

Training Package for Extension workers



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Developed with
Dairy Training Centre

Forage production and management

Part I Training manual

Part II Training Guideline

Preface

SNV Ethiopia, through EDGET project (Enhancing Dairy Sector Growth in Ethiopia, 2013-2018), engages in the capacity building, extension services and innovative support to the Ethiopian dairy sector particularly working with smallholder dairy farmers. The aim of the project is to increase milk production and productivity in order to double the income of the smallholder dairy farmers. EDGET is operational in the regions Oromia, Amhara and SNNP, and working with 65,000 dairy farming households.

The project works closely together with livestock regional bureaus and their respective zonal, woreda and kebele staff in delivering extension and other supports. One area of collaboration is the development of practical training and coaching tools and materials for extension workers based on a need assessment.

SNV has engaged the Netherlands based Dairy Training Centre (DTC) for the development of the Training package for extension workers. The documents were more elaborated and validated with the utmost contribution of high level experts from regional Livestock and Fisheries resources Development Bureaus/Agencies and Research Centers from the three operational regions of EDGET.

Overall nine training packages were developed on Breed Improvement and Fertility Management; Dairy Cattle Feeding and Nutrition Management; Dairy Cattle Health Management; Dairy Farm Management; Dairy Housing and Manure Management; Farm Economics; Forage Production and Management; Hygienic and Quality Milk Production; Young Stock Management.

This training package is on **Forage Production and Management.**

SNV, also on behalf of the experts that contributed and DTC, would hope to see the materials widely used outside the project areas by all interested dairy development practitioners. The materials will be available in hard copies and soft copies including on SNV website www.snvworld.org and other relevant websites.

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Abbreviations

AEZ	Agro-ecological Zone
ASN	Ammonium Nulphate Nitrate
CAN	Calcium Ammonium Nitrate
cm	Centimeter
DAP	Di-ammonium Phosphate
EDGET	Enhancing Dairy Sector Growth in Ethiopia
FLDP	Fourth Livestock Development Project
ha	Hectare
kg	Kilogram
masl	Metre Above Sea Level
mbsl	Meters Below Sea Level
MoA	Minisry of Agriculture
SNV	The Netherlands Development Organization
SSP	Single Superphosphate
TLU	Tropical Livestock Unit
TSP	Triple Superphosphate

I. Forage Production and Management Training Manual

1. Introduction

The booming demand for livestock and livestock production is taking place elsewhere in developing countries in response to continuous population growth, incomes rise and urbanization (Delgado et al., 1999). The demand is expected to remain strong for foreseeable future. Despite the projected increase in consumption, results (Delgado et al., 1999) indicated that total milk and meat consumption in developing countries is expected to exceed total production of these products in 2020. The debate remains important is however, the capability of smallholder in mixed crop-livestock systems which are presently producing at very low levels to meet growing demand for livestock products in developing countries. In developing countries, such smallholder systems need to transition to more intensive systems to meet these increasing demands. Smallholder dairy in developing countries is recognized as an important enterprise that can bring economic and livelihood improvements through its contributions to increase livestock productivity, income generation, the provision of jobs and the transfer of money from urban to peri-urban and rural areas, if it is intensified. This does not mean that there are no constraints. The major technical constraints to intensify livestock production in general and dairy production in particular are lack of good quality feeds, animal diseases, lack of improved breeds, poor infrastructure, limited market and availability of other inputs.

As elsewhere, the low productivity of Ethiopian dairy is a result of multiple limiting factors among which nutritional factors is the binding constraint to sustaining production of the sub-sector. Grazing lands are shrinking due to expansion of crop cultivation which is being driven by population increases. As a result, ruminants have to rely more on crop residues which are invariably of marginal quality, and forage from road sides or other marginal communal lands. While it is desirable to address all of these constraints wherever they are binding, priority should be given in the near term to places where there is substantial commercial potential and where the feed constraint is not binding. These authors added that improved dairy breeds are not likely to be used where adequate feed cannot be assured or only limited commercial potential exists, given their cost and greater demand for feed. Therefore, efforts to improve feed availability particularly in dairy potential areas should targeted to improve dairy production in the near term. The production of adequate quantities of good quality forages to supplement crop residues and pasture roughages is the only way to economically overcome the feed shortage (Alemayehu et al., 2016).

Improving dairy production through increased forage production is limited in Ethiopia due to, among other factors, poor extension and training. Thus, this manual is intended to provide training to extension workers and through them to smallholder dairy farmers a basic skill related to forage production and management. The first part of the manual provides an introduction to Ethiopian dairy sub-sector in terms of its feed shortage

and the role of forage production to overcome the shortage. Then, climatic, soils, vegetation and topographic features as well as agro-ecological zones (AEZ) of the country are presented. The major livestock productions existing in the country are also discussed. Finally, topics related to forage production, including forage production, major types of forage, management practices and utilization of forage as a feed are detailed.

2. Climate, Soils, Topography and Agro-Ecological Zones

Climatic conditions of the area, its soil types and topography determines the type of forage or any crop to be cultivated in that specific area. Ethiopia, with its extremely variable agro-climatic conditions, has several major ecological systems that support large and very diverse genetic resources (Alemayehu, 2006). Some ecological variables and important agro-ecological zones (AEZ) are detailed below. It is found to be crucial to discuss climate, altitude, agro-ecology and other factors because they are interrelated to forage production potential, thereby livestock production.

2.1 Climate

Climatic elements such as precipitation, temperature, humidity, sunshine and wind are affected by geographic location and altitude. Ethiopia, being near the equator and with an extensive altitude range, has a wide range of climatic features suitable for different agricultural production systems (Alemayehu, 2006). Temperature and rainfall are the most important climatic factors for agricultural production in Ethiopia. Altitude is a factor that determines the distribution of climatic factors and land suitability; this influences the crops to be grown, rate of crop growth, natural vegetation types and their species diversity.

As cited in Alemayehu (2006) rainfall in Ethiopia is generally correlated with altitude. Middle and higher altitudes (above 1 500 m) receive substantially greater falls than do the lowlands, except the lowlands in the west where rainfall is high. Generally average annual rainfall of areas above 1 500 m exceeds 900 mm. In the lowlands (below 1 500 m) rainfall is erratic and averages below 600 mm. There is strong inter-annual variability of rainfall all over the country (Alemayehu, 2006). In the north of the country the rainfall pattern is mainly bimodal, with the shorter of the seasons around March/April; the second rainy season often begins around June/July. In some areas the two seasons combine into a unimodal pattern; this is more common in the west and some northern parts of the country where rainfall is generally higher. Between these extremes, in the central highlands, there is a tendency for the two seasons to merge. The lowlands of the east and southeast contrast with the rest of the country by having a bimodal rainfall distribution, and have marginal rainfall for crop production. Temperature and rainfall, in combination with topography and soils, determine moisture availability, which determines vegetation and agricultural productivity (Alemayehu, 2006).

2.2 Soils

The variability in soils can be determined by a wide range of topographic and climatic factors, parent material and land use types. In different parts of the country, different soil forming factors have taken precedence. As cited by Alemayehu (2006), Ministry of Agriculture (MoA) have identified about 19 soil types throughout the country. The big proportion of the country's landmass is covered by lithosols, nitosols, cambisols and regosols in order of their importance (Alemayehu, 2006). This author cited that compared with the African standard most soils in the highlands of Ethiopia are fertile (FAO, 1984c). Contrary to most other African soils, the majority of Ethiopian highlands soils remain relatively fertile at depth. However, most highland soils are deficient in important nutrients and require fertilizer to sustain crop yields. Research has indicated that Ethiopian soils are generally low in available nitrogen and phosphorus and cannot produce high crop yields unless these are supplemented (Alemayehu, 2006).

2.3 Topography

Ethiopia is endowed with altitudes ranging from 126 mbsl (Dalol in Afar Depression) on the northern border, to the highest mountain (Ras Dashen in the Semen Mountains north of Lake Tana) rising to 4620 masl. The plateau in the northern half of the country is bisected by the East African Rift Valley, which runs more than 600 km north–northeast of the Kenyan border to the Koka Dam on the Awash River south of Addis Ababa. The rift valley then descends to the northeast and its lateral escarpments begin to diverge from each other crossing the Afar depression toward the Red Sea coast (Alemayehu, 2006). This arid, hot zone, with up to 90 growing days per year, is suited mainly to extensive grazing. It includes the lowest elevation in the country at 126 masl. The lowlands make up nearly 61-65 percent of the land-mass, and are the major nomadic pastoralist and agro-pastoralist areas. The topographic diversity of the country has resulted in the formation of a multitude of AEZs and subzones with varied farming systems (Alemayehu, 2006).

2.4 Agro-ecological zones

The suitability of an area for either animal or crop production, and the type of animal or crop to be produced in the area depends on the agro-ecological conditions of the area (Adugna and Aster, 2007). These authors added that the feasibility of cropping and the type of crops to be produced depend on climatic, edaphic and biotic factors. The extent of cropping and the type of crop, in turn, determine the quantity, quality and distribution of animal feed resources throughout the year that determines the animal production system of the area (Adugna and Aster, 2007). The multitude of AEZs is traditionally classified into five traditional categories based on altitude and temperature: *Bereha*, *kola*, *weinadega*, *dega* and *wurch*. However, the amount of rainfall and its distribution are also important in classifying common agro-ecological zones into eight categories, according to MoA cited in Alemayehu (2006). Table 1 indicates eight traditional AEZs and major agro-ecologies corresponding with them.

Tabel 1: Traditional agro-ecological zones of Ethiopia (as cited in Alemayehu, 2006)

Zone	Altitude (masl)	Mean rainfall (mm)	Temperature (°C)	Major agro-ecology
Bereha (dry-hot)	500–1500	<900	>22	Lowland (<1500 masl)
Erteb Kola (sub-moist warm)	500–1500	900–1000	18–24	
Weinadega (dry-warm)	1500–2500	<900	18–20	Midland (1500–2500 masl)
Weinadega (sub-moist cool)	1500–2500	900–1000	18–20	
Erteb Weinadega (moist-cool)	1500–2500	>1000	18–20	
Dega (cold)	2500–3500	900–1000	14–18	Highland (> 2500 masl)
Erteb Dega (moist cold)	2500–3500	>1000	10–14	
Wurch (very cold or alpine)	>3500	>1000	<10	

In the higher part of the Afro-alpine Mountains (*wurch*) plants are exposed to intense radiation, with much greater rise in the temperature of the aerial parts in contrast to their underground parts; transpiration is higher than the absorption of water by the plant, so, though moisture is not limiting, plants are mostly adapted to moisture deficiency (Alemayehu, 2006). He also added that the soil is often shallow, even though very rich in undecomposed organic matter. AEZs between 1500 and 3200 masl (*weinadega* and *dega*) are most productive zones where a wide range of crops are grown and many species of livestock kept (Alemayehu, 2006). In this mixed crop-livestock system rainfall is generally not limiting except in the far north and growing seasons are often very long ,with two crops per year in some areas. Due to high population, farming is dominated by smallholdings. Medium to large-scale dairying is found around big towns and cities (Alemayehu, 2006).

In many AEZs at low altitude between 500 and 1500 masl (kola) growing seasons are short to very short, so only drought resistant crops can be grown, unless irrigation is possible (Alemayehu, 2006). This zone is dominated by pastoralists who depend on livestock for their livelihoods. The major feed resource is native vegetation and thus net livestock productivity is very variable over time and space.

3. Dairy Production Systems

Dairy cattle can be reared in livestock production systems that have varying resources available to the farmer (Lukuyu et al., 2012). Following Tegegne et al. (2013), dairy production system in Ethiopia can broadly classified into pastoral, agro-pastoral and sedentary dairy systems. Pastoral systems are mainly found in the lowlands where livestock production is the dominant form of production to sustain the livelihood of pastoral society with no cropping, while agro-pastoral system combines both cropping and livestock production (Tegegne et al., 2013). Dairy production under both systems is low input-output system which entirely based on indigenous cattle. In sedentary dairy systems, where grazing land is available, cattle are reared on pasture. Elsewhere in East Africa, grazing lands are mainly comprises natural unimproved grasses and in the state of shrinkage (Lukuyu et al., 2012). Natural grasses can be improved by over-sowing with herbaceous legumes (e.g. *Trifolium)* or planting grasses (e.g. Rhodes grass) as an alternative method (Lukuyu et al., 2012).

In sedentary systems, the level of intensification may vary between small and large scale dairy systems. In the less intensified systems (small-scale dairying) the cattle graze for some time during the day and in the afternoon or evening they are supplemented with other forages like Napier grass (Lukuyu et al., 2012). In medium-scale intensive dairying farmers use all or part of their land to grow improved pasture and forage (Alemayehu, 2006), thus improved pasture and forages and purchased concentrates are sources of feed. Milk from crossbreed animals (Local Zebu crossed with Friesian), ranging from 5 – 8 liters per day is the main source of income and farmers use family labor and sometimes hire help for dairying and fattening (Alemayehu, 2006). As indicated in this literature, large-scale dairying with more intensive production are mostly found around peri-urban and urban areas and, to a lesser extent, around the previous farmer' cooperatives and few private rural areas.

Besides, Tegegne et al. (2013) indicates that the sedentary dairy systems are predominantly found in mid altitude to highlands, and in pockets in the lowlands and are further subdivided into urban, peri-urban and rural systems. Each of these systems is defined by its location, agro-ecology, their main production objective, resources and resource use, scale of production and management, market orientation, and access to inputs and services (Tegegne et al., 2013). Both the urban and peri-urban systems are located near or in proximity of Addis Ababa and regional towns and take the advantage of the urban markets (Ahmed et al., 2004). Urban dairy systems are focuses on production and sale of fluid milk, with little or no land resources, using the available human and capital resources mostly for specialized dairy production under stall feeding conditions (Tegegne et al., 2013).

Peri-urban dairy systems controls most of the country's improved dairy stock (Ahmed et al., 2004). They are operating at different scale of productions ranging from small to medium scale, and have access to land and usually practice mixed crop–livestock farming, which produces part of the feed in the form of crop residues and grazing (Tegegne et al., 2013). Coupled with urban dairy systems, these systems are characterized by high demand for milk. Milk from crossbred cows is directly sold to the consumers. The main feeds are agro-industrial by-products (concentrates), purchased bush hay, improved pasture and forages and crop residues (Alemayehu, 2006). The author added that milk production is continuous with yield per crossbred cow ranges from 10 to15 liters.

On the other hand, the rural dairy system is part of the subsistence farming system and includes pastoralists, agro-pastoralist, and mixed crop-livestock producers mainly in the highland areas (Ahmed et al., 2004). This system is non-market oriented and most of the milk produced in this system is retained for home consumption. Feed resources are natural pasture, crop residues and to lesser extent improved pasture and forages (Alemayehu, 2006). Methods including roadside grazing and tethering are also important feeding systems in smallholder rural dairy systems where land is scarce. However, animals may not get enough to satisfy their nutritional requirements

(Lukuyu et al., 2012). Milk yield is 1 liter per day, and average land area 0.25 ha per animal (Alemayehu, 2006). In high potential areas, dairy farmers may grow improved pasture and forages, mainly fed on cut-and-carry, and hay to supplement their dairy cattle. However, dairy farmers are not engaged in improved forage production due, among others, to lack of knowledge and skills. The following sections provide topics related with forage and pasture production and most common forages grown in the country with their management practices.

4. Improved forage and pasture production strategies

In many of potential areas of the country dairy production has been intensified due to development interventions encouraging intensification and the interest of farmers to intensify, while there is insignificant production of improved pasture and forages. Livestock feed resources in Ethiopia are mainly natural grazing and browse, crop residues, improved pasture, forage crops and agro-industrial by-products. Grazing lands have been degrading due to growing pressure on land resources from increasing populations and greater cropping intensity. Crop residues are also poor quality feed resources which could not provide nutritional requirements of the animal. Furthermore, costs for industrial by-products is too expensive for smallholder dairy farmers to afford. Producing improved forages can help dairy farmers to withstand the prevailing feed shortages in different AEZs. In dairy systems where feed scarcity is challenging, improving feed supply is possible if backyard forage production, under-sowing, over-sowing and growing improved pasture and forages are widely adopted (Alemayehu, 2006).

Over few decades, several forages have been tested in different AEZs, and considerable efforts have been made to test the adaptability of these crops under varying agro-ecological conditions. This has been resulted in a selection of quite a number of useful forages for different zones. Improved forage crops are commonly grown for feeding dairy cattle (Alemayehu, 2006). However, there has been limited spontaneous introduction of improved pasture and forages due to land scarcity and crop-dominated farming systems. On the other hand, there are several opportunities for improved forage production to be considered in improving forage development strategies (Alemayehu, 2002; 2006). First, there is a good opportunity for integration of pasture and forage crops in the existing farming system. Because of growing pressure on land resources from increasing populations and greater cropping intensity, forage crops can only be produced in sufficient quantities if livestock and cropping systems are integrated (Alemayehu, 2002). As indicated in this manual, livestock and cropping systems can be integrated in a number of ways, including agroforestry, intercropping and ley farming. One of the best opportunities for highland farmers to use land efficiently will be through the introduction of pasture and forages in the farming system (Alemayehu, 2006).

Second, besides higher yield and nutritional value of cultivated pastures over natural

pasture, the length of the productive season is longer for cultivated pastures, which provides an opportunity for dairy and fattening production to develop and use pasture and forage on a large scale (Alemayehu, 2006). Third, in addition to their feeding values, fodder trees and shrubs assists in increasing soil fertility, controlling soil erosion and providing firewood and timber. These legumes are well adapted to the current edaphic and grazing condition, they can be readily integrated into farming systems, and they retain their feeding value into the dry season and show great success in the higher potential areas of the country (Alemayehu, 2006). Fourth, irrigation based forage production through the use of high irrigation potential of the country is a good opportunity for dairy farmers in irrigation potential areas. Small-scale traditional irrigation has been practiced for decades throughout the highlands; small streams are seasonally diverted for limited dry season cropping. This is a good opportunity to grow off-season pasture and forage crops. Medium- and large-scale schemes are of much more recent origin, mostly in the Rift Valley for cash crops. There is some irrigated forage in the Rift Valley growing lucerne/Rhodes mixture for commercial fattening and dairy farming. The potential for irrigated forage is untapped and still there is a great opportunity for producing seasonal and long-term irrigated pasture and forages (Alemayehu, 2006).

Where farmers use a cropping rotation or have sufficient land, they can grow a short-term forage crops. These crops can be reliably introduced over a wide range of sites but are most appropriate for farmers who rely on dairy production for their income. Annual leguminous species mixed with cereals provide the best quantity and quality of forage in highland areas but annual legume forages optimize forage production in middle altitude and lowland areas. Farmers in Ethiopia are shifting towards perennial forage production strategies because annual forage crops do not integrate livestock and cropping systems except where fallow is commonly used. In these areas fallow reduction strategies based on leguminous forage crops are appropriate. Oats and vetch have performed well over a wide range of AEZs, with oats showing good tolerance of relatively low fertility and poor drainage. Lablab is very productive at lower altitudes and competes well with weeds whereas alfalfa does not persist under rain fed condition in Ethiopia (Alemayehu, 2002).

Forage and pasture development strategies and forages have been promoted widely into the crop–livestock system, traditional grazing areas, and around homesteads, within soil and water conservation structures and under plantation crops and forestry, particularly during Fourth Livestock Development Project (FLDP; Alemayehu, 2006). The strategies developed and successfully implemented by the FLDP in Ethiopia evolved from experiences in other countries such as Australia, South East Asia, New Zeeland, and Caribbean and an understanding of the importance of matching forage systems to AEZs (Alemayehu, 2002).

4.1 Backyard forage production

Backyard forage production is a strategy based on small plots and hedges of productive forage and browse planted within house compounds and around their boundaries. This is the most important initial strategy since it is developed in the farmer's household, and is very convenient for intensive feeding of dairy cattle. The higher fertility levels typically found in and around house compounds also helps with the successful establishment of backyard forage. This strategy has a major impact in exposing farmers to the management and productivity of new species and also provides a seed bank to help establish new plantings for other forage strategies. Woody leguminous browse species are particularly suited to this strategy because of their multipurpose benefits (e.g. provides forage and fuelwood, used as shelter, increased privacy, wood products construction and implements, and bee products) and rapid growth rates. Tall growing tropical grasses are also suited to backyard forage development. Backyard forage can be cut and carried to tethered or housed animals, or cut and conserved for dry season use in mixes with crop residues and natural pasture hay or roughages. The most commonly used backyard tree legumes in Ethiopia are leucaena, sesbania, pigeon pea and Tree Lucerne, whereas Greenleaf, silverleaf, alfalafa, vetch and vernano stylo are herbaceous forage legumes (Alemayehu, 2002). Similarly, grasses including Rhodes grass, elephant grass, panicum, phalaris and oats can be used as a backyard forage.



Figure 1: Backyard fodder plant

The backyard forage strategy provides an opportunity to reach large numbers of farmers very quickly and can therefore have a great impact nationally, even in the short term. Forage seedlings or sets can be planted in any pattern to suit the needs of the household but simple boundary hedges/shelter belts or forage blocks are the most widely accepted designs for backyard forage plantations. The extension emphasis should be on browse legumes and large grasses and the production of bare rooted seedlings in backyard nurseries. This ensures that farmers develop the capacity to grow their own seedlings or sets for expansion of forage development using contour forage strips and other strategies. In this way, farmers develop familiarity with the propagation, growth and management of key species. Backyard nurseries are typically 4 to 5 square meters in size and are initiated with small packets of seed containing 50 to 100 grams of seed. It is feasible to distribute these seed packets to vast numbers

of farmers each year. Wide distribution of seed and promotion of hedges, backyard forage banks, ensure the farmers' capacity to grow bare rooted seedlings for planting in other areas.

4.2 Under-sowing and inter-planting

Under-sowing and inter-planting is the establishment of forage species in an annual crop or perennial plantation. This strategy provides the most convenient approach to rapidly increasing on-farm forage supplies over a large number of farmers and should have a major impact in the short to medium term. The use of legumes in this system will contribute to the improved fertility and structure of cropping soils. This is normally the second strategy to promote after backyard forage has been adopted by farmers. Under-sowing and intercropping are probably the most important of the forage development strategies.

Under-sowing works best with sprawling, low growing annual legumes but can also work well with climbing legumes. The strategy is particularly suited to the production of tall growing cereals such as maize, sorghum or millet but also works with other cropping systems. Under-sowing with legumes produces large quantities of high quality forage for utilization by either post-harvest grazing or cut and carry systems. The under-sown forage protects the soil from erosive rains, can contribute nitrogen for the food crop, and balances the forage value of crop residues such as stover and straw to increase its intake and utilization. The strategy works well with sprawling and climbing legumes but is also effective with other forage legumes and dual purpose legumes such as cow pea.

Tree crops and some vegetables can also be under-sown or inter-planted with leguminous forages. The establishment of annual or perennial legumes under tree crops is a reliable strategy, which is well accepted by farmers. It is particularly appropriate to the more intensive horticultural and forestry systems where the under-sown legume is intensively managed with cut and carried systems for livestock feed. The strategy primarily involves lower altitude systems where fruit, coffee, coconuts, *enset* or khat (*Catha edulis*) are grown. There is also broad application with eucalyptus and Acacia plantations grown for fuel wood.

Where crop weeding practices are very thorough, forages should be under-sown at the time of final weeding. This avoids any risk of the under-sown legume competing seriously with the cereal crop but often means that the legumes have insufficient time to produce ripe seed prior to crop harvest. In areas of poorer weeding practices, under-sowing should coincide with an earlier weeding. In this way sufficient legumes survive any subsequent weeding to provide an adequate seeding capacity prior to crop harvest. Early maturing cereals generally favor better forage production because they compete with the under-sown forage legume for a shorter period of the growing season. The competitive balance between crop and under-sown or intercropped forage legume is very sensitive to sowing time. This will vary with soil and crop type, season,

and management practices, and is best determined using on-farm demonstrations. As cited by Alemayehu (2002) good stands of under-sown legumes produce 2500 to 3000 kg dry matter (DM) per ha from one cut in farmers' fields.

Highland wheat crops in Ethiopia under-sown with a range of indigenous *Trifolium* species yielded significantly more DM than control crops without under-sown legumes. The most significant outcome such works indicated that the successful intercropping of wheat with forage legumes without any significant reduction in wheat yield. The most common forage legumes suitable for under-sowing and intercropping are cow pea, verano stylo, Greenleaf, Wynn cassia, siratro, vetch, white clovers and native clovers under varying AEZs (Alemayehu, 2002).

4.3 Contour forage strips

Forage strips are broad based mixtures of herbaceous and tree legumes, and grasses planted on contour bunds or in narrow strips along the contour without any physical structures. This is a multipurpose strategy providing forage, shelter, soil stabilization, and fuelwood. Forage strips planted along the contour contribute to soil conservation by directing ploughing along the contour and by reducing run-off down the slope. This increases infiltration and reduces soil erosion, especially where a thick sward of grass or herbaceous legumes is included in the forage strip. Contour forage strips are particularly successful when perennial, thick rooted grasses are mixed with woody leguminous species. Because this strategy integrates forage production in cropping areas, potentially weedy species such as stoloniferous grasses should not be used for forage strip plantings.

Their key problem with forage strips is the difficulty some farmers have in establishing them where livestock have free grazing access to fallow land or crop stubbles after harvest. This problem is best overcome by involving shepherds in forage strip establishment and promoting cut and carry feeding of animals tethered in the field. Thus contour forage strips are more easily promoted once backyard forage and under-sowing is established to provide alternative forage sources to stubble and fallow grazing. Animals can be kept away from planted forage strips during their establishment if conspicuous species such as vetch are included in the forage strip mix. In some areas, alley farming can be developed by using long-lived browse species as part of the species mix for contour forage strips. Alley farming requires careful location and marking of contour strips which should be wide enough apart to allow ploughing and harvesting operations to take place without disruption. Alley farming is best established with bare rooted seedlings.

The most reliable tree legume (leucaena, sesbania, pigeon pea and Tree Lucerne), forage legume (siratro, axillaris, silverleaf, greenleaf, vetch, verano stylo, white clover, native clover, alfalfa, and makulotus) and grass (panicum, setaria, vetiver, phalaris and setaria) species can be used in contour forage strips. Pioneer species such as Pigeon Pea, *Phalaris*, and Greenleaf *Desmodium* are particularly reliable understory

species when planted with *Leucaena* or Tree Lucerne. Stoloniferous species such as Rhodes Grass are not suited to contour forage strips because of their weed potential in crop areas (Alemayehu, 2002). As indicated in this literature, contour forage strips produce between 2000 and 5000 kg DM per hectare of planted strip, or between 340 and 850 kg DM per hectare assuming 6 meter intervals and 1 meter wide strips. In addition to this benefit, there are yields of wood for fuel and construction, shelter benefits, nitrogen fixation and bee products (honey and wax).

4.4 Agroforestry

Agroforestry is the combination of trees and agriculture in an integrated and sustainable farming system. Many of the forage production strategies can be developed as agroforestry systems. In particular contour forage banks and under-sowing of tree crops or forest plantations can be designed as agroforestry systems where leguminous browse species provide an upperstory in a forage system or under-sown legumes and grasses provide an understory in a forestry or horticultural system. Agroforestry maximizes the use of land by adding a third dimension to the above and below ground areas of utilization. This aspect is particularly important for farmers with limited land resources. Because many agroforestry strategies include leguminous species, they are also attractive to farmers facing problems of declining soil productivity.

Experience in Ethiopia and elsewhere shows that the height and frequency of cutting agroforestry browse species has a significant impact on their productivity and forage value (Alemayehu, 2002). For example, as indicated by this author, *Leucaena* produces more DM at longer cutting intervals (more than 3 months) and moderate cutting height (75 to 100 cm) than more severe defoliation. Similarly, total DM yield of *Sesbania* increased with increased cutting interval with the highest yields recorded at 8 week cutting intervals. The 100 cm cutting height gave maximum yields from 12 month old *Sesbania.* Pigeon Pea also gives maximum yields with a cutting frequency of about 8 weeks.

4.5 Over-sowing common grazing areas

Over-sowing is the simplest of the forage development strategies and can be undertaken at very low cost depending on the seeding rates used. It involves broadcasting or sowing improved forage species into common grazing lands, native pastures and degraded areas without any cultivation or other inputs. Typically there is no attempt to modify grazing management but existing stocking rates should not be increased after over-sowing. The strategy includes sowing roadsides from vehicles and is suited to aerial seeding where very large areas are to be developed. Aerial seeding is also another way of establishing improved extensive grazing areas using over-sowing techniques. This strategy is most suited to pioneer legume species, which grow quickly and seed prolifically. Because of the low input nature of this strategy, incremental forage yields are not large but pioneer species with good grazing tolerance and natural seeding ability gradually colonize common areas and improve the overall species composition

available for grazing. Natural spread of seed with water movement, grazing animals and wind action can be rapid, enabling very large areas of land to be developed so long as grazing management is possible to enable plants to become established and set seed.

Farmers are more likely to gain long term advantages from over-sowing strategies if there is some of grazing management group or pastoral association, which manages common grazing areas. This could be associated with dairy user groups but requires the majority of farmers using common grazing land to recognize that there is an overgrazing or low productivity problem, which can be solved with over-sowing. The provision of seed and technical support for over-sowing strategies is a sufficient incentive to encourage farmers to organize grazing management groups or pastoral associations. Such organizations are only successful if they are initiated by farmers in response to their perceived needs. If suitable sites are chosen and effective grazing management of common lands exists, over-sowing of grazing areas is the most cost effective strategy for broad-scale forage production.

The most reliable species for over-sowing have been the stylos, which have established and begun spreading on an extremely wide range of sites in Ethiopia. Wynn cassia and climbing/sprawling legumes such as greenleaf and Siratro have also shown promise. Experience in the sub-humid middle altitude areas of Ethiopia shows that even after a short time over-sown *Stylosanthes guianensis* (cv Schofield) and *Desmodium uncinatum* can make up more than 15 per cent of pasture DM composition (Alemayehu, 2002). The key browse legume species suitable for over-sowing grazing area are leucaena, sesbania, and Tree Lucerne, whereas siratro, axillaris, greenleaf, silverleaf, seca stylo, Wynn cassia, verano stylo, white clover, alfalfa and makulotus are the most common legume species under varying AEZs. Similarly, Rhodes grass, panicum, setaria, buffel grass, phalaris and cocksfoot (Alemayehu, 2002).

4.6 Stock exclusion areas or forage banks

Stock exclusion areas are an important means of protecting degraded areas, key watersheds, and common land. They also provide an opportunity to develop forage banks for use during droughts or periods of seasonal forage shortage. Stock exclusion areas are particularly important for the conservation of highlands but are only accepted by farmers where they see sufficient benefits to organize grazing management groups or pastoral associations to control stock exclusion areas and voluntarily keep stock out. The introduction of browse species, productive legumes and improved grasses can rapidly increase the productivity of exclusion areas. The strategy is suitable for aerial seeding techniques which enable very large areas of land to be sown to forage quickly.

Cultivation is not necessary to establish forage banks or rehabilitate stock exclusion areas, especially on very bare sites, but broadcast sowing should take place after commencement of the main rains to ensure that there is enough soil moisture to sustain germination. Leguminous browse and tall grass species should always be included in

stock exclusion areas to maximize the production potential and drought resistance of the species mix. Woody species can be planted by direct seeding but generally develop more successfully where they are planted as bare rooted seedlings early in the main rainy season. Annual cut and carry forage production from improved low and medium altitude sites in Ethiopia is in excess of 6000 kg per hectare. Other benefits include soil conservation, better recharge of shallow aquifers, and production of fuel wood and bee products where browse species are included in the stock exclusion area. Tree legume, forage legume and grass species commonly used over-sowing grazing area can also be used for stock exclusion area strategy (Alemayehu, 2002).

Forage banks should be established at the beginning of the wet season. *Stylosanthes hamata* cv Verano and *S. guianensis* cv Cook are particularly suitable for forage banks and should be established with 8 to 10 kg seed per hectare. Forage banks are left un-grazed during the growing season to provide a supply of high quality forage during the dry season. Once established, these species can support up to 5 TLU/ha for up to 4 hours per day during the dry season (Alemayehu, 2002). Forage banks are particularly important for maintaining priority animals in the household herd – for example lactating and weaned animals. Browse legumes such as *Leucaena* and tree lucerne also act as good forage banks if they are left uncut during the growing season. Many farmers regard backyard browse plantings as forage banks and this is an appropriate use for backyard forage strategies, which should be promoted by extension agents. Annual targets for stock exclusion areas of 2 to 10 hectares per village area are possible but much larger areas have been rehabilitated where strong village support has resulted in the formation of grazing management groups to voluntarily exclude livestock from areas to be developed. The improvement of stock exclusion areas is suited to cut and carry systems and is rapidly adopted by farmers where there is a history of fattening and dairying.

4.7 Permanent pastures

Permanent pastures comprise a broad range of annual and perennial legumes and perennial grasses. Productive mixed pastures can be readily established, particularly in the low and medium altitudes with warmer growing conditions. Grazing management is a significant problem for sustainable pasture production in some regions, which is best overcome with cut and carry systems. Permanent pastures are most useful for dairy farmers who rely on optimal productivity of their livestock investment for their livelihood. Permanent dairy pastures should include a mix of legumes and grass species with high palatability and productivity. Siratro, greenleaf, silverleaf, seca stylo, Wynn cassia, verano stylo, white clover, vetch, alfalfa, and makulotus are the most commonly used legume forage species under for permanent pastures varying AEZs. Similarly, Rhodes grass, panicum, setaria, oats, phalaris and cocksfoot are the most common grasses to be used for this strategy (Alemayehu, 2002).

4.8 Other strategies

Aerial sowing: Aerial sowing enables very large areas to be over-sown with improved forage seeds. The success of establishment depends largely on the selection of suitable sites. The most suitable sites have rough often gravelly surfaces. Sites with compacted or hardpan surfaces do not enable good establishment of aerial sown or broadcast seed. *Stylosanthes* are particularly successful for aerial over-sowing – being extremely resilient to grazing and a successful pioneer species. It is particularly suited to the rehabilitation of large catchments, which include relatively inaccessible areas. Where grazing is restricted or there are protected niches because of thorn bushes or rocks, leguminous browse species should also be included in aerial sowing mixes. *Leucaena* is especially appropriate for this purpose.

Roadside sowing: Roadside sowing is a successful means of implementing the over-sowing strategy. It is quick and effective and provides an impressive visual impact which can be used to excite farmer interest and provide an incentive for the formation of grazing management groups or pastoral associations. This strategy can be highly cost-effective, particularly when using species with the ability to spread under grazing. Sowing a broad grid of suitable roads provides a convenient mechanism for introducing improved forage species to a large area since the rate of spread from a very long narrow transects is high. Ten km of roadside sowing equates to about one hectare of over-sown grazing land. Seeding rates are typically 0.5 to 1.0 kg per kilometer of roadside. Mixed seed should be emptied from sacks or buckets from the back of a reasonably fast moving vehicle. In this way the vortex currents carry seed onto the roadside verge. Roadside sowing is most suitable for quickly establishing and prolific seeding species, which tolerate grazing. The stylos are the most successful species used in roadside sowing in Ethiopia.

In summary, rain fed cereal and tree cropping systems in lowland areas present significant opportunities for integrating forage and crop food production. Longer growing periods and suitable thermal and soil conditions in much of this area enable under-sowing and intercropping strategies to be adopted successfully (Alemayehu, 2002). Under-sowing and intercropping strategies used in lowland farming systems are also suited to middle altitude systems. Tree crops can also be under-sown with sprawling leguminous forages, which maintain soil structure and fertility as well as producing forage. Permanent pastures and stock exclusion areas developed for improved forage production reduce grazing pressure on cropped areas and, where browse legumes are used, provide an alternative fuel source which releases dung resources for fertilization of cropped areas. Forage strip and alley cropping strategies are also suited to middle altitude cropping systems and have the advantage of being able to use a wider range of

species than the lowland or highland systems (Alemayehu, 2002). Highland cropping systems are less suited to under-sowing or intercropping but forage crops grown as relays or in rotation with cereal crops offer opportunities for better integration of livestock and cropping systems. Contour strips of browse or forage legumes combined with thick grasses increase the sustainability and productivity of most soils whilst also providing high quality forage to supplement low quality roughages and crop residues (Alemayehu, 2002).

5. Common Types of Forage

Potential forage crops can be grown in Ethiopian AEZs are presented in this section based on experiences from Ethiopia (Alemayehu, 2002) and Kenya (Lukuyu et al., 2007). The former author has presented forages which have proved successful in the FLDP, while the latter has discussed some major forage crops grown in East Africa. This information provide smallholder dairy farmers an opportunity to use these materials as a useful starting point for improved forage programs because of their adaptability and proven forage value. Some forages grown in East Africa and Ethiopia along with their, among other, suitable climatic conditions and soil characteristics for their cultivation are presented under Annex 1. One has to refer this Annex to understand climate and soil conditions under which each forage can grow best in order to give higher biomass that fulfil nutritional requirement of the animal.

5.1 Grasses

Most ruminant livestock in Ethiopia rely on local grasses for their roughage and much of their nutrition. Many of these species have low palatability, poor productivity and inadequate nutrients to maintain animals, especially during the dry season. Improved grasses, many of them selected from other parts of Africa, have better productivity, palatability and nutrient characteristics that make them desirable for inclusion in improved forage production programs (Alemayehu, 2002).

Nappier Grass

A fast growing, deeply rooted, perennial grass growing up to 4 meters tall that can spread by underground stems to form thick ground cover. Napier grass is a very important fodder crop in the cut-and-carry system of dairy production, for example in Kenya. It is high yielding; good palatability; good nutrient content when young (dark green, less than 1 meter tall); easy to establish and persistent; drought tolerant; very good for silage making; prevents soil erosion and can serve as a wind-break; can be intercropped with forage legumes such as desmodium. However, it is not suitable for direct grazing; attacked by various fungal diseases in some areas, such as head smut

in Central Kenya – some varieties are more prone to disease than others; takes a lot of nutrients from the soil - requires a lot of manure/fertilizer to get high yields; not very frost tolerant (Lukuyu et al., 2007).



Figure 2:Napier grass/Elephant grass (Pennisetum purpureum)

Climate: Napier grass can be grown at altitudes from sea level to 2,000 m – any higher, growth and regeneration after cutting is slow and it may die after frost. It does best in high rainfall areas, over 1500 mm per year, but survives well in droughts due to its deep root system.

Soils: Napier grass can grow in almost any soil but does best in deep, fertile, well drained soils.

Agronomic practices: Napier does best as a pure stand. To save labor, under cut-and-carry systems, it is recommended that the plot be situated as close to the zero-grazing unit as possible. Napier may also be planted to prevent soil erosion such as in strips along contours, along river banks and on steep slopes which are unsuitable for growing food crops. Prepare site by ploughing or digging. Make sure the site is weed free at the time of planting. If farmyard manure is available, it can be worked into the soil at this time. The best time to plant Napier is at the beginning of the main rainy season. Wait for two heavy down pours before planting. Either canes or splits can be used for propagation. Canes require less labor and planting material. If using canes, select mature Napier and cut a length with three to four nodes with buds from the middle part of the cane. Plant canes at an angle of at least 45 degrees. To use splits,

cut the Napier plant to 10 to 15 cm above the soil. Uproot and divide into small parts. Each part should have some roots covered with soil. Allow 0.5 m between plants and 0.5 m between rows in high rainfall areas and 0.5 m between plants and 1 m between rows in low rainfall areas.

Apply compound fertilizer (NPK: 20-20-0), 1 teaspoon per hole at planting time. After establishment, return as much as possible of the cows' manure back to the Napier. If practicing zero grazing, collect slurry and apply after every cutting in a furrow between the Napier rows. If applying dry manure, work it into the soil. Apply NPK (20-10-10 or 20-20-0) fertilizer during heavy rains at the rate of 4 teaspoons per plant. Additional top dressing may be done using CAN at the rate of 1 teaspoon per plant after cutting. Keep the plot weed-free, especially after initial planting. Once established, Napier grass is able to suppress most weeds other than very stubborn ones like couch grass. Weed after every cutting and avoid heaping soil around the plants. Napier is relatively free of pests and diseases but it is susceptible to Napier head smut in some regions.

Harvesting: Harvest from 3 to 4 months after planting, when the Napier is about one meter high. Cutting interval varies depending on rainfall but generally harvest when the Napier is about one meter high. Cut the plant to about 5 cm from the ground during the rainy season and 10 to 15 cm during the dry season. With good climate, soil fertility and management yields can be over 25 tones (dry matter) per hectare per year. Yields of about half this amount can be achieved with little or no fertilizer.

Feeding: Fresh material is commonly fed in stalls under cut-and-carry system. Chop the material into pieces about 5 cm long to avoid wastage. Do not graze directly. Excess Napier grass can be made into good quality silage. If it is not possible to make silage, leave a portion of the plot standing and continue to harvest the rest at the optimum height. When necessary, use the tops of overgrown Napier to feed cattle. The old canes can also be used as mulch or they can be made into compost.

Rhodes Grass (Chloris gayana)



Figure 3:Rhodes Grass (Chloris gayana)

A vigorous, perennial grass, originating in South Africa, with a strong root system giving good drought tolerance. It spreads quickly forming good ground cover and grows to 1.5 meters tall. It grows under a wide range of conditions and is useful in cut-and-carry system and for open grazing and is very popular for hay making. It does well in low rainfall areas and is drought tolerant; stands heavy grazing; very palatable; good for hay making. It is best grown in grazed plots or shut-up for hay making. However, it can be hard to establish due to poor seed germination; can be grazed out due to high palatability.

Climate: Rhodes grass grow at altitudes from 600 to 2000 m above sea level. It does well in areas receiving rainfall of more than 250 mm annually and also persists well under drought conditions.

Soil: Rhodes grass grows in a wide range of soil conditions but performs best in loamy, fertile soils. It does not do well in alkaline or very acid soils.

Agronomic practices: Plough and harrow the land at least once to make a fine seedbed. Harrow after the weeds have emerged to reduce competition during establishment. Sow immediately after harrowing. Sowing is usually established from seed but root splits can also be used. The best time to sow where there are two rainy seasons is during the short rains. Where there is one rainy season, plant from early to mid-rains. Sowing is done when the soil is loose (dry). Make furrows 25 cm apart using a peg. Drill the seeds in the furrows, at a seed rate of 12 kg per hectare. Cover the seeds lightly, for

example by pulling light tree branches over the furrows. For high productivity, apply nitrogen fertilizers preferably during heavy rains at the rate of 100 kg per hectare. Make sure the plot is weed-free during the initial period of establishment. Remove weeds between the rows using a hand hoe. No diseases of importance but common pests such as army worms may attack the pastures. Start harvesting or grazing soon after flowering. If cutting, cut close to the ground to stimulate spreading. Leave to re-grow again until next flowering. When well-managed, Rhodes grass can yield an average of 8 tones dry matter per hectare per year.

Feeding: Grazing Rhodes grass is the most common method of feeding Rhodes grass although some farmers use it for cut-and-carry. Tends to decrease in abundance on over-grazed pasture due to its high palatability. Rhodes grass is very good for hay making. It can also be used for seed production; up to 350 kg seed per hectare can be harvested.

Buffel Grass (Cenchrus cilaris)



Figure 4:Buffel Grass (Cenchrus ciliaris)

Buffel Grass is extremely drought tolerant and is a very robust grass for areas below 2000 m with more than 250 mm annual rainfall. It is adapted to heavy cutting or grazing but is less palatable than many other grasses. Buffel Grass establishes well from seed and is well suited to improvement of stock exclusion areas and rehabilitation of degraded areas.

Guinea Grass/Panic (Panicum maximum)



Figure 5:Guinea Grass/Panic (Panicum maximum)

Panic is an erect grass, useful for strip planting or mixed pastures in areas below 2400 m altitude with more than 500 mm annual rainfall. It grows on most soils but requires high fertility for good productivity. Panic produces good quality forage and is well adapted to cutting or grazing.

Setaria (Setaria sphacelata)



Figure 6:Setaria (Setaria sphacelata)

Setaria is a widely adaptable species for areas below 2400 m altitude with more than 700 mm annual rainfall. It grows on a wide range of soils and tolerates water logging. *Setaria* is ideal for contour forage strips where it can be established by direct seeding or from splits. It does not produce seed readily – an advantage for contour forage strip strategies because it reduces the risk of this plant becoming a weed.

Plicatulum (Paspalum plicatulum)



Figure 7:Plicatulum (Paspalum plicatulum)

Plicatulum is a very versatile, low input grass for areas below 2000 m altitude with more than 700 mm annual rainfall. It is drought tolerant and adapted to very low fertility soils and to water logging. Plicatulum tolerates heavy grazing once established and is well suited to stock exclusion areas and other degraded sites. It produces good seed crops and is not recommended for contour forage strips, although it has good soil conservation properties. Cultivar Bryan performs well in Ethiopia.

Phalaris (Phalaris aquatica)



Figure 8:Phalaris (Phalaris aquatica)

Phalaris is the most important grass species for forage development and soil conservation in Ethiopia. It has good forage qualities and is best mixed with other forages to optimize its value as a livestock feed. Phalaris performs well between 1800 and 3000 m altitude, is frost and drought tolerant and is productive with more than 400 mm annual rainfall. It requires fertile soils for strong growth but will survive on poor soils, although its conservation value is diminished on such soils because of weak growth. Phalaris establishes slowly but once developed is well adapted to heavy grazing or cutting. It is suitable for contour forage strips where its soil conservation properties are put to best use, but is also suitable for backyard forage and mixed pasture strategies. In intensive programs, Phalaris establishes well from splits either from nurseries or from breaking up old clumps. It requires through seedbed preparation for direct sowing and does not establish well with competition. Phalaris should be lightly grazed or cut during early establishment to encourage the plant to stool. Phalaris does not set fertile seed except where long growing seasons are possible, in which case annual seed yields of 300-400 kg per ha are feasible with adequate nutrition. This lack of fertility in many sites is an advantage for contour forage strip strategies because it reduces the risk of Phalaris becoming a crop weed.

Cocksfoot (Dactylis glomerata)

Cocksfoot produces high quality forage in areas above 2400 m altitude with more than 500 mm annual rainfall. It is less productive than *Phalaris* but has a role in mixed pastures and contour forage strips, where it should be mixed with leguminous species for best results.



Figure 9:Cocksfoot (Dactylis glomerata)

5.2 Forage legumes

Forage legumes are herbaceous (not woody shrubs) and are used in under-sowing, intercropping, over-sowing or grazing areas, improvement of stock exclusion areas, and in mixed pasture establishment. Forage legumes with a sprawling or climbing habit can also be used in backyard forage plots. Establishment is always by direct seeding (Alemayehu, 2002).

Siratro *(Macroptilium atropurpureum)*



Figure 10:Siratro (Macroptilium atropurpureum)

Siratro is a perennial, sprawling/ climbing forage legume with an important role in under-sowing and improving stock exclusion areas. Its primary use is for forage, with secondary uses being for erosion control and nitrogen fixation.

Climate: Siratro grows below 2400 m altitude and requires more than 600 mm annual rainfall.

Soils: Siratro is adapted to a wide range of well-drained soils, including low fertility sandy soils, but performs poorly on wet sites.

Agronomic practices: This section presents a summary of agronomic practices including, sowing, forage cultivation or development strategies, weeding and harvesting. Siratro establishes easily with sowing rates from 0.5 to 2 kg per ha and is a useful component of roadside and aerial seeding mixes. If newly established plantings are allowed to seed in their first year plant density will quickly increase because of heavy seed setting. This is one of Siratro's best features and makes it highly suitable for over-sowing strategies below 2000 m in areas with annual rainfall exceeding 750 mm. Seed production is best from crops grown on trellises, tall cereal crops or browse trees – with harvests of up to 1000 kg per ha possible. Siratro is an excellent understory species for plantation and forestry crops if tree spacing is sufficiently wide – this is essentially an agroforestry strategy with good soil conservation characteristics because of Siratro's ground cover characteristics. It climbs very vigorously and is useful for controlling weedy grasses and other species.

Feeding: Siratro requires careful grazing management for high productivity and is better suited to cut and carry systems based on under-sowing and stock exclusion area strategies. Repeated low cutting kills plants but they respond well to continuous light cutting. It has moderate palatability, which increases with age. Its low energy content makes it unsuitable as a quality dairy ration but it is useful for fattening dairy bulls or culled animals.

Axillaris (Macrotyloma axillare)



Figure 11:Axillaris (Macrotyloma axillare)

Axillaris is a perennial, sprawling/ climbing forage legume highly suited to under-sowing, intercropping and improving stock exclusion areas. It grows best in complement with Siratro and Greenleaf *Desmodium.*

Climate: Axillaris grows best in warm to hot areas below 2400 m altitude and requires more than 600 mm annual rainfall.

Soils: Axillaris is adapted to a wide range of soils, including low fertility sandy soils, and is moderately tolerant of waterlogging.

Agronomic practices: Axillaris establishes easily with sowing rates from 0.5 to 1 kg per ha and is well suited to roadside and aerial seeding strategies. Seed production is limited by a short flowering period and is more successful when crops are grown on trellises, tall cereal crops or browse trees. Harvests of up to 500 kg per ha is possible. It can be used as an understory species for plantation and forestry crops if tree spacing is sufficiently wide. It combines well with Elephant grass.

Feeding: Axillaris needs careful grazing management for high productivity and is most productive with cut and carry systems based on under-sowing and stock exclusion area strategies. It should not be cut below 20 cm since repeated low cutting will kill plants, but they respond well to continuous light cutting. It has low to moderate palatability, which increases with age and makes it suitable for over-sowing common grazing land and soil conservation areas. Livestock may need a familiarization period when they are first introduced to this forage.

Desmodium species

Desmodium is a trailing or climbing perennial legume with small leaves and deep roots which, in favorable conditions, forms very dense ground cover. It is popular in cut-and-carry systems. The best time to plant is at the start of rains. For areas with two rainy seasons, sow seeds during the short rains but plant cuttings during the long rains. The seeds can be sown either by drilling or by broadcasting. For drilling, make shallow furrows about 5cm deep spaced 30 cm apart. Cover the seed with 1 cm of soil and press softly. For broadcasting, spread the seed evenly over the seed bed. The nursery bed should be watered carefully and often. Shade may be provided but it should be removed soon after germination.

Desmodium can also be established from cutting. Its cuttings should be vines 60 cm long with soil still attached to the new roots. Make furrows 30 cm apart and 10 cm deep and plant the vines 30 cm apart. Desmodium can be grown between rows of Napier grass. Plant the Napier grass at a spacing of 1 m between plants and, wider than usual, with 2 m between rows. Make holes between rows of the newly planted Napier. Plant desmodium cuttings 30 cm apart, as you would sweet potato vines. When grown together with Napier, desmodium adds nitrogen to the soil, benefiting the Napier and reducing the amount of nitrogen fertilizer required for top dressing. Once desmodium has fully established, it forms a complete ground cover which smothers the weeds, thus reducing the labour requirement and cost of weeding the Napier plot.

Apply 500 g of phosphate fertilizer, TSP (45% P) or DAP (46% P, 18% N) to the 3 m by 3 m plot before sowing and mix thoroughly with soil. Alternatively add 15 kg dry farmyard manure to the seedbed before planting. Keep the plot weed-free especially during the early stages of establishment. When well established, desmodium is able to suppress weeds. Desmodium is a good quality supplementary forage with a high protein content. It should be given in small quantities mixed with basal fodders. Harvest just what is needed and spread it in the sun for a few hours to wilt. Chop and mix thoroughly with other forages, such as maize stover or Napier grass, then feed to the animals. Three to six kilograms of green desmodium is equivalent to one to two kilograms of the commercial concentrate. Excess desmodium may be cut, dried and baled into hay and used as a protein supplement. It can also be mixed with grass when making hay. There are numerous varieties but the two most common are greenleaf and silverleaf which are similar in many respects.

Silverleaf *(Desmodium uncinatum)*



Figure 12:Silverleaf (Desmodium uncinatum)

Silverleaf is a perennial, sprawling forage legume suited to under-sowing, intercropping and improving stock exclusion areas. It has stems and leaves covered in dense hairs which make them stick to hands and clothing. It has green and white leaves which are light green underneath.

Climate: Silverleaf grows below 2200 masl, requires more than 900 mm annual rainfall, and is tolerant of cool weather and light frosts.

Soils: Silverleaf should be grown on relatively fertile, well drained soils.

Agronomic practices: Silverleaf should be allowed to seed at least in the first season. It is palatable and thus is better managed for cut and carry systems. It requires a moderate to fine seedbed with sowing rates from 1 to 2.5 kg per ha. Because of this, it is not suited to over-sowing strategies. Seed production is more successful when crops are grown on trellises, tall cereal crops or browse trees with harvests of up to 400 kg per ha possible.

Feeding: Silverleaf needs careful grazing management for high productivity and is most productive with cut and carry systems based on under-sowing and stock exclusion area strategies. Continuous moderate cutting or grazing is preferable to occasional very heavy cutting or grazing.

Greenleaf *(Desmodium intortum)*



Figure 13:Greenleaf (Desmodium intortum)

Greenleaf is less tolerant of cool weather and light frosts. It is a perennial, sprawling forage legume suited to under-sowing, intercropping and improving stock exclusion areas as is one of the most important forage legumes available for Ethiopia. Its primary use is in forage production and its secondary uses are for nitrogen fixation and erosion control. It is leafier with reddish brown to purplish spots on the upper surface of the leaves and reddish brown stems.

Climate: Greenleaf grows below 2400 m altitude and requires more than 700 mm annual rainfall.

Soils: Greenleaf should be grown on fertile, well-drained soils and needs careful grazing management for high productivity.

Agronomic practices: Greenleaf requires a moderate to fine seedbed with sowing rates from 1 to 2 kg per ha and so is not suited to over-sowing strategies. Seed production is more successful when crops are grown on trellises, tall cereal crops or browse trees with harvests of up to 400 kg per ha possible. The simplest collection method is to strip ripe pods from the stalk, between thumb and forefinger. Pods are thoroughly dried, and seed is threshed out carefully using traditional mortar and pestle systems. It is normally possible to harvest and clean at least 1 kg per person day. Greenleaf is exceptionally successful under perennial tree crops and forestry because of its shade tolerance.

Feeding: Greenleaf should be grown on fertile, well-drained soils and needs careful grazing management for high productivity. It is most productive with regular cut and carry systems based on under-sowing and stock exclusion area strategies. Continuous moderate cutting or grazing is preferable to occasional very heavy cutting or grazing management for high productivity. It is most productive with regular cut and carry systems based on under-sowing and stock exclusion area strategies. Continuous moderate cutting or grazing is preferable to occasional very heavy cutting or grazing, and it should be allowed to seed at least in the first season. Greenleaf is palatable and thus is better managed for cut and carry systems.

The Stylos *(Stylosanthes species)*

The stylos are very useful because they are often extremely hardy, and will grow on soils of very low phosphate status and on some quite acidic soils. Palatability is variable, but always increases during the dry season when the plants "hay off", because of this, stylos are less suited to cut and carry systems and more suited to common grazing strategies such as over-sowing or improvement of stock exclusion areas. Most stylos establish readily by surface sowing even on rough seedbeds. Burying seed may prevent germination. Typical seeding rates are 1 kg per ha from over-sowing and 2 kg per ha for under-sowing. Establishment and early growth are assisted by controlling companion grasses with grazing.

Most stylos are tolerant of heavy grazing pressure, and some will set seed and spread even under severe grazing. In fact the key to good stylo management is to prevent excessive competition from companion vegetation by regular cutting or grazing. Stylos typically take two to three years to become fully established, after which their productivity increases significantly. This aspect of their growth should be taken into account during assessment of their capability in new areas. *Stylosanthes fruticosa* is native to some parts of Ethiopia. The stylos with proven capabilities in Ethiopia are discussed in the following sections.

Verano *(Stylosanthes hamate)*



Figure 14:Verano (Stylosanthes hamate)

Verano is a short-lived perennial plant growing to about 30 cm in height.

Climate: Verano grows best at low altitudes and needs more than 500 mm annual rainfall. It performs best in warm to hot environments with productivity and seed set significantly reduced by low temperatures including low night temperatures.

Soils: Verano is adapted to a wide range of soil types but performs best with good drainage.

Agronomic practices: This cultivar tolerates the fungal disease anthracnose, which affects most stylos. Verano seeds heavily (up to 1500 kg per ha) over a long period and is best harvested by sweeping the ground in the early dry season. For this reason, soils, which compact but do not crack in the dry season are more suitable for seed crops than cracking or self-mulching soils. It should be possible to harvest and clean at least 5 kg clean seed per person day from a good seed crop. Verano has a high proportion of hard seeds and quick establishment will be improved by treatment of seed. Because of its heavy seeding characteristics and ease of establishment, Verno is well suited to roadside and aerial seeding strategies.

Feeding: In the presence of vigorous grasses heavy grazing is usually necessary to maintain a high Verano population in the sward.

Seca *(Stylosanthes scabra)*



Figure 15:Seca (Stylosanthes scabra)

Seca is a long lived perennial plant growing to 150 cm in height.

Climate: Seca grows best below 2000 masl and needs more than 500 mm annual rainfall but is more cold tolerant than Verano.

Soils: Seca is adapted to poor, sandy, acid soils and requires good drainage.

Agronomic practices: This cultivar tolerates the fungal disease anthracnose, which affects most sytlos. It is the least palatable of the stylos and is very hardy, making it ideal for stock exclusion areas and over-sowing degraded common grazing areas. Its great genetic diversity makes it highly adaptable with a good capacity to spread. Seca seeds moderately (200-400 kg per ha) and is slow to flower in its first season. However, it has a strong capacity to rapidly increase in density after the first two seasons. Seed is best harvested in the early dry season by cut-and-thresh techniques followed by sweeping the threshing ground.

Feeding: On over-sown areas, Seca is most successfully spread by allowing animals to graze plants in full seed and then moving them to unsown areas where the seed passes through the animals and spreads the plant to the new area.

Cook *(Stylosanthes guianensis)*



Figure 16:Cook (Stylosanthes guianensis)

Cook is a long-lived perennial plant growing to 60 cm in height. This cultivar is susceptible to the fungal disease anthracnose, which affects most stylos.

Climate: Cook grows best at low altitudes and need more than 700 mm annual rainfall.

Soils: Cook is adapted to poor, sandy, acid soils and requires good drainage.

Agronomic practices: Cook seeds lightly (less than 300 kg per ha) and has a restricted flowering period. Because of this it is less tolerant of heavy grazing than other stylos. Seed is best harvested in the early dry season by cut-and-thresh techniques followed by sweeping the threshing ground.

Lablab *(Lablab purpureus)*



Figure 17:Lablab (Lablab purpureus)

Lablab is a vigorous annual or short-lived perennial legume with very vigorous seedlings, which is best promoted as a dual purpose species.

Climate: Lablab grows up to 2400 masl and requires more than 400 mm annual rainfall.

Soils: Lablab is suited to a wide range of soils but will not tolerate salinity or water-logging.

Agronomic practices: Being large seeded, it establishes easily on a

rough seedbed with seeding rates of 18-20 kg/ha for pure stands, 15 kg per ha for under-sowing and 2 kg per ha for forage strip sowings. Successful establishment requires the seed to be covered before germination. Lablab should be cut or grazed regularly and lightly. It should not be cut below 25-30 cm. Lablab seeds heavily (500-1000 kg per ha) with maximum yields being produced from trellised crops or those growing with browse trees.

Feeding: It has moderate palatability and cattle may require several days to become acquainted with it. Lablab leaf supplements other forages well and its seed is an excellent human food.

Wynn Cassia *(Cassia rotundifolia)*



Figure 18:Wynn Cassia (Cassia rotundifolia)

This is synonymous with *Chamaecrista rotundifolia.*

Climate: Wynn Cassia is a very hardy, low management species, which will persist and spread very rapidly in areas below 2000 m altitude. It is extraordinarily drought tolerant and can produce seed within two months of establishment, because drought stimulates early flowering.

Soils: Wynn Cassia is sensitive to frost and prefers sandy soils of low fertility. Wynn Cassia is extraordinarily drought tolerant and can produce seed within two months of establishment, because drought stimulates early flowering.

Agronomic practices: Wynn Cassia establishes well with over-sowing, even without any land preparation and with seeding rates less than 1 kg per ha. Heavy grazing of companion species assists with early establishment and normally encourages persistence by reducing competition from grasses. Wynn Cassia is suited to under-sowing strategies and will normally set seed before harvesting the companion crop, if sowing is undertaken at the time of final weeding. This species has shown remarkable ability to increase its density and spread from roadside and aerial seeding where there is little competition, making it ideal for rehabilitation of degraded areas. Wynn Cassia seed is best harvested in the same way as Verano stylo, with one person being able to sweep, thresh, and clean at least 2 kg of seed per day.

Feeding: Wynn Cassia tolerates heavy grazing pressure and because of its low palatability is well suited to over-sowing strategies and improving stock exclusion areas.

Cow Pea *(Vigna unguiculata)*



Figure 19:Cow Pea (Vigna unguiculata)

Cow Pea is an annual dual purpose legume suited to a wide range of environments. It has a wide range of genetic material.

Climate: Cow Pea grows in lowlands up to 2500 m and is drought tolerant – maturing with anything more than 300 mm annual rainfall, depending on cultivar.

Soils: Cow pea species grows on a wide range of well-drained soils and will tolerate gentle cutting or grazing during the growing season.

Agronomic practices: Cow Pea will establish on a fairly rough seedbed and is sown at 15 kg per ha for pure stands and about 12 kg per ha for under-sowing. Seed does not need to be inoculated in most parts of Ethiopia. Cow Pea is ideal for under-sowing or intercropping strategies and complements maize and sorghum particularly well. Seed should be collected for subsequent sowing before grazing. Cow Pea seed is also a valuable human food. It yields 500-800 kg per ha seed with under-sowing or intercropping strategies.

Feeding: Cowpea is utilized after harvesting the companion crop – either by cut and carry harvesting, or direct grazing. The mixed cowpea hay and stover makes excellent conserved forage for dairy animals.

Vetch *(Vicia dasycarpa)*



Figure 20:Vetch (Vicia dasycarpa)

Vetch is a vigorous climbing/ sprawling annual legume with a wide range of adaptation and high level of farmer acceptability.

Climate: Vetch grows well between 1500 and 3000 m altitude and is suited to a wide range of rainfall – typically anything above 400 mm per annum.

Soils: Vetch grows on a wide range of soils but requires good drainage for optimum productivity.

Agronomic practices: Vetch is ideally suited to under-sowing, mixed pasture and backyard forage plots and establishes readily, even on rough seedbeds. Typical sowing rates are 20 kg per ha for pure stands, 12 kg per ha for under-sowing, and 5-12 kg per ha as a pioneer component of mixed pasture. When sown at 12-20 kg per ha with oats, vetch makes excellent hay. On many sites natural regeneration from self-sown seed is minimal, necessitating annual sowing. Vetch is most suited to under-sowing and is self-regenerating where it is allowed to mature and seed before harvest of the companion crop. Seed yields between 400 and 1000 kg per ha are common but shattering occurs. Because of this, vetch grown on trellises or tall companion crops such as maize and sorghum are ideal for seed collection. One person can harvest and clean up to 15-25 kg seed per day. Languedoc Vetch (*Vicia sativa*) is better suited to low rainfall areas because it matures earlier than common vetch.

Alfalfa *(Medicago sativa)*



Figure 21:Alfalfa (Medicago sativa)

Alfalfa is a deep rooted, perennial herbaceous legume that produces a lot of stems and leaves and, upon maturity, small purple flowers. It is established from seed. It is used as a supplementary forage for dairy cattle. It is high in nutrients and highly palatable. Lucerne is used primarily as hay, but it can also be used in cut- and-carry systems and even as year round pasture. It is generally grown alone but can also be mixed with grasses or other legumes. Lucerne is best grown as a pure stand.

Climate: Lucerne will grow in a wide range of climatic conditions but does best in warm climates with a lot of sunshine. It will not do well unless adequate water is available.

Soils: Lucerne is adapted to a wide range of soil conditions but prefers deep, well drained, highly fertile loamy soils. It does not tolerate water logged or acid soils and occasional liming of the soil is required.

Agronomic practices: Prepare a very fine, levelled and firmed seedbed. Sow seeds at the start of rains, either in furrows or by broadcasting. Prepare shallow furrows 30 cm apart. If growing lucerne for the first time, the seed needs to be inoculated with rhizobia; follow instructions on the pack. Drill along the furrows or broadcast seed at a rate of 5 to 7.5 kg per hectare or, if growing under irrigation, double the amount of seed sown. Cover the seeds to a depth of approximately 0.6 cm. If possible, apply 100 kg of single super phosphate fertilizer per hectare before planting. To maintain a vigorous, productive stand, reapply phosphate fertilizer each year. Keep the plot

weed-free until full ground cover is achieved. Lucerne is susceptible to numerous pests and diseases which can cause damage at any stage of growth. Some important pests include lucerne weevil, caterpillars, cutworms/army worms, aphids and leafhoppers. Some important diseases are bacterial leaf spot, common leaf spot, downy mildew, stem blight and many others. They can be controlled by natural predators, use of chemicals, maintaining a healthy stand, crop rotation and use of resistant varieties. Harvest for the first time when the crop begins to flower. Cut at 5 cm above the ground every 5 to 7 weeks, or, if grown under irrigation, monthly. Dry matter yields can be up to 20 tons per hectare depending on management. In general, annual yields of lucerne decline with the age of stand, the decline being faster if the crop is poorly managed, affected by extreme weather or attacked by pests and diseases.

Feeding: When feeding as cut-and-carry fodder, leave the cut forage to wilt before giving to the animals to prevent bloat or mix the lucerne with grass. If lucerne is to be grazed, use a rotational grazing system, allowing 30 to 35 days for re-growth. Allow animals to graze only when the soil is dry to avoid root damage from trampling. To reduce the chance of bloat, use a commercial "stop bloat" preparation in the drinking water and do not turn hungry animals onto lush lucerne pastures. Excess lucerne is best conserved as hay or silage. For the best quality hay, cut the crop in the early bud stage. It is also possible to make silage but the crop must be wilted and an additive such as molasses applied or it can be mixed with other feeds such as sorghum. Lucerne can also be dried and processed into cubes, pellets or meal.

5.3 Fodder tree/browse legumes

Tree legumes are extremely important elements in improved forage production programs because of their productivity and multi-purpose uses (including fuelwood, construction timber, seeds, and bee products). Being perennial trees or shrubs they have a three dimensional root system and crown, which greatly increases the productivity of systems where land area is limited. Apart from large quantities of quality forage, browse legumes have deep rooting systems to increase their productivity during the dry season (Alemayehu, 2002).

Leucaena species



Figure 22:Leucaena species

Leucaena is a browse legume of great importance in Ethiopia. Its major use is in the production of highly palatable, nutritious forage. Its secondary uses include fuelwood production, nitrogen supply for companion crops, erosion control, and shelter. The various species of leucaena are perennial, deep-rooted, large shrub/small tree legumes growing up to 20 m tall. They have compound leaves with many thin leaflets, white flowers and produce a lot of seeds in pods. The leaves are a very good source of protein and can be used in both cut-and-carry and open grazing production systems. Re-growth occurs very fast after cutting. It can be used as shade in plantation crops, as living supports for climbing crops, such as passion fruit, and also for soil conservation and, being a legume, aids maintenance of soil fertility. The mature shrub can be cut for poles for fencing and wood fuel and as bee forage. Leucaena may be planted as single plants, single hedgerows or multiple hedgerows, in cut-and-carry plots, grazed plots, along boundaries or even along contours for soil erosion control.

Leucaena and its companion browse legumes are well suited to backyard forage programs, contour forage strips, agro-forestry systems such as alley cropping, over-sowing on sites with self-mulching soils, intercropping with perennial tree crops, and for soil conservation on stock exclusion areas. It is best established by direct seeding for all strategies except contour forage strips and agroforestry where seedlings are more appropriate because they reduce the risk of young plants being killed by early grazing. Bare rooted seedlings are the best strategy for nursery production of plants to be established in the field. When transplanting bare rooted seedlings, leaves should be carefully stripped from the seedling to reduce moisture stress. If bare rooted seedlings are planted the same day that they are dug from the nursery, 90 per cent survival is possible. This is why village nurseries are more practical than centralized nurseries

Climate: Leucaena grows from sea level up to 1900 m but performs best up to 1000 m above sea level. It does well in areas with rainfall above 600 mm per year.

Soils: Leucaena grows best on deep, well drained clay soils and does not do well in acidic soils.

Agronomic practices: Thorough seedbed preparation is required. Plough and harrow to make a fine seedbed. Leucaena is established from seeds which can be sown either directly into the field or in a nursery. To break seed dormancy, soak in warm water for 48 hours, or in boiling water for 4 seconds, or nip the broad (round) end. Inoculate the seed with the correct rhizobia. For direct sowing in the final growing site, make furrows 3 to 10 m apart and sow the seed at a rate of 1 to 2 kg per hectare, planting the seeds 2 to 3 cm deep. For nursery propagation, use plastic tubes filled with free-draining soil, sand and manure in the ratio of 3:2:1. Sow two seeds per tube. Water regularly as required and control weeds by hand pulling. One week after the seedlings emerge, thin to one seedling per tube. Transplant seedlings when they are eight weeks old. For a pure stand, prepare holes spaced 1 m by 1 m and at least 30 cm deep. For alley cropping or grazing, allow a spacing of 75 cm between plants and 3 to 10 metres between rows. Remove plastic tubes and place the seedling in the holes. Cover with moist soil and firm around the seedling. At the time of transplanting, apply triple super phosphate fertilizer at the rate of 120 kg per hectare, or one tablespoon per hole, and mix with soil. Leucaena seedlings are very susceptible to weed competition, therefore make sure the plot is weed-free when the seedlings are small. The psyllid insect (Heteropsylla cubenseis) is the most important pest and it can wipe out the entire crop, especially of the species L. leucocephala. To control it, plant species that are resistant to this pest such as L. diversifolia can be used. Biological control using a beetle and a parasitic wasp is showing promise. Damping-off is an important fungal disease affecting seedlings in the nursery. This is controlled by avoiding excess watering and using free-draining soil. Start harvesting at the beginning of the second wet season by cutting back to 50 cm above ground level. Cut twice during the wet season when re-growth is 50-60 cm, or once at the end and conserve as dry leaf meal. First grazing may be done when the plants are 1.5 m in height but it should be light at first. Avoid heavy grazing until the plants are fully mature, from 1 to 3 years old. Grazing or harvesting intervals can be 6 to 8 weeks or 12 weeks in less favorable conditions. When well-managed, leucaena can yield up to 2 tons dry matter per hectare per year.

Feeding: Leucaena is a high quality, very palatable supplementary forage. It is best cut and fed fresh or as dry leaf meal. Feeding excessive amounts can cause bloat and hair loss, therefore leucaena should not make up more than 30% of the total ration.

Sesbania *(Sesbania sesban)*



Figure 23:Sesbania (Sesbania sesban)

Sesbania is an adaptable browse legume which will live for up to 7 years and will grow in some environments not suited to either Leucaena or tree lucerne. It is highly palatable and its major use is a forage with secondary uses for shelter, and nitrogen fixation for companion crops. Sesbania wood is not useful for fuel or construction but can be used for fencing.

Climate: Sesbania produces best below 2000 m altitude, is very frost sensitive, and not very drought tolerant – requiring more than 600 mm annual rainfall for survival.

Soils: Sesbania grows on a wide range of soils including very poor acidic sands and waterlogged soils, but responds well to improved fertility.

Agronomic practices: Sesbania is highly suited to contour forage banks, living fences in backyards, and alley farming. It establishes rapidly from direct seeding and this is the establishment method of choice. When sown into a well-prepared seedbed at the beginning of the major wet season and kept weed free, Sesbania establishes rapidly. Cutting or browsing should not begin until the trees are more than 1 m in height. It does not self-seed easily so direct seeding is required for all establishment. Despite this, Sesbania seeds heavily, especially from trees, which have not been cut for 12 months, and can yield more than 1 kg seed per tree. Pods are harvested by hand and one person can typically harvest and clean 3-5 kg seed per day.

Feeding: It should not be cut or browsed before it has become established, after which regular cutting produces the best results. Cutting intervals of about 6 weeks result in good productivity. Infrequent cutting or browsing results in very low leaf to stem ratios. Sesbania produces less forage than Leucaena but what it does produce is of very high quality. It should be grown with other browse species to reduce the impact of insect attack, which can be severe in monocultures.

Pigeon Pea *(Cajanus cajan)*



Figure 24:Pigeon Pea (Cajanus cajan)

Pigeon Pea is a short-lived dual purpose shrub legume providing forage, grain for human consumption, and low quality fuelwood. It lives up to 4 years and is an excellent crop to improve food security and integrate forage and cropping systems.

Climate: Pigeon Pea adapts well in altitudes below 2400 masl and requires more than 350 mm annual rainfall for good production.

Soils: Pigeon Pea establishes rapidly on a wide range of well-drained soils.

Agronomic practices: Because of its use for human food, Pigeon Pea is a useful plant to introduce the concept of contour forage strips and alley cropping to lowland farmers. Once Pigeon Pea is established, and farmers are used to the idea of a productive third dimension to their cropping systems, longer lived browse species such as *Leucaena* can be introduced to fill gaps as Pigeon Pea dies out. The plant is best established by direct seeding using 10-50 kg per ha for pure stands (not recommended for forage strategies) and about 1 kg per km of contour forage strips. Seed should be sown into a well-prepared site and covered with no more than 2 cm soil. Early growth is slow but once established plants require little attention. Pigeon Pea intercrops very well with maize and sorghum. Pigeon Pea productivity depends very much on the cultivar used. Annual seed yields of 1500 to 3000 kg per ha have been recorded but pod boring insects reduce yields.

Feeding: Pigeon Pea tolerates only light cutting or browsing and is best developed in contour forage strips, house compound hedges, and intercropping strategies. It recovers well from light cutting and is highly palatable.

Tree Lucerne/Tagasaste *(Chamaecytisus palmensis)*



Figure 25:Tree Lucerne/Tagasaste (Chamaecytisus palmensis)

Tree lucerne is a temperate, multipurpose browse legume of major importance to highland areas of Ethiopia. It is one of the few highly productive browse species for altitudes above 2000 m altitude. Its primary uses are forage and fuelwood but farmers also value it for shelter, bee forage, nitrogen fixation, and soil conservation purposes. The species has a remarkable level of genetic diversity with major differences in canopy shape, branching habit, leafiness, and flowering capacity. This diversity is a major advantage in view of the wide range of AEZs over which the plant is grown.

Climate: Tree Lucerne is drought tolerant once established but requires more than 400 mm annual rainfall for maximum productivity. It is productive at an altitudes above 2000 masl.

Soils: Tree lucerne tolerates mild frosts but will not tolerate water logging at all. It is most suited to well-drained fertile soils but is productive on infertile acidic sands as long as they are well drained.

Agronomic practices: Tree lucerne is well suited to backyard forage programs, contour forage strips, agro-forestry systems such as alley cropping, over-sowing on sites with self-mulching soils, and for soil conservation on stock exclusion areas. It is best established by direct seeding for extensive strategies but intensive strategies such as backyard forage, contour forage strips and agro-forestry should use nursery-grown seedlings because early seedling growth is very slow. This also reduces the risk of young plants being killed by early grazing. Bare rooted seedlings are the best strategy for nursery production of plants to be established in the field. Seedlings should be planted the same day that they are dug from the nursery, making village nurseries more practical than centralized nurseries. Tree lucerne should be planted at about 50 cm between plants in the row for contour forage strips and alley cropping systems. Off-set double row planting is useful in some areas, in which case between rows spacing of 1 m are normally successful. Tree lucerne produces best with cut and carry systems

but is well adapted to browsing also. It should not be harvested until it has reached more than 1 m height. In Ethiopia annual yields of 1 kg DM forage per meter of contour forage hedge and up to 4500 kg DM per ha have been achieved on farmers' fields. Single trees in contour forage strips produce up to 1 kg seed per year after they are two years old. Seed is best collected by plucking ripe pods from the tree before they shatter. This is generally done on an opportunistic basis. Cut trees continue to flower and set seed and make seed collection easier because they have less height and more synchronized flowering.

6. Forage and Pasture Management

Inadequacy of high-quality forages on the farm is one of the major constraints limiting dairy production elsewhere in East Africa (Lukuyu et al., 2012) and in Ethiopia. Various recommended types of forages for different AEZs and their development strategies is detailed in the preceding sections. These forages varies on different aspects, including suitable climatic conditions and soils to be grown, how and where they are cultivated, and how they are consumed; either grazed or cut and fed; either as fresh green fodder or conserved as hay or silage. Thus, the following sections present handling and managements of forage from 'seed to feed', including major agronomic practices, forage conservation and pasture grazing management. Efficient pasture management including weed control, grazing management and soil fertility management results in high yields of good-quality pasture that can be fed to dairy cattle for high milk production (Lukuyu et al., 2012).

6.1 Forage establishment and management

Following Lukuyu et al. (2012), forage and pasture establishment methods discussed throughout this manual can be summarized into three: direct sowing, under-sowing or over-sowing. Direct sowing is a method of establishing pasture grasses without a nurse or cover crop. Care should be taken in terms of sowing periods and methods in order to get good quality and quantity forage. Forages need to be sown as early as possible in the rainy season. Sowing during the short rains is advantageous to eliminate annual weeds in areas receive bimodal rainfall. Sowing can be done either through broadcasting or drilling in rows 30 to 40 cm apart. Tiny seeds are not buried deep since their initial vigor is not sufficient to push through a heavy cap of soil, but mixing seeds with sawdust, rough sand or phosphate fertilizer helps for even distribution. Immediately after sowing compaction is recommended germination of the forage seed by improving contact with moist soil. Farmers can use tree branches or trampling by foot on small plots.

Under-sowing is a method establishing forages or pastures under a nurse or a cover crop. The nurse crop is grown together with pasture for economical land use. It can be harvested after maturity and the pasture left for 2 to 3 years. Lukuyu et al. (2012) recommended the following consideration for successful under-sowing.

- Broadcasting or drilling of pasture or forage seed mixed with fertilizer 3 days after planting wheat or barley.
- Where maize is the nurse crop, the forage seed will be broadcasted mixed with phosphate fertilizer in the maize field after the second weeding of maize (4 to 5 weeks after planting maize) or when maize is knee high.
- Grazing is not recommended during the establishment year to avoid grass still with weak roots being uprooted by the livestock.

Over-sowing is the introduction of improved pasture species (grasses or legumes) to a natural pasture. Over-sowing increases forage quality and productivity of natural pastures. It is also the easiest and most cost-efficient strategy for improving natural pasture. Although both grasses and legumes may be over-sown, legumes are more suitable, as grasses do not establish readily, especially on soils that are not loose. Over-sowing should be done in areas where soils are light and loose. Benefits become evident after about 2 years. The following advantages of over-sowing are mentioned in dairy feeding manual (Lukuyu et al., 2012).

- It is cheap due to minimal land preparation,
- Requires less seed and labor,
- Needs minimal management,
- Improved forage output,
- Able to control erosion, and
- Can improve soil fertility.

Among forage crops identified as the most important feed by smallholder farmers in East Africa, Napier grass or Elephant grass *(Pennisetum purpureum)* is the most common one (Lukuyu et al., 2012). It is a very productive, sterile grass for cut and carry systems with higher forage yield per unit area. It combines well with browse legumes and vigorous perennial forage legumes such as Greenleaf desmodium. Napier grass is planted as sets at the beginning of the wet season (Alemayehu, 2002). Experience from Kenya (Lukuyu et al., 2012) indicates that farmers are planting Napier grass through two methods; conventional method and the "tumbukiza" method. The former method involves planting one cane (with 3 to 4 nodes) or root split in holes 15 to 30 cm deep with 0.5 m by 0.5 m spacing in areas with over 1400 mm of rainfall. In areas with 950 to 1400 mm rainfall the spacing is 1 m by 0.5 m. When cane cuttings are used, bury the nodes, leaving one node above the soil surface. On the other hand, "tumbukiza" method ("tumbukiza" is a Kiswahili word meaning 'placing in a hole') is a new planting method started by farmers to increase productivity per unit of land. The method, which involves planting cuttings or root splits in well-manured holes, produces more herbage yields than the conventional method (Lukuyu et al., 2012). As

indicated in this manual, the method requires less land, forage regrowth is faster in the dry season, and thus feed is available for the animal even during the dry season. This method can be used by smallholder dairy farmers in Ethiopia to make use of large quantity of forage yield that can be obtained by adopting the method. Thus, steps followed by the Kenyan farmers to cultivate Napier grass through this method are presented following Lukuyu et al. (2012).

Step 1: Dig round or rectangular pits of 60 cm deep and 60 to 90 cm wide. Alternatively, make trenches of 60 cm deep and 60 to 90 cm wide and of various lengths depending on the farmer's preference.

Step 2: Separate topsoil from subsoil as you dig the pit or trench.

Step 3: Mix every 20-litre container (any convenient material) of topsoil with 1 to 2 20-litre container of farmyard manure and put it into the pit. For the trench, place topsoil and farmyard manure mixture every meter along the pit.

Step 4: Leave about 15 cm unfilled space at the top of each pit.

Step 5: Plant 5 to 10 cane cuttings or single root splits in the round and rectangular pits. In trenches plant 5 to 10 cane cuttings or single root splits every meter.

Step 6: Plant sweet potatoes or forage legumes between the pits to increase the quality of forage and to control weeds.

Lukuyu et al. (2012) indicated that the other fodder crop identified as the most important feed resources for the smallholder systems in East Africa is oats *(Avena sativa).* The forage is recommended as a fodder crop for the high-altitude regions of East Africa over 2100 masl and may be grown in pure stand or as a mixture with vetch. Oats can be established by drilling seeds in rows 30 to 40 cm apart. When oat is being grown as a pure stand, 70 to 80 kg seed is recommended per hectare. When grown as a mixture with vetch, 30 to 40 kg of oats and 20 kg vetch seed per hectare is recommended (Lukuyu et al., 2012).

6.1.1 Soil fertility management

Forage crops require additional nutrients from inorganic fertilizer or farmyard manure in order to attain maximum production from pasture (Lukuyu et al., 2012). Although soil nitrogen is adequate for forage productivity during the establishment year, it tends to drop during the subsequent year. Thus, manuscript from Kenya (Lukuyu et al., 2012) recommended top-dressing of grass in subsequent seasons with 5-7 bags of calcium ammonium nitrate (CAN) or ammonium sulphate nitrate (ASN) per hectare per year in three splits during the rainy season or 5-10 tons of farmyard manure. Added to this, in areas with phosphate deficiencies top-dressing with 2 bags of single superphosphate (SSP) or 1 bag of triple superphosphate (TSP) is recommended per hectare per year after the establishment year in addition to nitrogen fertilizer. Nitrogen fertilizer may be applied on 1 or 2 months before the dry season to increase yields during the dry season (Lukuyu et al., 2012).

The choice of soil fertility management by dairy farmers who cultivate forage for their dairy animals may depend on availability of capital resources, level of dairy and crop intensification and their level of reliance on forage as a dairy feed. For instance, Lukuyu et al. (2012) have recommended four fertilizer and manure management practices for Napier grass with the assumption that the choice depends on the financial resources of the farmer.

1. One to two bags of TSP or DAP fertilizer per hectare at planting followed by 5 to 7 bags of CAN fertilizer in three split applications per year, applied after harvesting and weeding in subsequent years.
2. Ten tons of farmyard manure per ha at planting. In the following years apply the same amount, preferably after every harvest.
3. TSP or DAP (0.5 to 1 bag) plus farmyard manure (5 tons) per ha at planting and apply 5 tons of farmyard manure per ha plus 2 to 3 bags of CAN in three split applications per year.
4. Sixty (60) kg of slurry in furrows at planting followed by split application of the same quantity twice a year or more frequently if possible after harvesting.

To increase yields of Napier grass during the dry season, one of the split applications of the recommended rate of nitrogen fertilizer should be done 1 or 2 months before the end of the rainy season (Lukuyu et al., 2012).

6.1.2 Weed and forage disease control

Weeds can reduce the productivity of the sown pastures, particularly during the establishment year, and should be controlled during the first year by either hand weeding or using herbicide (2-4D amine at the rate of 2.5 liters per hectare). In subsequent years fields are kept clean by slashing, hand pulling or mowing the weeds (Lukuyu et al., 2012). For example, Lukuyu et al. (2012) have recommender weeding of Napier grass after each harvest to maintain high productivity. In the same manual, hand weeding or spray with herbicide 2-4D amine 72 percent at the rate of 2.5 liters per hectare for oats, where spraying is done when oat is grown as a monocrop but not when grown with vetch).

Lukuyu et al. (2012) indicated that forage diseases have been emerging in Kenya with reports of smut and stunting diseases affecting Napier grass, one of the most important forages in the country. As they indicated in the manual, the disease is caused by a fungus, *Ustilago kameruniensis.* It affected Napier grass flowers early and the head is characterized by a loose black soot-like powder, which is the disease-causing spores. Affected Napier grass changes in appearance, the leaves become short and narrow, the internodes short, and the plant appears seriously dwarfed. In a stool, it starts with a few stems that when pulled, uproot easily and appear like a parasitic plant. The roots also appear shortened and dwarfed. The disease is spread by planting

diseased Napier grass, transporting disease-causing spores to clean Napier grass by wind or water or through farm tools, and manure from cattle fed on diseased Napier grass (with the spores). Thus, Lukuyu et al. (2012) have recommended the following control measures if the disease is observed on Napier grass elsewhere in East Africa.

- Uproot the diseased stems or stools and burn; do not feed to cows.
- Apply enough farmyard manure on the Napier grass to increase the yield, although it does not eradicate the disease.
- Avoid applying manure from cows fed on diseased Napier grass.
- Plant disease-resistant Napier grass cultivars, if available.

Napier grass stunting disease is caused by tiny bacterium-like organisms called *Phytoplasma.* The affected Napier grass appears pale yellow-green, leaf size is seriously dwarfed and internodes are shortened. There is normally a proliferation of tillers from the affected stool. The affected and stunted clumps will later die. The disease is spread by planting diseased stems and splits and by leaf hoppers and plant hoppers. The diseased grass is safe for livestock to eat and the disease cannot be spread through manure. The disease is confirmed to occur in Kenya, Uganda and Ethiopia (Lukuyu et al., 2012). No Napier grass cultivars presently known resist the disease, thus these authors suggested the following solutions to control the disease.

- Inspect Napier grass fields regularly, remove diseased stools and burn them.
- Use clean planting material from clean areas.
- Avoid harvesting the same area frequently before the grass is at the recommended height, as early cutting exposes the stools to sap-sucking plant hoppers that transmit the disease.
- In areas that are seriously affected, use alternative fodders such as giant panicum.

6.2 Seed harvesting, cleaning and storing

The production of forage and browse to overcome dry season livestock feed shortages is dependent on the availability of reliable supplies of quality seed at the time of planting (Alemayehu, 2002). Forage seed could not be an issue of challenge if a system of seed production and distribution is well established. Because of unestablished forage seed system in Ethiopia, smallholder farmers cannot access seed in their nearby area. Thus, besides feeding purpose, farmers need to develop forage for seed. This will help them meet their forage seed needs for the subsequent growing seasons. Legume seed should be dried as soon as possible after harvest to achieve a seed moisture content of 8 to 10 per cent. This ensures good seed viability. Seed can be sun dried without damage to the seed. Grass seeds should be heaped immediately harvest so that they will "sweat" to assist final maturation of the seed. Grass seed is more sensitive than legume seed and should be dried slowly to maintain its viability. Sun drying is not recommended

because of this but grass seed can be dried in the shade. All drying seed should be turned regularly – at least once per day – to ensure efficient drying. Dried seed is then threshed using animals, a mortar and pestle, or beating with sticks or flasils. Regular inspection of the seed is essential to avoid damage to the seed. Threshed seed is then cleaned to remove seeds of contaminant species, soil, chaff and poor seeds. Winnowing and sieving are the normal means of cleaning seed (Alemayehu, 2002).

Once cleaned, harvested seed must be stored in a cool, dry place. The length of life of a seed in storage depends on the environment in which the seed stored. For storage beyond 5 years seed should be kept at temperatures below 15°C with relative humidity below 4 percent. An indication of seed store suitability can be calculated by adding the average temperature (°C) and the average relative humidity (percent) from the store. This is the storage index. For example, a seed store with an average temperature of 20°C and average relative humidity of 45 percent has a storage index of 20 + 45 = 65. Short term storage (>6 months) requires a storage index of less than 80. Medium term storage (6 to 18 months) requires a storage index of less than 70 and long term storage (up to 5 years) requires a storage index of less than 50. Grass seeds should be stored in a sealed container but cotton sacks or woven bags are suitable for most legume seeds (Alemayehu, 2002).

Most tropical legumes flower and set seed over a long period and frequently shed seed quickly, thus, it is very difficult to judge when to harvest seed. Techniques used to judge ripeness include testing for ease of seed removal; seed hardness; and field color. When most seed can be easily removed by gentle rubbing or shaking, then seed is normally close to shedding and should be harvested. If seed rubbed in the palm of the hand is hard and dry then it is mature and ready to harvest. Grass seed should be bitten to ensure that it is full. The seed or pods of some species, for example Siratro, Rhodes Grass, tree lucerne and Leucaena, change color as they ripen. The optimum harvest time usually occurs before maximum flower density occurs. Hand harvesting of tropical pasture seed is more advantageous over mechanical harvesting that lead to high yields of good quality seed. Small seeds can be collected from threshing areas by sweeping. This technique is particularly suitable for stylos, Wynn Cassia, and Axillaris (Alemayehu, 2002).

6.3 Forage harvesting, conservation and preservation

The primary methods of harvesting and preserving forage crops include silage making, hay making, green chopping and pasturing. Each of these methods of forage harvest and/or preservation has benefits and limitations that make it more desirable than the others for a specific livestock operation. However, any given operation may use each of the methods at varying times, depending on the availability of resources. Farmers, based on the level their farm intensification, must review each management practice and evaluate their own production situation to determine which method to use to gain the maximum economic return (Schroeder, 2013). Forage conservation helps to bridge the quantity gap between livestock feed requirements and the production of forage.

If good quality forage is conserved, the nutritional gap between high quality (wet season) and low quality (dry season) forage may also be bridged (Alemayehu, 2002).

Harvesting time and condition of forages vary based on its maturity, moisture content, types of forage, and conservation methods to be used. For example, Napier grass must be cut regularly to maintain its forage quality (Alemayehu, 2002). It need to be harvested when 1 m high or every 6 or 8 weeks to obtain optimal quality and quantity (Lukuyu et al., 2012). One has to maintain a stubble height of 5 to 10 cm from the ground level at each harvest to avoid weakening the root system, which leads to low production in subsequent harvests. These authors also suggested that cutting of oats at milk stage and wilt it before feeding to prevent bloat. Oats can also be harvested when the grain is at milk or dough stage to be conserved as hay or silage. Because rain-based pasture and fodder production is seasonal, there are times of plenty and times of scarcity. It is thus imperative to conserve the excess for use in times of dry season scarcity. The aim of conservation is to harvest the maximum amount of dry matter from a given area and at an optimum stage for utilization by animals. It also allows for regrowth of the forage (Lukuyu et al., 2012). The two main ways of conserving fodder are by making hay or making silage, thus these methods are detailed below.

6.3.1 Hay making

Hay is fodder conserved by drying to reduce the water content so that it can be stored without rotting or becoming moldy (reducing the moisture content slows down the rate of growth of spoilage microorganisms). The moisture content should be reduced to about 15 percent. Not all grasses and fodder are suitable for hay making (Lukuyu et al., 2012). Hay produced from natural grasses, improved forage legumes and browse legumes is the most appropriate conserved forage for small-scale fattening or dairy production in Ethiopia.



Figure 26: hay

Forage conservation is especially important for dairy production because it ensures a supply of balanced nutrients for dairy animals throughout their lactation (Alemayehu, 2002). A mixture of grass and legume forage should be harvested for quality hay. The legumes increase the digestibility and intake of the conserved forage. For high quality hay, forage should be cut just before grasses flower in order produce good yields of hay with high digestibility and protein content. Although cutting hay after plants have flowered produces more hay, it is of lower quality than earlier cut hay. Quality hay is typically cut 4 to 6 weeks after the pasture or forage crop has been closed to grazing (Alemayehu, 2002). Harvesting and curing procedures are discussed below as presented in Lukuyu et al. (2012).

- Harvest the fodder for hay making when the crop has attained 50 percent flowering to get maximum protein digestibility which declines after wards.
- The fodder should be harvested after 2 to 3 days of dry weather so that drying will be possible.
- Where possible, drying should be done under shade so that the dried fodder retains its green color, which is an indicator of quality.
- Turn the fodder using a farm fork to ensure even drying.
- Check the dryness by trying to break the stem. If it bends too much without breaking, there is still too much water.
- Legumes and grasses can be mixed to make better-quality hay, e.g. Rhodes grass plus lucerne.

Although it is not practical and recommended under smallholder system, hay baling has been practiced for intensive or commercial dairy production. Baling the hay allows more material to be stored in a given space. A good estimate of the amount stored makes feed budgeting easier. Baling can be manual or mechanized, manual baling being more economical for small-scale dairy farmers. Manual hay baling is done using a baling box with dimensions 85 cm long by 55 cm wide by 45 cm deep, open on both ends. If the hay is well pressed, the box will produce an average bale of 20 kg. Hay can also be stored without baling by heaping it into a dome-shaped stack and covering it with a polythene sheet or a tarpaulin.

Hay should always be stored in a sheltered enclosure away from direct sunlight and rainfall, e.g. in hay barns. Rats and other rodents should be controlled as they can damage the hay. Good storage leads to provide good quality forage for our dairy animals. The quality of the hay should be evident on physical examination. Good-quality hay should:

- be leafy and greenish in color,
- have no foreign material mixed with it, and
- have no smell

6.3.2 Silage making





Silage is high-moisture fodder preserved through fermentation in the absence of air. These are fodders that would deteriorate in quality if allowed to dry. Silage can be made from grasses, fodder sorghum, green oats, green maize or Napier grass. An ideal crop for silage making should:

- contain an adequate level of fermentable sugars in the form of water-soluble carbohydrates;
- have a DM content in the fresh crop of above 20 percent; and
- possess a physical structure that will allow it to compact readily in the silo.

Forage harvesting stage and condition largely determines the quality of forage. Forage crops not fulfilling the above mentioned requirements and other harvesting procedures may require pre-treatment such as

- field wilting, to reduce moisture,
- fine chopping to a length of 2 to 2.5 cm to allow compaction,
- use of additives, to increase soluble carbohydrates

Concerning harvesting of forage, for example, Napier grass should be harvested when it is about 1 m high and its protein content is about 10 percent. Maize and sorghum should be harvested at dough stage, that is, when the grain is milky. At this stage, maize and sorghum grains have enough water-soluble sugars so it is not necessary to add molasses when ensiling. However, when ensiling Napier grass, it is necessary to add molasses to increase the sugar content. To improve silage quality, poultry waste and legumes like lucerne and desmodium may be mixed with the material being ensiled to increase the level of crude protein.

As presented in Lukuyu et al. (2012) good quality silage have several indicators. Well-prepared silage is bright or light yellow-green, has a smell similar to vinegar and has a firm texture. Bad silage tends to smell similar to rancid butter or ammonia. Natural microorganisms ferment the sugars in the plant material and in the added molasses

into weak acids, which then act as a preservative. The result is a sweet-smelling, moist feed that cattle like to eat once they get used to it.

6.4 Pasture grazing management

Lukuyu et al. (2012) indicated that the following should be observed in terms of forage grazing management:

- In the establishment year grasses reach the early flowering stage 3–4 months after planting. At this stage the plant is not firmly anchored in the soil and therefore it is usually advisable to make hay rather than graze the pastures to avoid the risk of the cattle pulling out the young shoots.
- If the pasture must be grazed during the establishment year, grazing should be light enough (use calves) to allow the plants to establish firmly in the soil.
- For maximum benefit, use the pasture not later than the start of the flowering stage. Graze or cut at intervals of 4 to 6 weeks, leaving stubble at 5 cm height.
- Graze animals when the grass is at the early flowering stage by moving animals from paddock to paddock.
- One animal will need 1–2 acres of improved pasture per year in areas receiving over 900 mm rainfall.
- Conserve excess pasture in the form of hay for dry-season feeding.



Figure 27:Cows in the field

7. Forage and Pasture Utilization

Forage crops are annual or perennial or permanent crops, cultivated on arable land and grazed or fed to stock either green as cut-and-carry or in a conserved form like hay or silage. They are known to be highly productive per hectare (dry matter yield) compared with permanent pastures. These crops are also grown

They are characterized by as supplementary feed during the dry months of the year (Lukuyu et al., 2012). Improved forage can be used to maintain more animals, to provide increased quantities of better quality forage to same number of animals, or to strategically feed selected groups of animals. If increased forage production is used to maintain more animals the increment in production is relatively small and will depend on the additional number of animals (Alemayehu, 2002). For smallholder farmers who depend on dairy for their income and livelihood there are significant opportunities to increase production by increasing the quantity and quality of forage available to lactating animals. Nutrition is a more significant constraint to sustaining milk production in Ethiopia than is the genetic potential of dairy animals.

Forages can be fed to animals either fresh (grazed directly or cut-and-carried), dried (for example as hay) or preserved as silage. Some forages, such as Napier grass, which have long stems, should be chopped into approximately 3 cm lengths before feeding to cattle. This makes it easier to mix with other feeds, such as concentrates, and also prevents wastage by making it more difficult for cattle to select only their favorite parts of the plant (Lukuyu et al., 2007). When designing a ration for dairy cattle, especially more productive cows, it is necessary to provide enough forage to supply the fiber and bulk required but at the same time to supply the energy and protein required to support the desired level of milk production. Dry cows can survive pretty well on forage alone and, provided they are given enough good quality forage, milking cows can produce 5 to 10 liters of milk per day from forage alone. But if the forage is of poor quality – such as rice straw or dry maize stover – then production levels from just forage will be much lower. And higher yielding cows simply cannot eat enough bulk forage to obtain all the nutrients they need – their guts fill up before they are able to absorb sufficient nutrients - and they have to be given other, more nutrient-rich feeds which are called supplements (Lukuyu et al., 2007).

7.1 Quality of forage

Good quality forages are those that contain relatively high levels of energy and protein. Young, dark green Napier grass is an example of a good quality bulk forage. Examples of low quality bulk forages are dry maize stalks and wheat straw which are low in both energy and protein – they are cheap but are high in fiber and low in digestibility: they make the animal feel full but provide few nutrients. Farmers can make some judgments about the quality of a forage from its appearance, smell and texture. For fresh forages, those with more leaf than stem, that are dark green and that feel soft are likely to be better quality than those that are mostly stem, have yellowish leaves

and stems or that feel hard or woody. Avoid feeding musty smelling or moldy forages. The poorer the quality of the bulk forage, the more supplements will need to be fed to enable high yielding cows to produce as much milk as they are capable of (Lukuyu et al., 2007).

7.2 Forage supplementation

Supplementary forages can be used in two ways: either to compensate for poor quality bulk forages or to substitute for concentrates: for example three kilograms of fresh calliandra can replace one kilogram of commercial dairy meal. Supplementary forages can be fed fresh, dried as hay, for leaves of shrub and tree legumes as dry leaf meal, or preserved as silage. But they should be fed with caution as feeding large amounts of some supplementary forages can cause bloat and other problems. Usually supplementary forages should not make up more than 25 to 30 per cent of the ration on an as-fed basis. (Lukuyu et al., 2007).

7.3 Grazing on improved pasture

Stocking rate is the number of animals (animal unit) for which a grassland unit (hectare) can provide adequate dry-matter forage for a specified length of time. Stocking rate influences animal performance, pasture recovery, long-term pasture production and long-term pasture species composition. Stocking rates should represent a balance between grazing pressure (pasture demand) and carrying capacity (pasture supply). The ultimate goal should be to optimize both animal and pasture production over the long term, as opposed to maximizing only one or the other. In general, improved pastures can support higher stocking rates than native or unimproved pastures (Lukuyu et al., 2012).

7.4 Problems associated with forage consumption

Bloat is one of the problems associated with feeding legume forages to animals. Bloat is a potentially lethal expansion of the stomach in ruminant animals, which can occur after they have eaten large quantities of legume forage. During digestion, legumes can create a stable foam in the rumen that blocks the normal escape of gas. Distention of the stomach creates breathing difficulties that can be lethal. Fear of bloat causes many producers to avoid the use of forage legumes. However, most of the specific situations that cause bloat can be avoided. For example, Lucerne is a supplementary forage that cattle like to eat and it is a good source of protein. But if cattle eat too much there is risk of bloat. The risk can be reduced by wilting fresh lucerne for a few hours before feeding in cut-and-carry systems. In grazing systems, use of a commercial 'stop bloat' preparation in the drinking water can be helpful. Also, hungry cattle should not be turned out onto lush lucerne pastures. Leucaena is a high quality, very palatable supplementary forage. It is best cut and fed fresh or as dry leaf meal. Feeding excessive amounts can cause bloat and hair loss, therefore leucaena should not make up more than 30 percent of the total ration.

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Glossary to Terms

This section presents definition of important terms related to forage production, management and utilization. Definition for some terminologies are supported by detail explanations in order for users of this manual to better understand that specific term.

Aftermath: Residual or regrowth of forage produced after haying or grazing. Aftermath growth is sometimes grazed in the fall, after plants have become dormant.

Agroforestry: Agroforestry is where trees and shrubs producing browse or forage pods are integrated with cropping systems.

Annual crops: Plants that germinate, establish, flower, set seed and die in one growing season.

Biennial crop: A plant that completes its life cycle in two years. A true biennial is a plant that germinates, establishes and produces only vegetation in its first year and then produces vegetation and seed and dies in its second year.

Bloat: Bloat is a potentially lethal expansion of the stomach in ruminant animals, which can occur after they have eaten large quantities of legume forage.

Bulk forage: The cheapest ingredients, and the ones that form the largest part of the dairy cow's ration, are the bulk forages. These are plant feeds with high fiber contents such as fresh grass, maize thinning, weeds, hay, straw and stovers.

Companion Crop: A companion crop is a crop (usually a cereal crop) grown with a perennial forage during the establishment year, but may also include annual or short-lived forage species in mixtures. Companion crops are competitive with forage seedlings.

Crop by-product: Crop by-products are fibrous plant materials left behind after harvesting human food crops and are available in many areas where crop agriculture is practiced. They are generally high in fiber, low in digestibility and low in crude protein. On small farms in developing countries they form the principal feed of ruminant livestock during dry seasons. Crop residues include straw and chaff from cereal grains (rice, wheat, barley, oats), stover (maize, sorghum), maize cobs, bean haulms, and sugar cane tops and bagasse.

Digestibility: Digestibility refers to the proportion of the forage digested by the animal. The digestibility is generally expressed as a percentage. Digestibility may be expressed as digestible dry matter (DDM), which is the forage dry weight minus the faces dry weight. In vitro digestibility is determined in a laboratory using rumen microflora in a test tube.

Dry matter: Dry matter is the percentage of the forage that is not water. Dry-matter content is important because all animal requirements are made on a dry-matter basis. Comparing different forages without using the percent of dry matter as a baseline would be impossible. The dry matter of fermented feeds (hay and silage) is underestimated because of the volatile fermentation products that are used by the animal. Dry matter is also very important because the moisture content will give clues as to how a forage

will preserve when stored by baling or ensiling.

Fodder: Forages that are specially grown for feeding to livestock, such as Napier grass or fodder legumes, are usually referred to as fodders.

Fodder banks: Fodder banks refer to fodder left standing in the field to be used during times of feed scarcity. They can be used all year but are meant to cushion the farmer against forage scarcity expected during dry seasons.

Forage: A forage crop is one grown for pasture, hay or silage. The vegetative plant material, including stems, leaves and heads, used for livestock feed. Grasses are often developed for suitability for forage (i.e. forage types) versus turf or reclamation type, etc.

Hay: Dried grass or herbaceous legumes prepared as a way of conserving grass for feeding to cattle.

Intercropping: Intercropping is where crops for human consumption are under-sown or intercropped with forage legumes.

Legume: Legumes are plant in the *Fabaceae* family. This family is made up of broad leaf forbs that have a symbiotic relationship with rhizobia bacteria, which fix atmospheric nitrogen.

Ley Farming: Ley farming is where crops for human consumption are relayed or rotated with forage legumes.

Nitrogen Fixation: The symbiotic relationship between rhizobia bacteria and a legume where the bacteria form a nodule on a root or root hair and convert atmospheric nitrogen available in the air between the soil particles into a nitrogen from that is usable by the plant.

Palatability: The acceptability of a plant to the livestock grazing or consuming it. Given a choice, livestock will find one forage species or parts of the same forage more palatable than another.

Seed Bank: Un-germinated seeds present in the soil, generally from forage crops that have produced seed that shattered onto the ground.

Silage: A way of preserving grass and other materials for feeding to cattle in which the grass is fermented.

Stocking Rate: The number of livestock per area of pasture, usually expressed as animals or animal unit per hectare, but may be expressed as hectares per animal unit.

Standing hay: Grass or other crops left standing in the ground to dry naturally and cut or grazed as needed.

Roadside: Roadside grazing involves herding cattle on the roadside where they graze on natural unimproved pastures. It is popular in areas with land shortage.

Tethering: Tethering restricts the cow to a grazing area by tying it with a rope to a peg.

Annex

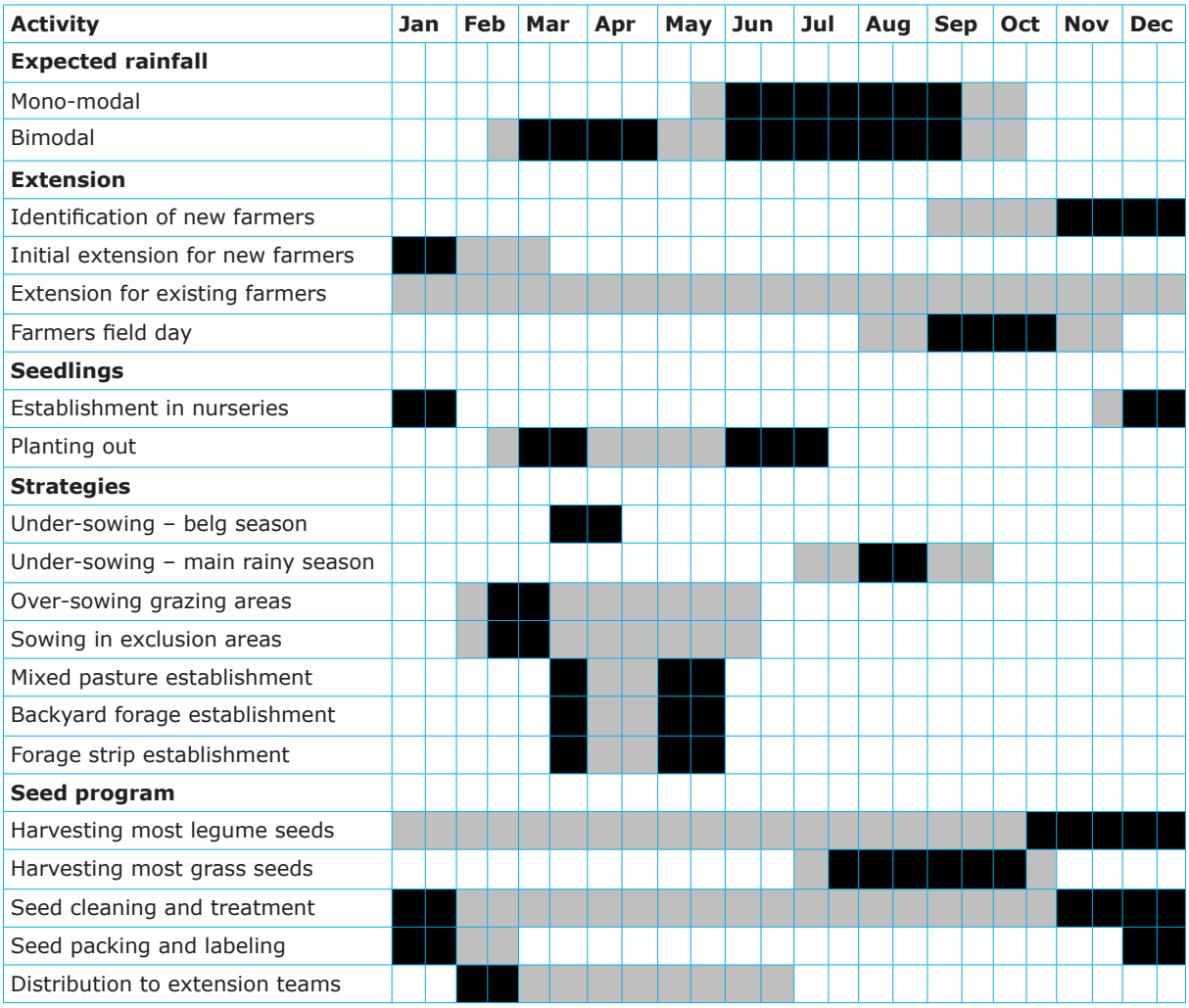
Annex 1: Improved forage crops that can be grown in Ethiopia and suitable climatic and soil characteristics for their cultivation.

Type of forage	Rain fall (mm)	Altitude (masl)	Soil	Planting material	Notes
Forage Grasses					
Napier or Elephant grass (*Pennisetum purpureum*)	Over 1500	Up to 2000	Grow in almost any soil but does best in deep, fertile, well drained soils	Cuttings	
Rhodes grass (*Chloris gayana)*	Over 250	600 to 2000	It grows in a wide range of soil conditions but performs best in loamy, fertile soils. It does not do well in alkaline or very acidic soils	Seed	
Buffel Grass *(Cenchrus Ciliaris)*	Below 2000	Above 250		Seed	Medium frost tolerance, high drought tolerance, low waterlogging tolerance
Guinea Grass/Panic *(Panicum maximum)*	Below 2000	Above 600	Grows on most soils but requires high fertility for good productivity	Seed	Medium tolerance to frost, drought and water logging
Setaria *(Setaria sphacelata)*	Below 2000	Above 800	A wide range of soils and tolerates water logging	Seed	Medium tolerance to frost and drought, and high tolerance to water logging
Phalaris *(Phalaris aquatica)*	Below 2400	Above 400	Fertile soils for strong growth but survive on poor soils	Seed	High tolerance to frost, drought and water logging
Forage Legumes					
Lablab *(Lablab purpureus* or *Dolichos lablab)*	750 to 2500 to establish and 200 to 2500 once established	Up to 1000	Tolerates acidic/low fertile soil; no water logging	Seed	
Siratro *(Macroptilium atropurpureum)*	Below 2000	Above 500	Well-drained soils: low fertility sandy soils, but performs poorly on wet sites		Low tolerant to frost, drought and water logging
Axillaris *(Macrotyloma axillare)*	Below 2400	Above 500	Low fertility sandy soils, and is moderately tolerant of water logging		Low tolerant to frost, drought and water logging
Verano *(Stylosanthes hamate)*	Below 2400	Above 500	A wide range of soil types but performs best with good drainage		Moderately tolerant to frost, drought and water logging
Seca *(Stylosanthes scabra)*	Below 2400	Above 500	Poor, sandy, acidic soils and requires good drainage		Moderately tolerant to frost, drought and water logging
Cook *(Stylosanthes guianensis)*	Below 2400	Above 600	Poor, sandy, acidic soils and requires good drainage		Moderately tolerant to frost, and low tolerant to drought and water logging

Type of forage	Rain fall (mm)	Altitude (masl)	Soil	Planting material	Notes
Wynn Cassia *(Cassia rotundifolia)*	Below 2400	Above 400	Prefers sandy soils of low fertility		Highly tolerant to frost, and moderately tolerant to drought and water logging
Cow pea *(Vigna ungulculata)*	Below 2400	Above 350	Well-drained soils		Moderately tolerant to drought and water logging
Common vetch *(Vicia dasycarpa)*	Above 2000 (1500 to 3000)	Above 400	Good drainage for optimum productivity		Highly tolerant to frost, and moderately tolerant to drought and water logging
Native clover *(Trifolium species)*	Above 2000	Above 500			Moderately tolerant to frost, and highly tolerant to drought and water logging
White clover *(Trifolium repens)*	Above 2000	Above 500			Low tolerant to frost, and highly tolerant to drought and water logging
Maku Lotus *(Lotus pedunculatus)*	Above 2400	Above 600	Grow on well drained to those that are water logged		Low tolerant to frost, and highly tolerant to drought and water logging
Greenleaf/silverleaf desmodium *(Desmodium intortum/ Desmodium uncinatum)*	850 to 1500	800 to 2500	Wide range but not alkaline; not tolerant to drought	Seed and cuttings	
Lucerne or Alfalfa *(Medicago sativa)*	500 to 1000	Up to 2400	Deep, fertile loams, not acidic; no water logging	Seed	
Tree Legumes					
Trichandra *(Leucaena trichandra)*	1100 to 2000	200 to 2500	Neutral-alkaline, well drained	Seed	
Diversifolia *(Leucaena diversifolia)*	1500 to 3500	500 to 2500	Neutral-alkaline, well drained	Seed	
Pallida *(Leucaena pallida)*	500 to 1500	800 to 2500	Neutral-alkaline, well drained	Seed	
Leucaena *(Leucaena leucocephala)*	Above 600	Up to 1000	Heavy, fertile, neutral to alkaline; not acidic; well drained	Seed	
Sesbania *(Sesbania sesban)*	500 to 2000	100 to 2300	Tolerates acid, alkaline and saline soils; well adapted to periodic flooding and water logging	Seed	
Griricidia *(Griricidia sepium)*	600 to 3500	Up to 1200	Tolerates moderately acid soils but needs moderate fertility; no water logging	Cuttings	
Tagasaste or Tree Lucerne *(Chamaecystisus palmensis)*	350 to 1600	Up to 1000	Slightly acidic to neutral; free draining: do not tolerate water logging	Seed	
Pigeon pea *(Cajanus cajan)*	Below 2400	Above 250			Highly tolerant to drought, and low tolerant to frost and water logging

Sources: Alemayehu (2002); Lukuyu et al. (2007);

Annex 2: Important forage activity calendar for Ethiopia, as cited in Alemayehu (2002).



Forage Production and Management Training Guidelines for Extension Workers



II. Forage Production and Management Training Guideline

A. Lesson matrix – Forage production and feed improvement

Lesson Matrix	
Topic / Serial #	
Practical Lesson	Lesson 1
Date	
Venue	
Duration	1 day/ Day 1 of the Course
Type of students	EDGET Extension Workers
Suggested number of students	16
Starting situation	Students have very little or no experience with Forage Production and Feed Improvement
Learning Objectives:	The student is able to:
Skills	-Develop a forage production strategy in line with the farm's objectives and land resources -Calculate forage requirements given the dairy herd size -Plan forage supply for scarcity periods -Prepare land for sowing or planting/ Sow/ plant/ weed/ apply herbicides and pesticides/ cut or harvest forages at the right growth stage -Make hay and silage -Treat crop residues with urea to improve nutritional value -Make UMMB
Knowledge	-Explain which agro – ecological zones are present in Ethiopia and which forage crops can be grown there -Explain various forage production strategies -Explain principles of plant growth -Explain the difference between grasses and legumes -Explain the difference between annual and perennial species -Explain the use of inoculants in legumes -Explain how to grow most common forage species -Explain how to calculate forage requirements on small holder farms including planning for scarcity periods -Explain how to make hay and silage -Explain how to treat crop residues with urea -Explain how to make UMMB
Attitude	Convince farmers that forage production is a crucial part in dairy farm management influencing not only milk production but also the health and fertility levels on the farm and especially the income a farmer can earn

Time in minutes	Brief Content	Role trainer /didactical methods	Teaching aids	Role/activities Participants
15	-Opening of the Course, getting acquainted with each other, explanation Module Book and Course Objectives	-Explaining/ guiding/ making trainees feel at ease	-Module Book	-Listening, introduction of themselves, asking questions, answering questions
30	-Sharing experiences with forage production and feed improvement management -Distribution Forage Production and Feed Improvement Manuals	-Asking for experiences to get an idea about student level -Introduction to Forage Production management	-Forage Production Management Manual	-Sharing experiences -Check contents of Manual
75	-Agro-ecological zones in Ethiopia and related forage crops -Forage production strategies on small holder farms -Calculation of forage requirements during the year and scarcity periods	-Sharing experiences/ lecturing/ PPT -Sharing experiences/ lecturing/ PPT -Calculation assignment forage requirements	-Manual -PPT -Small holder farm -Assignment forage requirements	-Sharing experiences/ listening/ asking questions/ assessing
30	Break			
120	-Factors influencing growth -Use of fertilizers and manure/ compost -Grasses and legumes -Tropical versus temperate -Use of inoculants in legumes -Factsheets of most common forages used in Ethiopia	-Sharing experiences/ lecturing/ PPT/ assignment economics of improving grassland/ growing of forage instead of buying -Assignment questions manual forage production	-Manual -Manual use of fertilizer/ manure/ compost -PPT/ video Desho Grass -Worksheet economics forage prod. -Question list	-Sharing experiences/ listening/ watching/ asking + answering questions/ making assignment economics/ answering questions assignment
60	Lunch			
180	Visit of small holder farm and implement following practical lessons: -Assessment forage production strategy -Assess quality of forages grown on the farm -Prepare land for sowing/ planting, apply manure/ compost, sow/ plant, apply chemical fertilizer/ weed, apply herbicides/ pesticides, cut and weigh, determine dry matter, feed and determine whether quantity is enough given herd size	-Travel to farm -Explaining assignments and worksheets: *skill list *Yield determination of yield of various forages present on the farm *Assess quality of forage maize crop using assessment form	-Small holder farm -Hoes, rakes, measuring tools, wheel barrows, buckets, back sprayer, weighing scale, micro wave oven for dm-content determination -Maize assessment form	-Visit small holder farm/ assess strategy/ exercise practical skills in forage production/ cut and weigh and feed
30	-Summary/ reflection/ homework	-Summary theory/ testing knowledge -Common made mistakes -Study manual Forage Production and Use of fertilizers/ manure and compost	-PPT -Manuals -Assignments -Homework study Manuals	Answering and asking questions

Lesson Matrix	
Topic / Serial #	
Practical Lesson	Day 2 Forage Production and Feed Improvement
Date	
Venue	
Duration	1 day/ day 2 of the Course
Type of students	EDGET Extension Workers
Suggested number of students	16
Starting situation	Students have very little or no experience with Forage Production and Feed Improvement
Outcomes	The student is able to:
Skills	-Develop a forage production strategy in line with the farm's objectives and land resources -Calculate forage requirements given the dairy herd size -Plan forage supply for scarcity periods -Prepare land for sowing or planting/ Sow/ plant/ weed/ apply herbicides and pesticides/ cut or harvest forages at the right growth stage -Make hay and silage -Treat crop residues with urea to improve nutritional value -Make UMMB
Knowledge	-Explain which agro – ecological zones are present in Ethiopia and which forage crops can be grown there -Explain various forage production strategies -Explain principles of plant growth -Explain the difference between grasses and legumes -Explain the difference between annual and perennial species -Explain the use of inoculants in legumes -Explain how to grow most common forage species -Explain how to calculate forage requirements on small holder farms including planning for scarcity periods -Explain how to make hay and silage -Explain how to treat crop residues with urea -Explain how to make UMMB
Attitude	Convince farmers that forage production is a crucial part in dairy farm management influencing not only milk production but also the health and fertility levels on the farm and especially the income a farmer can earn

Time in minutes	Brief Content	Role trainer / didactical methods	Teaching aids	Role/activities Participants
120	-Introduction on silage and hay making, treatment of crop residues with urea, making of UMMB	-Explanation/ presentation of hay and silage making techniques, urea treatment of crop residues, making of UMMB	-PPT, manuals, pictures, videos -Samples of hay/ silage/ treated straw/ UMMB/ various ingredients	-Listening, sharing experiences, asking questions, observing
30	Break			
120	Visit of small holder dairy farm; Selection of grass in right growth stage/ assess quality/ cutting grass/ weigh and determine yield per ha/ drying grass/ use of simple hay baler/ making bales of hay of grass already dried earlier/ storage of bales	Demonstration of skills, instruction, assisting/ coaching of students while making hay	Farm/ grass or other forage crops for hay making/ hay samples/ weighing scale/ bags for weighing/ tools for drying/ hay baler	-Observing demonstrations/ ask questions/ practice
60	Lunch			
180	Visit of small holder dairy farm -Making silage using plastic bag: select forage crop in right growth stage, weighing, chopping, making molasses mixture with water, filling silage bag, compaction, tying bag airtight, etc. -Assess quality of silage pit (if present)	Demonstration of skills, instruction, assisting/ coaching of students while making silage	-Excursion farm -Silage storage quality assessment form	-Observing demonstrations/ ask questions/ practice
30	-Summary/ reflection/ homework	-Summary theory/ testing knowledge -Common made mistakes -Study Feed Improvement Manual	-PPT -Manual -Assignments -Homework study Manuals	Answering and asking questions

Lesson Matrix	
Topic / Serial #	
Practical Lesson	Day 3 Forage Production and Feed Improvement
Date	
Venue	
Duration	1 day/ Day 3 of the Course
Type of students	EDGET Extension Workers
Suggested number of students	16
Starting situation	Students have very little or no experience with Forage Production and Feed Improvement
Outcomes	The student is able to:
Skills	-Develop a forage production strategy in line with the farm's objectives and land resources -Calculate forage requirements given the dairy herd size -Plan forage supply for scarcity periods -Prepare land for sowing or planting/ Sow/ plant/ weed/ apply herbicides and pesticides/ cut or harvest forages at the right growth stage -Make hay and silage -Treat crop residues with urea to improve nutritional value -Make UMMB
Knowledge	-Explain which agro – ecological zones are present in Ethiopia and which forage crops can be grown there -Explain various forage production strategies -Explain principles of plant growth -Explain the difference between grasses and legumes -Explain the difference between annual and perennial species -Explain the use of inoculants in legumes -Explain how to grow most common forage species -Explain how to calculate forage requirements on small holder farms including planning for scarcity periods -Explain how to make hay and silage -Explain how to treat crop residues with urea -Explain how to make UMMB
Attitude	Convince farmers that forage production is a crucial part in dairy farm management influencing not only milk production but also the health and fertility levels on the farm and especially the income a farmer can earn

Time in minutes	Brief Content	Role trainer /didactical methods	Teaching aids	Role/activities Participants
120	-Discussion homework -Making of UMMB, make recipe/ weigh out quantities/ mixing of ingredients/ prepare moulds/ make blocks/ put them in place for drying	-Discussing/ asking -Explaining and discussion	-Manual -PPT/ video -Assignment -UMMB ingredients -moulds + press -weighing scale -ready UMMB as example	-Asking/ discussing/ listening/ making UMMB
60	Break			
120	-Explanation assignment/ assessment and assessment forms -Making working groups	-Explaining and discussion + explaining assignment	-Assignment and assessment forms	-Asking/ discussing/ listening/ prepare for assignment
60	Lunch			
180	-Visit of assigned small holder dairy farm and implement assignment/ assessment	Guiding/ coaching	-Assignment/ assessment	-Students collecting and processing information
30	-Summary/ reflection/ advises for assignment	-Summary theory/ testing knowledge -Common made mistakes -Finish assignment/ assessment	-PPT -Manual -Assignment -Homework study Manual	Answering and asking questions

Lesson Matrix	
Topic / Serial #	
Practical Lesson	Day 4 Forage Production and Feed Improvement
Date	
Venue	
Duration	1 day/ Day 4 of the Course
Type of students	EDGET Extension Workers
Suggested number of students	16
Starting situation	Students have very little or no experience with Forage Production and Feed Improvement
Outcomes	The student is able to:
Skills	-Develop a forage production strategy in line with the farm's objectives and land resources -Calculate forage requirements given the dairy herd size -Plan forage supply for scarcity periods -Prepare land for sowing or planting/ Sow/ plant/ weed/ apply herbicides and pesticides/ cut or harvest forages at the right growth stage -Make hay and silage -Treat crop residues with urea to improve nutritional value -Make UMMB
Knowledge	-Explain which agro – ecological zones are present in Ethiopia and which forage crops can be grown there -Explain various forage production strategies -Explain principles of plant growth -Explain the difference between grasses and legumes -Explain the difference between annual and perennial species -Explain the use of inoculants in legumes -Explain how to grow most common forage species -Explain how to calculate forage requirements on small holder farms including planning for scarcity periods -Explain how to make hay and silage -Explain how to treat crop residues with urea -Explain how to make UMMB
Attitude	Convince farmers that forage production is a crucial part in dairy farm management influencing not only milk production but also the health and fertility levels on the farm and especially the income a farmer can earn

Time in minutes	Brief Content	Role trainer /didactical methods	Teaching aids	Role/activities Participants
120	Students prepare for presentation	-Guidance and coaching	-target farms	-Preparing presentation
60	Break and arrival of farmers			
120	Presentation assignment results	-Assessing performance	-Projector/ white board/ flip overs	-Group presentations
60	Lunch (students and farmers)			
60	-Assessment result per group	-Reflection on assignment results and assessment score	-Discussion per group	-Reflection and discussing assessment result
60	-Brainstorm on farmer training including gender issues	-Lead discussion and gives ideas how to train farmers in the topic	-Experiences during the Course -Checklist gender in training	-Active participation in the brain storm session
30	-Evaluation of course	-Explaining evaluation form	-Evaluation form	-Filling evaluation form
30	Closing	-Final Remarks -Awarding certificates	-Certificates	-Listening and receiving their certificate

B. Judging the condition of a maize plot for silage making

Criteria	Variety :	Variety :	Variety :
Height :			
Plant firmness :			
Presence of weeds :			
Quality of cob :			
Number of cobs/ plant :			
Distance between the rows :			
Number of plants/ ha :			
Ripeness of the cob/ dm % of the crop/ advise for silage making (see table below) :			
Expected yield in kg product :			
Expected yield in kg dm :			
Judgement :			

Ripeness stage	DM % whole plant	Relative DM yield	gTDN/ ME MJ/ kg DM	Conservation losses	
				DM	gTDN/ ME MJ
Milk ripe : yellow grain/ milky/ a lot of tension in the grain	18 - 21	85	640/ 10,08	10 - 15	15 - 20
Soft dough ripe : darker yellow/ like dough/ some moisture when grain is squeezed	21 - 25	90	670/ 10,64	8 - 12	11 - 15
Dough ripe : dark yellow/ firm top of grain	25 - 29	95	690/ 11,02	6 - 10	8 - 12
Hard dough ripe : firm grain/ difficult to put your finger nail in the grain	29 - 35	100	710/ 11,39	4 - 8	6 - 10

C. Assignment calculation forage requirements for a smallholder dairy farm

1. Calculate the forage dry matter requirements of a smallholder farm taking into consideration the following information:

-Crossbred cows (Boran x HF), F1, body weight 500 kg

-2 lactating cows, 1 dry

-1 calf 3 months old, 1 young stock 1 year old and 1 pregnant heifer 2 years old

2. Calculate how many hectares of forage the smallholder farmer needs to grow to achieve forage requirements.

3. Assuming a dry season period of 3 months how much forage has to be conserved to feed the above herd ? In what form should the forage be conserved?

D. Assessment form written report (Group score)

Group members:.....

Subject / Title:.....

Group Score..... (out of 60, each item can score from 1 to 10 points, 1 = very poor/ 10 = excellent)

	Excellent	Good	Average	Poor	Very poor
1. Introduction - Objective of the report was indicated - Method of work is explained - Content of the report is introduced					
2. Description of the actual situation - Description of Forage Production and Feed Improvement Management					
3. Data collection and analysis of the actual situation - Data collection and processing/ KPI's - Analysis of data - Identification & Relative importance of constraints					
4. Proposal for improvement - Technical description of the proposal - All tasks implemented and included in the Report - Quality of proposed improvements - Organisational aspects of the proposal					
5. Conclusion - Based on the contents of the report - Clear and well formulated					
6. Quality of the Report - Language - Level (for farmer) - Lay out - General impression					

Assessment is passed with a score of minimum 35 points

E. Assessment form for observation of student during presentation

Name trainer:

Enterprise presented:

Observer:

Date:

Behaviour criteria; The participant:	**Remarks and score by observer (range from 0 (insufficient) to 5 (very good))**
1. Has prepared the correct and required teaching aids	
2. Presentation can be followed by all including farmers	
3. Presentation follows a logical path and is divided in clear steps if required	
4. Links the level of knowledge and skills instructed to the level of the farmers	
5. Can execute the basic skills required for the lesson	
6. Speaks clearly and is pleasant to listen to	
7. Makes contact with the group and keeps this momentum during the lesson	
8. Stimulates interaction with the participants	
9. Provides for feedback during the presentation to check if message comes through	
10. Can describe to which extend outcome was realised	
Further Remarks and final score :	

Minimum score for passing the assessment will be 30.