

# Training module on livestock feed and forage innovations

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International Livestock Research Institute

Training Module



**AICCRA**  
Accelerating the Impact of CGIAR  
Climate Research for Africa



# Training Module on Livestock Feed and Forage Innovations

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# General Introduction

**Kindu Mekonnen\***

The livestock sector plays a significant role in sustaining the livelihoods of 80% of livestock keepers and other inhabitants of rural areas of Ethiopia (FAO, 2011). It serves as a source of protein rich food (milk, meat, and eggs), provides employment to many rural and urban people, provides services such as a transport and draft power in the mixed crop-livestock farming system, serves as a source of organic fertilizer (manure) to replenish soil fertility depletion, and is a store of wealth for savings and a major source of foreign exchange (FAO, 2011; Shapiro et al., 2017).

On an annual basis, demand for milk and beef from 2012-2050 is expected to grow by 2.6 and over 3%, respectively, which translates into major increases in volume terms (FAO, 2018). Realizing this demand requires substantial investments in the livestock sector. The government of Ethiopia has given special emphasis to the livestock sector with the objective of adequately exploiting its potential for rural poverty reduction, food security, export earnings, and job creation for youth and women. Improving animal feed resources is one of the main strategies for achieving these objectives together with breed improvements, better management of animal health issues and creating enabling environments including capacity development (NPC, 2015).

Encouraging efforts have been made by government institutions, non-governmental organizations, national, continental, and global projects, and private sector actors engaged in research and development to address the challenges that hamper development of the Ethiopian livestock sector. Some institutions have tried to introduce and demonstrate improved livestock technological innovations while others attempted to facilitate scaling of validated livestock innovations. However, reach and impact of improved livestock technologies are not at the level of their potential and expected scale due to various reasons. Most significantly, the current realities on the ground particularly climate change, rapidly growing human population and increasing demand for animal source food call for a more integrated approach - covering capacity building, multistakeholder platforms, market linkage, targeting of beneficiaries, policy strengthening - to the formulation of needs-based interventions.

Realizing the current challenges, a capacity development training module on livestock feed and forage innovations has been produced with a financial support from Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) and Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) projects to contribute to the bigger picture of the Ethiopian livestock development. The capacity building training module (current version) targets livestock feed and forage extension experts, forage seed producers and marketers, feed and forage scaling development partners and media (local televisions and radios) in the Ethiopian highlands. The capacity development training module consists of seven chapters, which covers wider topics including cultivated forages, fodder

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trees, crop residue management, feed formulation, estimating feed demand at scale, forage seed system, scaling and media coverage of feed and forage technologies.

The current livestock feed and forage innovations training module will be further reviewed and revised to increase its readability. There will be also an effort to produce a second version for wider circulation.

# Chapter 1 : Cultivated Forages Production and Utilization: With Reference to Selected Annual and Perennial Forages for the Ethiopian Highlands

Melkamu Derseh\*, Aberra Adie, Kindu Mekonnen and Peter Thorne

## LEARNING OBJECTIVES

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*This chapter intends to provide relevant information on selected forage crops that have high potential to contribute to feed availability in the smallholder system. At the end of this chapter, learners will be able to:*

- *Understand the potentials of cultivated forages towards the intensification of the mixed crop-livestock system and climate change mitigations*
- *Describe the essential features of selected forage crops and their utilization practices*
- *Identify suitable forage growing niches for their effective integration in the smallholder system*
- *Provide advice to livestock keepers and feed producers on the proper production and utilization of cultivated forages.*

## INTRODUCTION

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Cultivated forages have a potential to produce high feed biomass of good nutritional quality and contribute to increase livestock productivity. As feed scarcity is the major constraint affecting livestock production in Ethiopia due to dwindling natural pasture lands, growing cultivated forages has increasingly become a necessity to supplement available feed resources. The transition from free/open grazing to tethering of animals in restricted areas or backyards also demands adoption of cut-and-carry feeding practices. Forages that grow fast and can be harvested frequently for such feeding practices will be very important as a coping strategy in the foreseeable future. Mixing cultivated forages with crop residues is another strategy to improve the quality of the diet consumed by dairy cows in the mixed farming system. Farmers who have crossbred dairy cows continue to be challenged by poor quality of available feeds and the high cost of supplemental concentrate mixes. Home-grown cultivated forages and fodder trees have a considerable potential to replace commercial concentrate mixes. Several cultivated forage options have been evaluated and passed through the national variety release process for wider use and scaling. Use of cultivated forages in the smallholder system, however, has remained very much limited, and its contribution to the overall feed biomass

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production is low. Among the major constraints include the presence of stiff competition for land and resources, use of unimproved animals especially for milk production, the subsistence nature of the farming in rural areas with limited market access for fluid milk, lack of knowledge and awareness about the benefits and methods of cultivation and utilization practices for these forages. This training manual is compiled with the objective of providing a hands-on information for practitioners on the essential agronomic and utilization practices for selected annual and perennial forages that have potential to be integrated in the smallholder system. The annual forages included in this manual are Oats, Vetch, Cowpea, Lablab, Fodder beet, whereas the perennials are Bracharia grass, Desho grass, Napier grass, Alfalfa, Rhodes grass, and Tree lucerne. The manual gives a brief description of the nature of the forages' agro-ecological adaptations, basic agronomic practices, and use as feed for livestock.

## **WHY CULTIVATED FORAGES?**

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### **High biomass yield of good nutritional quality**

Research for development trials have demonstrated that improved forage species generally have higher herbage yield potential than natural pasture and the quality of these forages make them good supplements to locally available feeds. Yield potential of improved grasses usually varies from 8.0 to 15.0 t DM/ha/yr with a mean of about 13.0 ton/ha. Yield of herbaceous legumes also varies from 6.0 to 10.0 t DM/ha with a mean of 8.0 t DM/ha. Productivity of tree legumes ranges from 9.0 to 13.0 t DM/ha with a mean of about 10.5 t DM/ha. These yield potentials have been recorded under rain-fed conditions in which mainly a single cut is possible per year. If forage production could be supported by supplementary irrigation, multiple cuts could be possible and the potential herbage yields could be far higher than the figures indicated above, especially in the case of perennial forage species. The digestibility, crude protein and energy content of these forages are quite good and make them good home-grown supplements to improve livestock productivity.

### **Forages as food-feed crops**

Some of the forage crops can serve as food feed crops. Africa RISING research for development trials have demonstrated the potentials of applying multiple cutting management for oats so that the crop produces forage in the early stages of growth and then allowed to mature for seed production. By following such practices farmers can produce significant amount of feed biomass in the rainy season while also producing grain for food or seed. In some areas farmers of the country, there are already similar practices. For example, in Selale areas farmers sow oats early in the short rains (April) and start feeding their animals starting from Mid-July until early September. The leftovers after this time will be allowed to mature for grain production mainly to use it as food crop and in rear cases as a seed-sources for the next planting. Similarly, sweet lupine, pigeon pea and cow pea have been demonstrated as important dual-purpose crop. Therefore, dual purpose forage crops have a special niche where feed and food shortages are equally important.

## Ecosystem services

Sustainable natural resources conservation is a primary agenda to increase agricultural production and productivity. In this respect forage crops play a vital role in controlling soil erosion, improving water infiltration, and increasing soil organic matter and fertility. Some of the forages can be planted on soil bunds to reinforce the structure and at the same time produce good amount of forage biomass through a cut-and-carry management. Legume forages and fodder trees fix atmospheric nitrogen and improve soil fertility. These crops also play an important role in sequestering atmospheric carbon and contribute to local climate change mitigations efforts. Moreover, the good quality nature of these forages allows reduction of enteric methane emissions from ruminants and contribute to reduced greenhouse gas emission per unit of livestock product produced.

## Integrated pest management

Cereal crops including maize sorghum, and millet are affected by insect pests, mainly stemborer. This insect can be controlled by applying the push-pull technology, which involves intercropping these cereals with a repellent forage (Desmodium) that repels or deters the insect from reaching the crop. Brachiaria and Napier grasses serve as an attractant trap plant when planted on the borders of crop fields. This push-pull technology, in addition to controlling the pest provides good quality feed for livestock and contribute to soil fertility through nitrogen fixation.

## Forages as cash crops

The emerging fodder markets in different regions of the country show that use of cultivated forages as cash crops can be a lucrative business. Green fodder markets are now widely common in southern Ethiopia and hay is an important commodity all over the country. Given the high yield potentials of cultivated forages and the current market price for green fodder and pasture hay, the potential income from direct sale of forages as cash crop is huge. For instance, estimated gross returns from Napier grass production under supplemental irrigation can reach more than one hundred fifty thousand birr per hectare per year. This gross income appears to be much higher than commonly produced cereal crops.

## **OPTIONS/NICHES TO INTEGRATE FORAGES IN THE EXISTING FARMING SYSTEM**

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Though it is mostly recommended that forages for seed production are planted as a pure stand on a well-prepared seed bed for each variety, due to shortage of farmland, forages can be planted either as a pure stand or in combination with other crops depending on their compatibility. They can also be planted at homestead/ backyard or outfield depending on the species and available land size.

### Outfield forage production

Forages for seed production could be planted as a pure sward outfield where food crops are planted. Annual forages like oats and vetch can easily be planted on a farmland like other food crops during the main rainy season. As they are seasonal, they can be harvested the same time with food crops,

with no threat of free grazing animals. Seed production from perennial forages can also be done outfield if there is enough land, and that land is well protected from disturbances of animals or humans. The land should also be suitable for irrigation and close to water sources to use when needed.

## **Backyard forage production**

Perennial forages, like alfalfa, Napier grass, MPTs, and root crops like fodder beets may be planted in locations where routine follow up and monitoring could be ensured and protected from damage by free grazing domestic or wild animals. Backyards are good locations for such species also for supplemental irrigation and manuring when necessary. When forage crops are planted at backyards or homestead, they can serve other purposes like shade, windbreak (hedge rows), fence, beautification of the homestead etc.

## **Trellises**

Trellises is the system of growing climbing legumes on a support. The support may be in the form of posts, wire fences, or growing trees. The advantage of trellising includes increased seed yields, easier and more efficient seed harvesting.

## **Live fence**

MPTs can be planted as live fence around homestead or on farm boundaries and margins where land for pure planting is a limitation.

## **Hedgerow farming**

This is a system where fodder trees are planted in rows of 5-10 meters apart or wider (depending on the type of trees and area available) and the space between the tree rows is planted to other forage crops or other food crops.

## **Intercropping/under-sowing**

The establishment of annual or perennial legumes under food crops, agroforestry trees including fruit trees, shade, or ornamental trees, etc. In areas where crop land size is a limitation, some forages can be intercropped with existing food crops or other forages. For example, cowpea and lablab can be intercropped with maize or sorghum. Desmodium can be intercropped with Napier, under coffee.

## **Relay cropping**

This is a method of planting one crop right before the harvest of the other crop. An example could be planting annual legumes like lablab, cowpea or vetch under the maize crop at or after the ear formation (grain filling) of the maize. In doing so the second crop (the legumes) will benefit from the existing moisture with a bit of supplemental irrigation if available to produce seeds from the legumes without harming the main crop.

## **Double cropping**

This is a mechanism where two crops are grown on the same piece of land alternatively. Example is planting annual forages during the belg season and food crops during the meher season. In doing so,

the fertility and structure of the soil could be maintained or improved especially if forage legumes are planted at the first season.

## SWC structures (strip planting on soil bunds)

Physical soil and water conservation structures built by private farmers or government initiatives could be potential spots to plant forages for seed production. However, species which can serve the SWC purpose have to be carefully selected. Fodder trees like tree Lucerne, sesbania and Leucaena and herbaceous forages like Napier and desho grasses are possible candidates for this niche. Herbaceous legumes like vetch, clover and desmodium could also be planted on contour lines or soil bunds but care is needed during seed harvest so that the seeds don't shatter and invade the crop land.

## FORAGE CROPS CULTIVATION AND USE

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### Forage oats

#### Description

Oats (*Avena sativa*) is an erect annual grass up to 2 m tall, with a fibrous root system. Oat is suitable to grow in mid-land and cool highland agro-ecologies of Ethiopia (2300-3000 m altitude areas, with an annual rainfall over 800 mm and minimum and maximum air temperatures of 6°C and 24°C, respectively). Oat is not as sensitive to frost as wheat. When moisture is not limiting it also performs well in warmer, humid mid-altitude tropical environments. Oat needs more water than any other cereal except rice. Oat thrives on a wide range of soil types and can grow on poorly drained soils. It grows on soils that are sandy, low in fertility, or highly acidic (as low as pH 4.5), but it performs best on well-drained, fertile, loamy soils. Due to its tolerance to poor soil fertility and to frost, its low requirements of external inputs such as fertilizers, and its dual-purpose character (food and fodder), oat has favorable prospects in the highlands of Ethiopia, especially for resource-poor farmers.

#### Establishment

Oat is propagated by seed. Seeds 2-3 months old normally have more than 85% germination. Oat seeds kept under natural cold conditions in the highlands of Ethiopia still germinated after 15 years of storage. Under tropical highland conditions, the seeds are broadcast or drilled (row spacing 15-20 cm) at a rate of 90 kg/ha. Lower seeding rates are recommended for grain production. In the high-altitude tropics, oat is usually sown at the onset of the rainy season. When grown for forage, oats for fodder most often produced in mixture with vetches (*Vicia spp.*) at the rate of 25 kg vetch + 75kg oats per hectare. Growing oats-and vetch as a mixture provides a good balance of nutrients for livestock. The general fertilizer recommendation is to apply 18-23 kg N and 20-30 kg P per ha at sowing and top-dressing with urea at tillering. Oat is best grown in rotation with barley, wheat, faba bean, pea and sometimes with fallow or a green manure. When oats planted in pure stands weed control could be the same as other cereals like wheat and barley (hand weeding or herbicides). But when in mixture with vetches it is usually hand weeding at early stage of its growth.

## Harvesting, utilization and conservation

Oats provides three yield components: green fodder, grain, and straw. The grain could be crashed and processed in different forms and utilized as energy supplement, while the green fodder could be fed green or in the form hay or silage. The straw from grain harvest is also used as poor roughage feed. The forage produced from oats-vetch mixture has a balanced protein and energy content (15% crude protein and 10 MJ ME/kg DM) and can improve animal performance considerably compared to pure oats. Compared to other cereals, oats grain has a high protein (16.9%) content and a good amino acid profile, with a high level of lysine. When oats grain is processed the hulls and brans could be used as animal feed. Oat could be harvested manually by sickle or scythe, for forage normally after heading (milk to dough stage). If multiple cutting management is employed, the first cutting should take place before stem elongation, and subsequent harvests can be done as found necessary. For grain production, the crop is harvested when the seed is in the hard dough stage, which is normally at the end of the rainy season. The harvest is left in the field for sun-drying and is subsequently threshed (grain crop) or piled (forage crop). The green fodder or hay can be fed alone or in mixture with other feed.

## Dry matter production

In Ethiopia oats is commonly produced under rain fed condition. It performs very well under irrigation. The dry matter forage and grain productivity varies among the different varieties, fertility of the soil, environmental conditions, and the different agronomic practices. When oat is harvested for green fodder, hay, or silage the dry matter yield could range 8–15 t/ha. In the Africa RISING project sites, the biomass yield was found to go as high as 19 t/ha. In this project trials two times cutting of oats provided higher yield than one time cutting. The yield potential increases when oats is grown in mixture with vetch.

## Seed production

The grain yield of oat in Ethiopia varies over the different agro-ecologies and varieties, where grain yield is lower for forage varieties. Oats grown for seed production uses lower seeding rates and higher fertilizer levels. Seed yields on average ranges between 1 to 3.5 t/ha with average straw yields of about 5.5 t/ha. When people use oats for food dehulling with local mills is required. The hull generally accounts 25 -35% of the total grain weight and mostly used for animal feed.



Oats and oat-vetch mixture forage (Photo credit: ILRI)

## Vetches

There are different species of vetch, which are annual herbaceous legumes with some distinctions among the different species. This forage has a scrambling with climbing habits. The flowers are purple to blue and sometimes white. The seeds are blackish brown. Vetch is a very important forage well adapted in the cooler highlands of Ethiopia with average annual rainfalls up to 1000 mm. The highly productive and well adapted species include *Vicia villosa*, and *V. dasycarpa*. Vetches like well drained soils and not tolerant to waterlogged soils. They are fast growing and are not drought tolerant. Vetches grows best in air temperatures ranging 8 to 19°C on soils with pH between 6 and 7.5 but can grow and tolerate soil acidity. They are tolerant to frost, however when they are grown for seeds pods are severely damaged by frost. Vetches for seed production should be grown in frost free areas. Vetches like sun shines and depressed with shades. In Ethiopia vetches could grow in altitudes ranging 1800 to 3000 masl. It is most often used for green manuring and for forage and in the latter case grown in mixture with oats.

### Establishment

Vetch forages are cultivated mainly under rain fed systems. They can easily be established by sowing seeds at the onset of the main or short rain seasons in the highlands of Ethiopia. Early planting at the onset of the rainfall helps vigorous growth and suppresses weeds. Vetch most commonly sown by broadcasting but can be sown in rows 30 cm apart. Row planting has an advantage only for early-stage field management. Seeding rate is 25 to 30 kg/ha with 2-4 cm soil depth (covering). Vetches grow well without fertilizer application, but on soils with poor fertility applying 100 kg/ha DAP (18 kg N and 46 kg P<sub>2</sub>O<sub>5</sub>/ha) improves productivity. When vetch grown in mixture it has an advantage of climbing and improves forage productivity. Oats and vetch should be planted simultaneously at the seeding rate of 25 kg vetch plus 75 kg oats per hectare. The seeds need to be sown independently on the same field for uniform distribution. *V. villosa*, *V. dasycarpa* and *V. atropurpurea* could also be over sown on natural pasture to improve natural pastures. Seeds need to be mixed with manure with good moisture. Weeds are controlled through better agronomic practice like early planting, pre-emergence herbicides or hand weeding. Vetches are most often free from diseases and pests.

### Harvesting, utilization and conservation

Grazing of vetch pasture by livestock is not common and they don't withstand grazing. The best way of utilization vetch forage is in the form of green feed, hay and silage, especially when mixed with oats. The right time of harvest is about 50% of flowering. However, harvesting stages and time should be adjusted to maximize both yield and quality of both the oats and vetch forage. When making vetch or oats/vetch hay, care should be taken to minimize leaf shattering. Collection of harvested forage should be done in early mornings. The dried forage needs also to be baled early mornings. When conserved as silage it has to be mixed with cereals like maize or oats, or they have to grow in mixture together. When vetch is under sown in maize it may be harvested at the right time and used as feed or conserved. However, when mixed with small perennial grasses like panicum and elephant grass it is very good to harvest all the mixed forage at a time.



## Dry matter production

Hairy vetch (*Vicia villosa*, *V. dasycarpa* and *V. atropurpurea*) are high yielding forage legumes. It can produce 5 to 10 t/ha DM /ha in Ethiopia, where there is one harvest per year. However, recent trials by the Africa RISING and ILSSI project demonstrated that vetch can regrow well after the first cut, provided that the soil has good moisture content. Most often yields from oats vetch mixture is higher than either of the pure forms.

## Feeding values

The average nutrient content of vetch (*Vicia villosa* var *dasycarpa*) forage grown in different sites in Ethiopia summarized from 78 reports showed 21.8 % crude protein, 42.4% neutral detergent fiber, 34.7% acid detergent fiber, 7.17% acid detergent lignin, 2.21 Mcal/kg metabolizable energy, 66.9% in vitro dry matter digestibility, 1.18 % calcium and 0.33 % phosphorus on dry matter basis. Vetches are very palatable to livestock. As a high-quality forage, it is usually supplemented to poor roughage diets or supplied as mixtures with other forage crops like oats.

## Seed production

Vetches are good seeders, but their indeterminate flowering and susceptibility to frost are the major bottle necks. Seed production from *Vicia sativa* and *Vicia narbonensis* is easier as they are early maturing and good seed producers. However, seed crops of *Vicia villosa*, *dasycarpa* and *atropurpurea* are late maturing varieties, has indeterminate growth of flowers, in this process frost occurs and damages usually at early pod stage. Therefore, vetch seed production should be done in frost free areas. In Ethiopia seed productivity ranges for *V. villosa* 7 to 23 qt/hq, *V. dasycarpa* 7 to 21, *V. dasycarpa* 5 to 20, *V. sativa* 8 to 27 and *V. narbonensis* 4 to 29 qt/ha. Forage seed productivity is affected by the level of management, soil and environmental situations.



Vetch forage (Photo Credit: ILRI)

## Lablab

Lablab (*Lablab purpureus*(L.) Sweet (Family - *Fabaceae*) is a highly productive annual or occasionally short-lived perennial herbaceous forage legume. It is vigorously trailing, twining plant. Stems robust,

trailing to upright to 3-6 m in length; leaves are trifoliolate. Flowers could be white, blue or purple depending on the type of variety. Pods 4-5 cm long, containing two to four seeds and sometimes 6-8 in some varieties. Seed colors are pale brown, or black with a linear white hilum or can range from white or cream through to light and dark brown, red to black with the sizes of 1.0 cm long x 0.7 cm broad.

## Adaptation

Lablab is widely cultivated in many places in Ethiopia both under rain fed and irrigation. Lablab grows very well in areas from sea level to 2000 masl with rainfall regimes between 650 to 3000 annually. It is also drought tolerant, but loses leaves when drought is prolonged. Lablab grows in a wide range of soils but has low tolerance to salinity. Grows well in pH range of 4.5 and 7.5. It is tolerant to high temperatures but susceptible to frost and do not perform well under moderate and heavy shadings. It best performs in average daily temperatures between 18 to 30oC.

## Establishment

Row planting is suitable for managing lablab fields. Lablab most often planted in rows 80 to 120 cm apart and 30 to 50 cm spacing between plants. The spacing should be adjusted according to the fertility of the soil, the level of available moisture and the air temperature as these conditions determine the vigor of its growth. A seeding rate of 15 to 25 kg/ha is adequate. Usually, lablab is sown without application of any fertilizer. But if the soil is poor application of phosphorus is advantageous. In Ethiopia 100 kg/ha DAP is applied at planting. Application of lime on acid soil improves productivity. Lablab most commonly grown in mixture with maize, sorghum and millet. In some areas it is grown in mixture with perennial grasses like panicum. Under-sowing is done at the first weeding of the main crops like maize (like 30 days after planting) at lower seeding rate of about 10 kg/ha. Planting lablab in under-sowing has plenty of advantages including, improvement in soil fertility, reduce production costs and efficient use of labor and land. Lablab could be attacked by anthracnose, leaf-spot and powdery mildew A stem rot may attack the plant under wet conditions. The seeds during growth (pods) and storage could also be attacked by different insect's and beetles.

## Harvesting utilization and conservation

Lablab is high forage producing legume and the green forage could be directly fed to animals or stored as hay or silage. Lablab could start flowering starting about 2 months after sowing and the forage is ready to be utilized as animal feed. It should be harvested at the initiation or before flowering for forage. If moisture is not limiting, three harvests per year are possible from annual type lablab. Lablab is not tolerant for grazing, and grazing is not a common practice. Lablab makes excellent hay, similar to alfalfa hay in quality, if the leaf is adequately preserved. However, because the stem is coarse and fibrous, it may be difficult to dry. Lablab can produce good quality silage, alone or mixed with maize, forage sorghum or millet. When lablab is ensiled alone, it is recommended to cut and wilt the lablab to 30 to 35% DM over 18 to 24 hours before ensiling. This increases the concentration of soluble sugars and thus facilitate fermentation. Mixing with cereal crops (maize or sorghum) favors fermentation. The addition of molasses is not necessary.

## Dry matter production

Higher herbage yield is obtained in warmer areas with adequate moisture. It produces 6 to 9 t/ha dry matter. In warmer areas with adequate moisture productivity is very high. In areas like the rift valley



when it grows with irrigation forage productivity is very high. In the cooler highlands productivity is low and most often attacked by insect pests. When lablab produced in integration with maize, sorghum or millet, forage biomass yield of 2-4 t/ha dry matter could be harvested.

### Feeding values

The average nutrient content of Lablab forage grown in different sites in Ethiopia showed 17 % crude protein, 44% neutral detergent fiber, 32% acid detergent fiber, 6.14% acid detergent lignin, 2.27 Mcal/kg metabolizable energy, 68% in vitro dry matter digestibility, 1.51% calcium, 0.44% phosphorus, 2.78% potassium, 0.29 % Mg, 2.78% potassium and 35.7 ppm Na on dry matter basis. As a high-quality forage lablab forage should be used as a supplement or fed to animal in mixture with other low-quality roughages. When animals feed with high moisture lablab forage alone it may cause bloats. The leaf is highly palatable and does not contain anti-nutritive factors such as tannins. The stem has low palatability.

### Seed production

Seed productivity varies with the different varieties, production management and environment. But lablab is a very good seed producer on average 10 to 25 qt/ha. The seed are usually attacked by weevils and needs to be stored properly.



Lablab fodder plot (Photo credit: ILRI)

## Cowpea

Cowpea (*Vigna unguiculata* (L.) Walp. (Family - *Fabaceae*) is a herbaceous, prostrate, climbing, or sub-erect to erect annual legume forage, growing 15-80 cm high. Leaves are alternate, trifoliolate with petioles 5-25 cm long. Inflorescence racemose, flowers white, cream, yellow, violet or purple. There are accessions with determinate and with indeterminate growth habit. Pods 10-23 cm long with 10-15 seeds/pod. Seeds are variable in size and shape, square to oblong and variously colored, including white, brown, maroon, cream and green.

## Adaptation

Cowpea is one of the most widely grown and well adapted crop in moist low and mid altitude areas like Pawe, the rift valley areas, and other mid-altitude agro-ecologies in Ethiopia. Cowpea grows in wide range of soil types but most prefer in lighter soils. It grows in very acidic soils (pH 4.0) and low soil fertility and can also grow in strongly alkaline soils. Lablab grow for forage in rainfall regimes between 700 to 1100 mm annually, but lower for grain production. Cowpea best grows in lower altitudes in Ethiopia from sea level to 1700 m with air temperatures of 25 to 35°C and highly susceptible to frost specially in some highland areas where occasionally occurs frost.

## Establishment

Cowpea is common to be sown by broadcast or in rows 30 to 60 cm apart. Seeding rates of 20 to 35 kg/ha is commonly used at sowing depth of 3-5. On soils with poor fertility 100 kg/ha DAP (18 kg N + 46 kg P<sub>2</sub>O<sub>5</sub>/ha) as a blanket recommendation is applied in Ethiopia. Cow pea is also grown in integration with maize, sorghum, and millet. Cowpea is susceptible disease and pests.

## Harvesting, conservation and utilization

Cowpea has a diversified use. The biomass is used a very quality forage for livestock while, the grain, green pods and leaves are used as human food. Accordingly harvesting of cow pea is determined by the intended purpose. The grain is also used as supplement feed to livestock. Cowpea has great flexibility in use: farmers can choose to harvest them for grains or to harvest forage for their livestock, depending on economical or climatological constraints. Cowpea starts flowering starting 30 days after planting and green forages could be harvested at stage of 50% flowering and fed to livestock as cut and carry.

## Dry matter production

For livestock the whole biomass is harvested at pod stage. At this stage the dry matter forage yield is about 7 t/ha, but the yield can go as high as 10t/ha under good conditions. In addition, cow pea has also quality straw after grain harvest that could be used as feed for livestock.

## Feeding values

Cowpea is highly palatable and high intake for livestock. It has high nutritive value with CP in green foliage 14-21% and in crop residues 6-8%, in grain 18-26%; IVDMD of foliage >80%. IVDMD of residues after grain harvest 55-65%. The average nutrient content of cow pea forage grown in different sites in Ethiopia summarized from 288 reports showed 21.08 % crude protein, 39.8% neutral detergent fiber, 26.2% acid detergent fiber, 3.9% acid detergent lignin, 1.07% calcium, 0.44% phosphorus and 535 ppm iron on dry matter basis.

## Seed production

Grain productivity of cowpea is very variable. This is mainly due to varietal differences in addition to management and environmental variabilities. Reports show grain yield ranging between 1 t/ha to 4 t/ha.



Cow pea forage (Photo Credit: ILRI)

## Fodder beet

Fodder beet (*Beta vulgaris* subsp. *Vulgaris* L.) is an annual/biennial plant with thick roots that is suitable for cultivation in a cooler climate. The roots are a rich energy source for livestock. Fodder beet needs a long growing season (6–7 months) and rich soil to perform well.

### Adaptation

fodder beet grows in the highlands of Ethiopia (1800–3000 masl) with annual rainfall of at least 750 mm. It needs a rich and well-drained soil. The crop is sensitive to acid soils and a pH above 6.5 to 8.0 is suitable for the growth of fodder beet. In case of acid soils application lime before planting would be necessary. Crop is not suited to waterlogged areas. Declines in yield at low soil fertility. It is susceptible to frost.

### Establishment

Fodder beet requires a clean and well-prepared seedbed and does better in light or medium soils. The crop responds well to fertilizer applications and commonly 100 kg/ha of DAP or about 10–15 t/ha of farmyard manure should be applied at establishment. Manure varies in quality and hence rates may vary depending upon soil types and previous cropping. Fodder beet requires effective hand weeding, especially during the early establishment period (the first 1–2 months). Hoeing and piling the soil around the roots is essential to facilitate increased root development and growth. The recommended seed rate is 5–10 kg/ha. Under rainfed conditions, seeds should be planted just at the beginning of the main rainy season. Seeds should be sown 2 cm deep and in rows 50 cm apart. The plants can later be thinned to give 20–25 cm spacing between plants. Alternatively, Seedlings can be raised in nurseries for 1–2 months and transplanted to main plots at the beginning of the rainy season. This approach has provided very good results in the Africa RISING project sites. Seedlings can be raised with supplemental irrigation during the belg season and then immediately transplanted to fields when the rainy season enters. This practice gives farmers more control of the survival of the crop, ensures longer plant growth period and higher yield.

## Harvesting and utilization

The roots can be harvested about 6 months after planting when they are at their maximum size. The roots should be harvested carefully by digging them out of the ground. They need to be washed and separated from any soil material. In general, washed roots can be used in intensive management systems on dairy or fattening farms by chopping before feeding. Tops may also be fed to livestock after wilting. The tops can also be grazed or ensiled. Roots can be stored after harvest for 4–5 months if not damaged during harvest. The high sugar content makes fodder beet palatable and a valuable energy source for ruminants. Lactating cows must be gradually adapted to eat fodder beet, starting with small amounts (e.g. 1 kg of tuber in the morning and 1 kg in the afternoon) and gradually increasing the amount over a week. However, intake per day should not exceed 0.8% of the animal's live weight to avoid risk of acidosis. Potential toxicity can be reduced by feeding cows the fodder beets after they have been fed other roughage feeds. The tuber can also be included in the diet of pigs.

## Dry matter production

Fodder beet requires a lot of work, but rewards are high in terms of yield and animal performance. The average tuber yield is around 20 tons of dry matter/ha. The leaves/tops will also contribute a further 3–4 tons of dry matter/ha.

## Feeding values

Roots are high in energy (12-13 MJ of metabolizable energy per kg dry matter) but low in protein with crude protein values of 6-10%. It is highly digestible (70-80%). Tops/leaves have relatively higher nutrient levels than the roots. On-farm feeding experiments in the Africa RISING sites showed that supplementation of fresh fodder beet at a rate of 8-10kg per day results in a milk yield increase of up to 30% in lactating cows.

## Seed production

Fodder beets flower and produce seeds in the second year after planting, though the root decreases in size. When the seeds of fodder beet are ready for harvest, they can be collected by stripping. Seed yield is about 400–500 kg/ha.



Fodder beet plant (Photo credit: ILRI)



## Napier grass

Napier grass (*Pennisetum purpureum*, Schumacher) is a perennial bamboo like tall tropical grass that can grow up to 7.5 m height. It is also called Elephant grass and king grass. It is the highest forage yielding grass. The stems can grow up to 3 cm diameter and the leaves extend 30 to 120 cm length and a width of 1- 5 cm wide. The roots are extensive and deep up to 4.5 m.

### Adaptation

In Ethiopia the grass grows in a wide geographical location. It grows vigorously in warmer and humid areas with moist ecologies and under irrigation from sea level to 2000 masl. In addition, there are elephant grass strains well adapted to cooler areas up to 2400 masl like Holetta and Arsi areas but susceptible to frost. However, it recovers quickly after frost damage. Frost damage can be minimized by proper arrangements of harvesting before the onset of frost. It is also drought tolerant due to its deep root systems but less tolerant to flooding and waterlogging. It grows very well on wide range of soil types preferably on loam and drained soils with pH ranges of 4.5 to 8.2. Elephant grass grows best in temperatures between 25 to 40°C. It performs very well in areas with >1000 mm but can grow starting 200 mm annual rainfall.

### Establishment

Elephant grass most often established by propagating stem cutting or root splits. In warmer areas cuttings from matured stems can successfully establish, while in cooler wet highlands, in areas with poor soil fertility and moisture stresses root splits are more appropriate. Elephant grass is planted in rows 1 m apart and 50 cm spacing between plants. The spacing between rows and plants could be adjusted according to the agro-ecology, fertility and water availability. Elephant grass requires phosphorus and nitrogen fertilizer during establishment at the rate of 100 kg DAP/ha. Once it is established application of animal manure periodically is the best strategy. As alternative urea/nitrogen dressing is important. It should be applied after harvesting. The rate of application depends on the fertility status of the soil. But application of 46 – 92 kg nitrogen per hectare per year could be optimum under Ethiopia condition. Elephant grass is a very vigorous plant in warmer areas with adequate moisture and companion crops are not very common. It could be grown on field borders and soil bands of other field crops like maize. However, in cooler or moisture stress or poor soil fertility areas forage annual and perennial legumes like vetches and Desmodium could be intercropped. The major problem of Elephant grass is Napier stunt virus disease. This is very common in most East African countries like Kenya, Uganda and Tanzania. But it is not reported in Ethiopia.

### Harvesting, utilization and conservation

Napier grass most often not grazed by livestock. The best way of using Napier grass as feed is cut and carry or in the form of green feed or silage. Harvesting elephant grass at appropriate height of growth is important to balance quality and yield gains. Many research results in Ethiopia and other African countries recommend Napier grass to be harvested when the forage reaches a height between 1 meter and 1.5 meters' height. After harvesting Napier grass it has to be chopped to smaller sizes for efficient utilization. In areas where frost is prevalent, elephant grass forages should be harvested before the occurrence of the frost. Frequency of harvesting depends on the level of moisture availability. Frequency of harvesting depends on the level of moisture availability. In times when conservation is required Napier grass could be chopped or shredded and made into silage with some

additives like molasses. However, there are varieties with morphological features suitable for hay making and some other for grazing.

### Dry matter production

Forage yields depend on soil fertility, moisture level and distribution, temperature and management. DM yields of 10-30 t/ha/year is common, (and up to 85 t/ha/yr) if well fertilized and irrigated. However, when soil fertility is poor, rainfall is low, and temperatures are cool productivity is usually low and ranges 5 to 15 t/ha/year. Studies in the highlands showed more frequent cuts (up to 60 days) give less dry matter yield than prolonged harvesting of 3 to 6 months under rain fed conditions, but better leaf and crude protein content.

### Feeding value

Elephant grass is usually primarily used to feed dairy cattle as cut and carry system. But could be fed to all ruminant animals. It is palatable. The green forage should be chopped to size of 3 to 4 cm or shred and fed to animals. Dairy animals could produce more than 10 liters of milk/day with feeding of elephant grass forage without any concentrate supplement. The average nutrient content of Elephant grass forage grown in different sites in Ethiopia showed 9 % crude protein, 64% neutral detergent fiber, 38% acid detergent fiber, 4.3 % acid detergent lignin, 2.02 Mcal/kg metabolizable energy, 66% *in vitro* dry matter digestibility, 0.5 % calcium, 0.34% phosphorus, 3.66% potassium, 0.17 % Mg, 384 ppm Fe and 131 ppm Na on dry matter basis.

### Seed (Planting materials) production

Though seeds could be produced and used for establishment, seeds of elephant grass is very rarely produced and used. The most common sources of planting materials are stem cuttings and root splits. Cuttings taken from the basal of moderately mature stems containing 3 nodes could be used for planting. The basal part should be buried with the nodes at slant (at 45°) position. Cuttings can also be planted horizontally into a furrow, to a depth of 5-10 cm. Normally planted in rows 0.5 m apart. Root splits most often used in cooler agro-ecologies. Cuttings could be handled with plastic bags could be transported and can be used for planting up to 2 week-time.



Napier grass plot (Photo credit: ILRI)

## Brachiaria grasses

### Description

*Brachiaria* grasses are of tropical origin and have very good forage potential with very good palatability and the ability to perform on poor soils and on soil and water conservation structures. The common *Brachiaria* grasses of importance include *Brachiaria mutica*, *B. decumbens*, *B. ruziziensis*, *B. brizantha* and hybrids of these species such as Mulato II. In recent years these grasses have been placed by some authors in the *Urochloa* genus. These grasses are suitable for grazing or cut-and-carry system, either to be directly fed or to make hay or silage.

### Adaptation

In Ethiopia *Brachiaria* species are becoming very important since the last few years. The grasses perform very well warmer humid areas and grow well in the rift valleys of Ethiopia (1500 – 2000 masl) under irrigation. Best performs in warm and high rainfall areas (1000 to 1300 mm annually). Tolerate flooding but not waterlogging. Grow on a wide range of soil types including those of low fertility, low pH (as low as pH 3.5). *Brachiaria* is native to the upland tropics, and most productive in the lowland humid tropics, subtropics and at higher altitudes. Prefers temperatures above 19°C. It has intermediate tolerance to shades and is very suitable for ground cover. *Brachiaria* is a good pasture for grazing and very tolerant for grazing. can be burnt during the dry season and recovers rapidly from stolons and seed with the onset of rains

### Establishment

*Brachiaria* could easily be established from seeds and could also be propagate vegetative. The seed has a dormancy period of about 6 months after the seed is harvested and needs to be stored to break dormancy. Mostly planted in broadcast at the rate of 5 to 10 kg/ha depending on seed bed preparation, and most importantly agroecology. High seeding is recommended at high altitude cooler environments. Root stalks could also be planted at a density of 250000 /ha. *Bachiaria* performs under poor soil fertility conditions, but it responds to nitrogen and phosphorus fertilizers. However, to keep the pasture productive there is a need to apply fertilizer like manure every 2 to 3 years. Application of urea 50 kg/ha after every harvest keeps *brachiaria* productive. Its growth is vigorous with a dense soil cover and usually not compatible with most forage legumes, but under heavy grazing creeping legumes can be integrated. *Brachiaria* in most cases is generally free from pests and diseases, however recently released hybrid *Brachiaria* (Mulato) has been observed to be highly susceptible to pests (spider mite) during the dry period. These pests can also affect other crops and would use the grass as a reservoir. It is therefore important to monitor such pest infestations, and when happens, the grass should be cut and used to control the spread of the pest. Nowadays, in areas where Napier stunt is a problem like Kenya and Uganda, *Brachieria* is used in place of elephant grass specially in integrated maize forage production systems.

### Harvesting utilization and conservation

Depending on the production system and the way *Brachiaria* forage is cultivated the forage could be harvested and utilized in different ways. In many places, *Brachiaria* pasture planted for permanent pastures and is grazed by livestock. It is known to its high tolerance to heavy grazing. The leaf area

recedes showing some bare soil under lower rainfall conditions, but the stolons persist. It also grown as fresh feed under cut-and-carry systems by smallholders and for conservation. It is recommended to be harvested at stages between 10 - 50% flowering stage and is persistent under regular cuttings. But very frequent cutting results in prostrate leaf growth which is difficult to harvest. Brachiaria is also conserved as hay to be used in the time scarcity. It has also been planted as grazed ground cover in plantations and gives good cover for erosion control on hillsides.

### Dry matter production

Brachiaria produces leafy forage even during the dry season. The productivity clearly varies with the level of moisture availability. The average yields over different locations and years is 13.0 t/ha dry matter per year under rained conditions, when managed with supplementary irrigation the yield obtained can be higher than 20 t/ha dry matter per year.

### Feeding values

Brachiaria is an average good quality forage, and its palatability is also good with an average nutrient composition and digestibility for ruminant animals. Brachiaria is a productive leaf forage and at optimum harvesting stage for forage the leaf to stem ratio ranges between 1.75 and 2.06. The average nutrient content of Brachiaria grass evaluated in Ethiopia showed 11.5% crude protein, 8.6% ash, 60% neutral detergent fiber, 35% acid detergent fiber, 5.7% acid detergent lignin, and 60% *in vitro* dry matter digestibility on dry matter basis. The hybrid cultivar (Mulato II) was found to contain exceptionally high crude protein (18%), which is comparable to some legume forages.

### Seed production

Brachiaria is known to produces a quality seed in many places. However, country seed production in not widely practiced in Ethiopia due partly to the requirement of this grass for an extended day length to bear viable seeds. As a result, propagation is mainly done through root splits. In other countries, seed yields ranged between 400 to 4000 kg/ha. Fresh seeds are dormant up to 9 months. Prolonged storage or acid scarification breaks seed dormancy.



Brachiaria grass (Photo Credit: ILRI)



## Desho grass

### Description

Desho (*Pennisetum pedicellatum*) is a grass that is indigenous to Ethiopia and belongs to the *Poaceae* family. The scientific name of this grass is still unsettled. EIAR refers this grass as *Pennisetum glausifolium*. The grass is a perennial forage and has an extensive root system that anchors it well in the soil. It grows upright and can reach a maximum height of 90–120 cm, depending on soil fertility.

### Adaptation

Desho grass can grow anywhere from 1,500–2,800 masl; the optimum elevation is over 1,700 masl. The crop can grow well in medium-to-low fertility soil.

### Establishment

Desho requires very good land preparation. Splits of grass from root clumps can be used as planting material; grass clumps should be uprooted and separated into several splits. Stem cuttings from matured plants that have at least three nodes can also be used as planting material. For soil and water conservation purposes, it is recommended to plant at 10 cm intervals along bunds, with at least 10 cm between rows. For grazing land, it is recommended to plant at 50 cm intervals with 50 cm between rows. The leafy part of planting material should be removed before planting to reduce competition before establishment. After tilling the soil with hoes, place the split in the soil and press the basal soil around the seedling. Compost or manure should be applied at a ratio of about 4,500 kg/ha during establishment and about 1000 kg for maintenance. If using fertilizer, about 100 kg/ha should be used during establishment and 25 kg/ha should be applied for maintenance. The establishment and maintenance of desho requires labour and the crop is susceptible to intensive free grazing.

### Harvesting and utilization

Desho grass should be harvested when it is 8 cm high, and the highest yield can be obtained if it is first harvested 4 months after planting. The grass is suitable for a cut-and-carry system and as silage or hay for dry season feed.

### Dry matter production

It produces a high amount of biomass (10–20 tonnes dry matter/ha) with a potential for 2–4 cuttings per year with rainfed production and up to 9 cuts per year when using irrigation. The use of desho for feed and land management is increasing rapidly. Desho grass can be used as year-round livestock fodder. It is effective for erosion control through strip planting and can help rehabilitate degraded land. Desho grass can also improve grazing land management. Desho provides a small business opportunity for Ethiopian farmers through the sale of the cut grass and the planting materials.

### Feeding value

Desho grass is highly palatable and can be used as a good source of basal forage for all classes of livestock. On average this forage has a crude protein content of 10%, neutral detergent fibre of 61%, acid detergent fibre of 37%, acid detergent lignin of 6%, and in vitro dry matter digestibility of 58%.

## Seed production

The grass rarely seeds and propagation is mainly through root splits.



Desho grass (Photo credit: ILRI)

## Sweet lupine

### Description

Sweet lupine (*Lupinus angustifolius*) is an introduced and well adapted in Ethiopia. It is an annual legume that reaches a height of 60-150 cm. It is deeply tap-rooted reaching up to 2.5 m. The stems are robust and hairy, with profuse lateral branching. The leaves are digitate, and the leaflets are narrower than in white lupine. The inflorescence is a terminal, 3 - 30 cm long, false raceme bearing many blue pea-like flowers. The flowers are usually blue in color, but some new varieties have white flowers. Flowers produced 4 to 6 cm long hairy, pods producing 4 to 6 seeds per pod. The pods are large and shatter readily once mature, making them difficult to direct harvest. The seeds are hard coated, and they can remain viable in the soil for up to 20 years.

### Adaptation

White lupine is widely grown in northwestern Ethiopia since many years ago. But its food and forage value are very low due to its high alkaloid content. Since the early 2009 sweet lupine has been evaluated and registered in Ethiopia. Sweet lupine is palatable to humans and livestock. The species prefer light to medium textured well drained soils. It grows on acidic to neutral soils. Lupine is not tolerant to waterlogging, grows on soils with poor soil fertility. It grows from the warm mid altitudes to cool humid highlands mainly on nitosols and acrisols.

### Establishment

In Ethiopia where white (Bitter) lupine is produced. Lupine is sown on fallow lands with minimum tillage and virtually no type of agronomic practices like fertilize application, weeding etc is employed. However, as sweet lupine is important crop for both human and livestock its normally produced under improved management practice. The seeding rate of sweet lupine is 80 kg/ha (75 to 100kg). It is preferably planted in rows 40 cm apart and 10 cm between plants at the onset of main rain season (rain fed). Sweet lupine is tolerant to acidic soils and preferably planted to rehabilitate acidic soils. For

better productivity fertilizer depending on fertility levels should be applied. The general recommendation is 100 kg/ha DAP (18 kg N + 46 kg P<sub>2</sub>O<sub>5</sub>) at planting. Lupine starts flowering about 68 days after planting and the seeds matured at 156 ages of planting. Lupine is not tolerant to frost. Diseases and pests are not major problems for Lupine in Ethiopia. But in some cases, it could be affected by cut worms and maggots. Sweet lupine is mostly grown to produce grain, herbage and for green manuring. The grain is used for human and animal feed, the herbage for animal feed and soil fertility. It is commonly planted as a break crop / rotational crop to improve soil fertility but not common in mixture with other crops.

### Harvesting, utilization and conservation

Lupine could be harvested for three purposes for grain, forage, and green manuring. For seed or grain production lupine will be harvested when pods get brown, and the seeds get yellow. The grain is a good quality food for human being and a protein supplement to mono-gastric and ruminant animals. The forage could be used as feed for livestock by direct grazing or conserved as hay or silage. Grazing could occur before flowering stage but mostly recommend after stage of pod formation and could be done several times during the season of growth. Stubble grazing after removing the mature grains is also providing quality forage for livestock. Lupine plants cut after pod formation and left to dry and make hay for livestock. Dry forage of lupine could be pen-fed to livestock and the bitterness lupine made it necessary to wait for livestock to get used to it. It is also possible to make silage from lupine forage. It is recommended to cut it at the young flat pod stage and wilting for 24 hours and add molasses (3-4%). Another option is to ensile lupine forage in association with maize or sorghum. In countries like Ethiopia legumes like lupine is very attractive to most farmers as it gives different options of utilization.

### Dry matter production

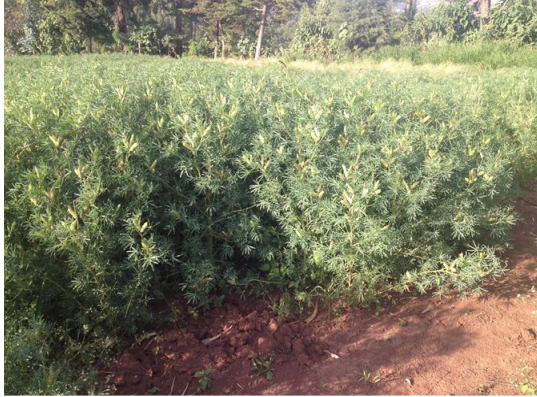
Sweet lupine seeds from "sweet" cultivars are used as protein source in animal feed. Sweet lupine stubbles left after pod collection are used for forage and silage. Sweet lupine flowers are also a good source of forage for honeybees. The forage dry matter yield reported is more than 5.8 t/ha dry matter.

### Feeding values

Both the grain and herbage have a very good feed value for livestock. The grain and leaves are palatable for animals. The grain has an average crude protein content of 36%, neutral detergent fiber of 34%, acid detergent fiber of 25%, acid detergent fiber of 5.7 and digestible organic matter of 86% on dry matter basis. The forage harvested at the optimum stage has very high crude protein content ranging between 18% to 20% based on dry matter basis.

### Seed production

As a dual-purpose crop lupine is produced both for the grain and forage production. Lupine produces quality seed; production of seed crop follows improved management practices. Seed harvesting should be made when the pods are mature (pods brown and seed yellow). Seed production is affected by frost and need to be produced in frost free areas. Grain yield varies with variety, management, and environment, but on average it produces 2.7 t/ha in a range of 1.7 to 3.5 t/ha.



Sweet lupine field and sweet lupine grain (Photo credit: ILRI)

## Rhodes grass

### Description

Rhodes grass (*Chloris gayana*) is a tufted, usually stoloniferous perennial tropical grass. It can grow 1 to 2 m height and is leafy. The stems have 2 to 4 mm thickness and leaves grow 25-50 cm long with a width of 3 to more than 9 mm. It is deep rooted up to 4.5 m. The inflorescence comprising 6-15 ascending or spreading, spike-like racemes 4-15 cm long, usually light, greenish brown (rarely yellow) in color, ripening to darker brown. Spikelets about 3.5 mm long, comprising 3-4 florets.

### Adaptation

Rhodes grass in Ethiopia grows from high altitude areas like Holetta (2400 masl) to very low and hot areas like Afar but reported to grow It can grow from sea level up to 2000 masl in the tropics. The most ideal place is in warm moist humid areas under rain fed and irrigation. It grows well on most well drained soils, except very heavy clays with pH between 5.5 and 7.5, but will grow down to pH 4.5 and up to 10. It is popular in irrigated pastures, particularly where irrigation water may be too saline for other species and under rain fed conditions of 500 to 1200 mm/year. Rhodes grass perform best when average air temperature is between 20 to 37oC and has also significant frost tolerance in the highlands but has poor shade tolerance.

### Establishment

Rhodes grass could easily be established from seeds, but it can also propagate vegetative. In Ethiopia rhodes grass is usually sown by broadcast at the seeding rates ranging between 2 -10 kg/ha depending on the agro-ecological conditions and seed bed preparation conditions. In cooler and wet highland areas sowing at the onset of the rain season at higher seeding rates (10 kg/ha) is an advantage. Freshly harvested seeds should be kept up to 6 months before sowing to break dormancy. Rhodes can grow on soils with poor fertility and highly responsive to fertilizer. The level of application will be good if it is based on soil test. But a blanket recommendation of 100 kg/ha DAP at planting and 50 – 100 kg/ha urea after forage clearing are used in many places. Application of fertilizer needs to be seen from its economic feasibility. Rhodes grass could be grown in mixture with grasses like panicum and Cenchrus and legumes like Desmodium, Stylo and Alfalfa. In rear cases some pests and diseases of Rhodes

grass can occur, however, they rarely have any economic impact. Weeding could be controlled using selective broadleaf herbicides like 24D or early mowing which reduces the vigorous effects of annual weeds specially in the very highland areas.

### Harvesting, utilization and conservation

Rhodes is fast growing especially if moisture and fertility is not limited. In the cooler highlands its establishment is slow and harvesting starts late. But in warmer areas it can reach for harvesting after 3 to 4 months of planting. Rhodes grass is very tolerant to heavy grazing and recovers very fast after burnings. Rhodes should be harvested while it is green (early blooming of about 50% blooming).

### Dry matter production

The highest yields are obtained in warmer moist humid agroecologies with high level of moisture. Yields in irrigation is very high as it provides multiple cuts per year. In the cool highlands yields are lower than in the warmer mid and low altitude areas. Growth of Rhodes in the first year is slower specially in the highland areas and yields are very high in the second year. Considering different variables forage yields could range between 10-25 t/ha dry matter per year. Forage yields more than 30 tons/ha are also reported on very fertile soils with adequate availability of moisture.

### Nutritive value

Rhodes grass is readily palatable for livestock. palatability declines when the grass over matures and the stubbles after seed harvest. When Rhodes grass is produced under irrigation and used as cut and carry or made into silage, it is highly palatable, and the nutritive values is also very good. Rhodes grass hay is very good basal diet to be supplemented with concentrate feeds for highly productive dairy cows. The average nutrient content of Rhodes grass forage grown in different sites in Ethiopia summarized from 84 reports showed 8.85 % crude protein, 68.6% neutral detergent fiber, 38.2% acid detergent fiber, 4.7% acid detergent lignin, 2.10 Mcal/kg metabolizable energy, 62.4% *in vitro* dry matter digestibility, 0.47% calcium, 0.32% phosphorus, 2.31% potassium, 0.14 % Mg and 58.56 ppm sodium on dry matter basis. There is not any anti-nutritional compound in Rhodes forage reported.

### Seed production

Rhodes grass is a good seed producer in Ethiopia. Rhodes grass field for seed production should be applied with adequate amount of fertilizer up to 100 kg/ha urea after clearing the herbage. The cleared field will start initiation of flowering within 2 months if moisture is not limited. The seed matures and ready for harvest within 3 to 4 weeks after start of flowering. After harvesting the heads manually, it should be piled to sweat (mature) for about a week before it is threshed. Rhodes could give 2 or 3 crops per year depending on availability of moisture. Seed yields could range 200 to 500 kg /ha. Fresh seeds have dormancy and need to be stored for about 6 months. Stored seeds are viable for more than five years.





Rhodes grass (Photo credit: Getnet Assefa)

## Tree lucerne

### Description

Tree lucerne (*Chamaecytisus palmensis*) is one of the few leguminous fodders and fertilizer tree species that perform well at high altitudes. The plant fixes and adds nitrogen to the system, enhancing livestock, crop and soil productivity. Commonly referred to as tree lucerne or tagasaste, it is native to Spain and also grows in Australia, Ethiopia, South Africa, Rwanda and New Zealand.

### Adaptation

Tree lucerne can grow in areas from 2,000 to over 3,000 metres above sea level (masl) in the Ethiopian highlands. It requires 350–1,600 mm of annual rainfall. The soil in which it is planted should be well drained.

### Establishment

Seedlings must be raised for at least three months in a nursery and are raised by private, community and government nurseries. Seedling production systems include bare-rooted and container systems. Tree lucerne seeds must be scarified or immersed in boiling water for one minute. Seedlings that are at least 45 cm tall are preferable for planting and a planting hole of 30–40 cm in depth is recommended to protect the taproots. Lucerne trees should be planted at least 25 cm apart from each other. The commonly recommended optimal spacing for tree lucerne plantation is 1 meter between plants and 1 meter between rows. When intercropped with other crops, wider planting spaces can be used. It can be planted as a live fence, a fodder lot, a part of soil and water conservation structures, a boundary plant or intercropped with crops and vegetables. Tree lucerne seedlings require regular spot weeding. Fencing should be erected to protect the trees against incursion by

livestock, including trampling and browsing during the establishment period. The use of mulch and/or manure is recommended to help retain moisture in the soil and suppress weeds. The plants should be watered soon after planting to improve survival and growth rates.

### Harvesting, utilization and conservation

Cutting the tree at a height of 1–1.5 m provides good biomass. The plant can be harvested 2–3 times per year, depending on growing niches and management practices. Access to reliable water supply and management factors—including fencing planted seedlings to protect from browsing, mulching during dry periods, clean spot weeding and applying organic fertilizers significantly enhances survival and growth of tree lucerne at Africa RISING planting sites.

### Dry matter production

On a well-managed farm, tree lucerne can be harvested and used as animal feed within nine months of planting. The lucerne tree can produce more than 4–8 tonnes of foliage dry matter per hectare when it is grown by using optimal planting spaces of 1 meter between plants and rows.

### Feeding value

The leaves and edible branches of tree lucerne contain large amounts of crude protein (20–25%) and digestible organic matter (>70%). The foliage can be fed to livestock green or wilted or preserved in the form of hay and used as needed. Giving a lactating dairy cow a 1 kg per day supplement of dried tree lucerne leaf feed can increase milk yields by up to 1.2 litres. Giving a fattening sheep a 300–400 g per day supplement of tree lucerne hay feed can increase daily body weight gain by 70 g. Tree lucerne foliage has got moderate levels of condensed tannins which do not affect feed intake and digestibility but would help to improve the overall ruminal fermentation of the feed consumed. Animals which are not adapted to eating tree lucerne foliage, should be introduced gradually, as palatability may be low at the first exposure. Wilting the foliage before feeding to cattle is recommended to improve palatability. Mixing with other feed resources before feeding is important.

### Seed production

Tree lucerne flowers extensively and as a result it is an important bee fodder. Smallholders who keep beehives can benefit quite a lot from this tree. Tree lucerne bear a considerable amount seed and the seeds can also be used as good sources of poultry feed.



Tree Lucerne fodder tree (photo credit: ILRI)

## Alfalfa

Alfalfa (*Medicago sativa*) is one of the most important leguminous perennial forage crops cultivated worldwide. This forage has superior nutritional quality, palatability, high biomass yield and adaptability to wide range of climates. The forage can be included in the diet of all class of animals as a source of protein. In poultry it serves as a source of carotene and minerals. Alfalfa has exceptionally a deep root system that can reach to more than 4 meters depending on the soil depth and fertility. This makes it tolerant to drought and cold and can survive extreme seasonal shocks and regenerate to provide forage throughout the year. It is highly suitable for irrigated fodder cultivation.

### Adaptation

Alfalfa can grow in low and high-altitude areas ranging from 600 to 2800 meters above sea level. As a result, it has high adaptability to cool and warm climates. This shows that alfalfa can be cultivated in most parts of Ethiopia although optimal conditions may not be fulfilled. The optimal growth conditions for this crop are 25°C average day-temperatures and 600 to 1200 mm annual rainfall. It favors a long day season and bright sun light. It grows best on deep, well-drained, sandy to fertile loamy soils, with 6.5-8.0 soil pH. However, it is susceptible to acid soils and liming prior to alfalfa establishment is needed in areas where the pH is lower than 6.5. Alfalfa is tolerant of drought due to its deep roots. Alfalfa responds well to irrigation but does not stand waterlogging or soil compaction.

### Establishment

Alfalfa forage is readily established from seeds. The seeds of alfalfa are small in size and good land preparation is needed before seeding. The soil needs to be ploughed repeatedly to ensure smooth and even texture of the land for seeding. A seed rate of 10-12kg/ha is recommended. Seeds can be drilled in rows of 50-70 cm apart at a depth of 2-3 cm. The seeds can also be broadcast; however, they need to be diluted (mixed) with sand prior to seeding for ease of handling and uniform distribution over the land. Under normal condition the seeds germinate within ten days, and it is important to monitor the field for weeds within one month after planting. Alfalfa is a nitrogen fixer and does not need fertilization under normal condition. For good results, however, it is recommended to apply di-ammonium phosphate fertilizer during the time of establishment at a rate of 100 kg/ha. The forage could reach for the first harvest in 3 months. It is recommended to start the first forager harvest after it starts to flower.

### Harvesting, utilization and conservation

Once established, alfalfa is capable of growing vigorously under optimal conditions. Subsequent harvests can be done frequently when the regrowth reaches above 50 cm height. With supplemental irrigation, alfalfa can be ready for harvest within 3-4 weeks, with a possibility of more than 12 harvests per year. The forage is highly palatable and can be used in different forms: as green feed, hay, pellet, and silage with other feed types. When grown in the backyard on small plots, the forage is ideal to use in a cut-and-carry system as an important protein supplement to lactating cows and other classes of livestock. When grown on large scale, farmers can make excellent quality hay from this forage that can be transported longer distances and traded commercially. For hay making the best stage of harvest is when 25-50% of the forage flowers. Alfalfa also makes very good pellets that can be used as a valuable ingredient in compound feed formulations.



## Dry matter production

Alfalfa is one of the highest yielding forage legumes and under good management it produces 15 – 20 tons dry matter per ha. Under irrigation it can produce up to 27 tons dry matter per ha. Regular hoeing and manuring would help to maintain high yield harvests per year. If the plot is unattended with regular hoeing and weeding, the yield potential may reduce after the third year of harvest. Therefore, it is important that alfalfa forage plots are managed properly to obtain the highest yield potential from the planted forage.

## Feeding value

Alfalfa is the king of all forages in terms of quality, as Napier grass is in terms of dry matter yield. It has 22-26% CP, 30-40% NDF, 25-30% ADF, 3.5-4.5% ADL, and more than 70% organic matter digestibility. As any other forage the quality of alfalfa forage depends on the stage of maturity at harvest, and the highest quality is obtained before the forage flowers. However, to balance yield and quality attributes it is advisable to harvest the forage at the initiation of blooming. Alfalfa can effectively replace commercial protein supplements in the diet of ruminants. In dairy cows feeding this forage plays an important role by providing the required nitrogen for protein synthesis, optimal level of readily degradable fiber that maintains high feed intake and productivity. The net energy content of one kg of alfalfa forage dry matter translates to more than 1.5 kg of milk in lactating cows. In poultry, alfalfa is an excellent source of vitamins and minerals.

## Seed production

Alfalfa easily bears viable seeds, but it requires adequate pollination. It is highly advisable for seed producers to establish beehives in the proximity of alfalfa seed production plots. This will give farmers a double advantage; use the plant as bee forage and ensure proper pollination. Seed yield per harvest could range from 225 kg to 500 kg per hectare.



Alfalfa forage planted in rows (photo credit: ILRI)

## CHAPTER SUMMARY & KEY TAKEAWAYS

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Cultivated forages provide multiple benefits to smallholder livestock keepers in the mixed crop-livestock system. Although their primary production is to obtain high quality feed, their integration in the farming system can contribute to increases in crop yields through control of soil erosion, improvement in moisture infiltration, nitrogen fixation and land rehabilitation. The common features of the selected forage crops described in this chapter is that they are high yielding and are of better quality, allowing farmers to harvest a considerable amount of feed biomass from small plots. The crops can be integrated in such a way that competition for land is minimized, and the complementarities are amplified by planting the forages on hedge rows, terraces, on fallow lands, as intercrops, mulches and in rotation with other food crops. The key takeaway messages from this chapter are the following:

- Cultivated forages have multiple benefits for smallholder farmers when they are integrated in the farming system appropriately
- As the traditional feed resource base of the country is dwindling, use of cultivated forages to produce feed for livestock has become a necessity
- The price of supplemental feeds in the local market is increasingly become expensive. This challenges farmers who depend on purchased feed resources to meet their feed shortfalls. Home-grown cultivated forages have demonstrated their potential to replace expensive energy and protein supplements, which would ultimately reduce the cost of production and increase household income.
- On the other hand, use of cultivated forages as cash crop provides alternative opportunities to generate significant amount of income for farmers
- Cultivated forages play key role in contributing to climate change mitigation and adaptation in the smallholder system; mainly by reducing enteric methane emissions from livestock, increasing carbon sequestration and water infiltration into the soil, land rehabilitation as well as control of soil erosion.

## PRACTICAL EXERCISES

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- Take the district or specific area where you are living or working currently. Try to describe the agro-ecology and farming practices in that area. Which cultivated forage would you recommend introducing in that area? Which growing niche you recommend the forage(s) to be cultivated? Provide explanations to your recommendations
- How do you evaluate the competitiveness of forage crop cultivation as cash crops? Hint: Try to relate current forage market prices in the local market, forage yield potential of the cultivated forages indicated in this manual, and yield and prices of other common crops in the area.

# Chapter 2 : Crop Residues Nutritional Improvement Methods / Techniques

Getinet Assefa\*

## LEARNING OBJECTIVES

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*This chapter intends to achieve trainees to know, the estimated total production and nutritional characteristics of major crop residues used as livestock feed in Ethiopia and the different nutritional improvement techniques suitable to small and medium level farmers in the mixed crop- livestock production systems.*

*At the end of this chapter learners will be able to:*

- *Understand the available crop residues and their nutritional characteristics in Ethiopia*
- *Know the possible methods that could be used to improve the nutritional quality and utilization of crop residues before and after the crop is harvested*
- *Know the different inputs, materials and facilities required in processing of crop residues to improve feeding values in different procedures (physical, chemical and biological means)*
- *Understand how and the levels of nutritional quality improvement of crop residues through the different improvement methods could be achieved*
- *Trainees will be able to know the procedures of treating crop residues using*
  - *Urea and*
  - *Effective microbes*
- *Understand how treated crop residues will be fed to livestock efficiently and all the precautions to be taken when feeding livestock*

## CROP RESIDUES RESOURCE BASE IN ETHIOPIA

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Crop residues are the remains of crops after the grains or valuable part is removed. These includes the straws from (tef, barley, wheat, oats, finger millet), stovers (maize sorghum and peril millet, haulms (chickpea, grass pea, field pea, lentil, etc.), oil crops residues (ground nut), vegetables residues, sugarcane tops and bagasse, sweat potato vines, and main others. Crop residues have divers uses. It is primarily used as feed and bedding for livestock. A significant amount of crop residues is also used for household fuels. Building materials, soil mulches and substrate for cultivation of mushrooms. It is also used for soil mulching, animal bedding, biofuel production, etc

In the crop-livestock mixed farming systems of Ethiopia crop residues are the main sources of roughages as feed for ruminant animals. According to the CSA (2019) it is estimated that crop residues contribute about 30 to 35% of the feed resources. During the last two to three decades the total

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acreage and production of crops and residues is increasing and its importance is increasing while the area of grazing lands is declining.

The importance of different crop residues varies in the different agro-ecologies. In the cooler highlands, barley, oats and rye straws are very important while in the mid altitude areas, tef, wheat finger millet are the main residues. In the mid to lowland area maize, sorghum and pearl millet are dominant crops. As a nation Maize, Sorghum, tef and wheat are the major crops in terms of cultivated areas and total grain and residue production. According to CSA (2017), the grain production from major crops were, about 267,789 tons of cereals, 29,786 tons of pulses and 8,551 tons of oil crops. Though their distribution and importance of the different crops are mainly agroecological based, the total grain and residue yields of cereal crops in Ethiopia are indicated in Table 1.

Table 1. Estimated grain and residue yields of main cereals in Ethiopia

NO	Crop	2017/18		2020/021	
		Grain yield (tons)	Residue yield (tons)	Grain yield (tons)	Residue yield (tons)
1	Maize	83,959	167,918	105,571	211,142
2	Sorghum	51,693	129,231	45,174	112,935
3	Tef	52,834	79,251	55,100	82,650
4	Wheat	46,430	69,644	57,801	86,702
5	Barley	20,530	30,795	23,391	35,087
6	Finger millet	10,308	12,370	12,030	14,436
7	Rice	1,510	1,963	2,682	3,487
	Total	267,263	491,173	301,749	546,438

Source: CSA, 2018 and CSA, 2021

Generally, crop residues are poor in quality. They are low in crude protein, energy and digestibility and very high in fibre. Though roughages are the natural feeds of ruminant animals, they don't usually support any meaningful production, unless crop residue feeds are supplemented with other nutrient rich feeds. The mean nutritional value of most common crop residues in Ethiopia are indicated in Table 2.

Table 2: Nutrient composition (%), digestibility (%) and metabolizable energy (mcal/kg DM) of commonly found crop residues in Ethiopia

No	Crop residue	CP	NDF	ADF	ADL	IVDMD	ME
1	Barley straw	3.4	73.9	48.3	6.2	53.5	2.0
2	Maize stover	2.8	70.1	34.7	4.0	58.0	2.1
3	Oats Straw	3.2	51.1		6.1	62.7	2.27
4	Tef straw	4.2	76.4	44.7	5.4	53.2	1.94
5	Wheat Straw	4.4	74.4	49.6	7.0	53.6	2.01
6	Finger millet stover	4.1	69.5		4.0	55.5	1.97
7	Bean Straw	7.6	57.2	44.6	8.3	54.1	1.99
8	Chickpea straw	4.4	54.9	41.1	10.3	51.8	1.91
9	Faba bean straw	8.8	59.2	46.8	13.2	55.6	1.97

No	Crop residue	CP	NDF	ADF	ADL	IVDMD	ME
10	Field pea straw	5.6	73.0	57.3	16.4	49.4	1.85
11	Groundnut haulm	10.0	43.9	58.3		64.0	2.15
12	Lentil straw	8.0	62.4	44.1	9.3	55.0	2.03
13	Linseed straw	5.2	64.6	52.5	14.0	48.8	1.82

Source – ILRI

CP=crude protein, NDF= neutral detergent fibre, ADF= Acid detergent fibre, ADL= Acid detergent lignin, IVDMD= in vitro dry matter digestibility, ME=metabolizable energy

## CROP RESIDUES IMPROVEMENT METHODS

The quality and quantity of crop residues produced could be maximized at different stages of the crop production. The producer has to select the appropriate variety that best suits for grain and residue production, follow good agronomic practices and should be harvested at the right time. This should follow, proper and timely threshing, collecting of the residue, storage and finally apply different techniques to further improve the feeding value of the residues. The main focuses to be made in the pre-harvest management and post-harvest treatment options of crop residues suitable for most smallholder farmers are discussed as follows.

### Preharvest crop management

The amount of crop residue produced, and its quality of a given crop is affected by the variety and all agronomic practices. Selection of varieties is primarily for the grain productivity. When grain yield and quality are similar among varieties, it is always advantageous to look the variety with the highest biomass yield. For example, there are varieties of sorghum which are taller and late maturing. There are also shorter and early maturity varieties. In areas where these varieties grown, biomass yield need to be considered as it is important for livestock feed and many farmers prefer the taller varieties. Such practice should also be considered in other crop species and varieties and is one of the good strategies to increase residue yields.

One most critical step very much affecting the crop residues yield and quality is the harvesting time. In some areas crops are not harvested at the right time. This is commonly practiced in many crops like maize in different areas of Ethiopia. Such practice resulted in a very rapid and significant deterioration in the feeding value of the crop residue. Therefore, crops need to be harvested at the right time. Once the crops are harvested it should be threshed properly and collected as quickly as possible and the residues to be stored in such a way that it is not exposed for rain, sunshine and pests such as termites.

## Postharvest management of crop residues

As the quality of crop residues are poor it is usually advantageous to improve the feeding values to boost its intake by animals, digestibility and increase nutrients through different methods. Generally, crop residues are treated physically, chemically and biologically. The use of these methods varies from place to place. Based on the prevailing situation and the feasibility of the methods farmers can use the suitable and appropriate options. Here are the main treatment options of crop residues.

### Chopping and grinding

#### Chopping

Chopping is the most common physical treatment of crop residues widely utilized by smallholder farmers. Its primarily important for crop residues with thick stems like maize, sorghum and pearl millet. Moreover, it is also beneficial to chop other crop residues like wheat, barley, oats, faba bean, grass pea, lentil etc. Chopping could be done by small hand tools like machete and chopping machines, which is usually run by electric or diesel engines. There are also manual chopping machines.

Roughages could be chopped in a size of 1-4 cm and if water is available, it is good to spray and stay for about 4 hours before feeding to animals.

The advantages of chopping roughages like crop residues and hay are:

- Chopping minimizes wastage of feed
- It avoids selective feeding and maximizes its utilization. Animals usually select the most nutritious parts like leaves to stems. Hence chopping minimizes selective feeding of animals.
- Chopping increases intake of roughages
- Improve the overall feed use efficiency to increase productivity.

When farmers produce different types of crop residues including cereals and legumes, chopping and mixing this crop residues in different proportion to meet a certain level of protein and feeding targeted animals is very important. Such mixtures are usually more palatable and nutritionally good. Farmers are also traditionally feed such mixtures for fattening and dairy animals.

#### Grinding

If the means and options are available, crop residues may also be ground by residue grinding machines to sizes of 0.6 to 0.8 mm sieve size. Such practice is reported to be very effective. The ground crop residue is usually mixed with other feeds and fed to animals directly or even the mix could be made to pellets.

Generally chopping and grinding increases intake by animals by more than 25%. It has also reported such practice increases feed passage rate and overall efficiency of feed utilization. Under Ethiopian condition nutritionally poor crop residues like cereal straws and stovers could be chopped and mix with chopped haulms like grass pea, lentil, field pea, chick pea and faba-bean. Chopped and ground crop residues, can be feed to animals in mixture with green feeds, concentrate feeds based on the requirements of animals.



If facilities are available passing chopped and ground crop residues in pressurized steam could improve the digestibility and intake of crop residues.



Chopping of crop residues with machete (left) and grinding and chopping using motorized choppers (right) (Photo credit: ILRI)

## Urea treatment

Fibrous crop residues are characterized by an imbalanced array of nutrients, of which fermentable nitrogen (< 5%) and digestibility (<50%) are limiting. Feeding strategies should therefore aim to maximize fibre degradability in the rumen, optimize microbial protein synthesis. Fibre digestion in the rumen is enhanced by supplying a readily fermentable sources of nitrogen and giving readily digestible energy feeds.

To improve feeding values of cereal crop residues, different chemical treatments has been developed. However, these chemicals are not easily available and not affordable for many of the farmers and more importantly handling the treatment procedures requires strict precautions and skills as most of them are toxic. However, urea has been utilized for many years in different countries. This is an old method which has been started in the 1940s in Norway and Germany, since then it was expanded to many countries all over the world. The technique is very appropriate for many developing countries due to its ease of applicability and utilization.

The main benefits of using urea to treat crop residues for smallholder farmers are:

- The treatment procedures are simple
- Urea is available in most of smallholder farmers as it is mainly used as fertilizer
- Urea treatment doesn't have any negative health effects both in animals and human beings
- It remarkably improves the nitrogen (crude protein) and digestibility of cereal crop residues

## The chemistry of treating crop residues with urea

Urea treatment consists of spraying a solution of urea to a dry mass of straws and stovers and covering with locally available materials in order to form an airtight seal (anaerobic conditions). Urease is an enzyme which slices the urea molecule and hydrolysis of urea takes place only in its presence. Urease is produced by ureolytic bacteria which is naturally occurring on straws and stovers. Therefore, treatment conditions should thus favor the development of ureolytic bacteria within the crop residue being treated; adequate moisture, temperature, treatment duration, at the same time deterring any microorganisms which might cause mold or decomposition are critically essential. The only case where it might be necessary to artificially add urease for urea treatment is when the treatment is carried out with very little water at low or even fresh ambient temperatures. The main nutritional effects of urea treatment of crop residues are:

- Improve crude protein contents like from 4 to 9%
- Improve digestibility by up to 40%
- Improve intake sometimes doubles intake

## Procedures of urea treatment of crop residues

### Materials required

1. Crop residue – normally crop residues for urea treatment are cereal residues (Straws and stovers) and poor roughages like natural pasture hay. The crop residues or roughages could be more effectively treated if they are chopped to smaller sizes (2 to 4 cm)
2. Plastic sheets or other protecting and sealing materials
3. Urea – Fertilizer grade urea are normally used for treating cereal residues.
4. Molasses (Optional)
5. Water – clean water is required to dissolve urea and sprayed on the crop residues
6. Pits silos, plastic bags or any sealing facilities – these are materials required to put the treated residues under high compaction and sealed conditions.
7. Balances and watering cans - these are used for weighing the crop residues and urea. The watering will be used to mix and make the solution and watering cans used to spray the solution on the crop residues uniformly. Alternative local measuring materials could also be used.





Dissolving urea in water using small container (left) and mixing the dissolved urea, molasses in a larger container and stirring to mix it properly (right) (Photo credit: ILRI)



Photo: Spraying the urea molasses solution on straw (left) and chopped stover (right) spread on a plastic sheet. (Photo credit: ILRI)



The crop residue sprayed with the urea and molasses solution will be filled to different types of silos (left) bags (right) or other airtight containers and need to be compacted finally sealed to make air tight. (Photo credit: ILRI)

### Urea Treatment Procedures of Crop Residues

- Prepare a silo, pit, silage bags, or large volume plastic barrels – the type and volume of the silos or containers should be based on the total volume of crop residues to be treated and availability of resources. A farmer with 2 crossbred cows can make about 200 kg straw which is enough for 2 weeks. For this a silo size of 1m wide by 2 m long and 1M deep is enough.
- Prepare the crop residues to be treated – it should be chopped and weighed.
- Prepare 5 kg of fertilizer grade urea to treat 100 kg of crop residue
- To improve palatability and digestibility of treated crop residues it is advisable to add about 10 kg of molasses for 100 kg of crop residue (but this is optional and not a must).
- Good level of moisture in the crop residue is advisable for effective urea treatment. The recommended moisture content of the treated product is about 30%. Based on this, depending on the level of moisture in the crop residue and weather conditions 60 to 80 litres of water is enough to treat 100 kg of crop residue
- Mix the 5 kg of urea with 60 to 80 litres of water and then add 10 kgs of molasses and stir to mix uniformly
- Spread the chopped 100 kg crop residue on a plastic sheet and spray with the mixed solution. It is advisable to uniformly spray to all the crop residue by turning properly. Spraying repeatedly or portion by portion is advisable than do it at once.
- Finally fill to the silo, plastic bag or silage container and make the maximum possible compactions to remove air inside. At the end seal with plastic cover or any air thigh material to facilitate anaerobic conditions. Put heavy loads like stones at the top.
- The treated crop residue will be ready for utilization in 21 days. From the silo a required amount of treated crop residue will be taken out and spread on a plastic sheet for overnight before it is fed to animals.

Practical conditions which affect successful treatment of crop residues by urea include; the presence of urease, the application rates of urea, moisture content of the straw/stover and application rate during treatment, ambient temperature and the length of treatment period, the degree of sealing for creating anaerobic conditions and the quality of crop residue. The average improvement levels in Ethiopia are presented in Table 3.

Table 3. Responses of cereal crop residues to urea treatment under local condition

Crop residues	Crude protein (%)		Dry Matter Digestibility %	
	Untreated	Urea Treated	Untreated	Urea Treated
Barley straw	4.0	7.4	40.4	59.4
Tef straw	3.8	8.9	56.6	60.8
Wheat straw	2.4	7.3	38.0	48.0
Mean	3.4	7.9	47.0	56.1

## Effective Microbes (EM) treatment

Biological treatments of crop residues are widely used in many countries, however, in most developing countries they are not well developed and utilized. Among other biological treatments of crop residues, use of Effective Microbes (EM) is the widely used biological treatment technology. Effective microbes are first established in Japan in the 1980s. Effective microbes is the mixture of lactic acid bacteria, yeast and photosynthetic bacteria. In Ethiopia EM technologies were introduced about 15 years ago, and it is also recent technology in most developing countries.

Effective microbes help to increase digestibility of fibrous feeds like crop residues by directly producing enzymes, organic acids, amino acids, hormones and other chemicals inside the digestive system of the animals.

In addition, these effective microbes rapidly multiply themselves and controls the effect of other harmful microorganisms. It also suppresses microorganisms that produces bad smells like in barns and improve the overall productivity of animals.

### Sources of EM solutions and preparations

For treatment of crop residue, EM is commercially available as effective microbes' solution one (EM-1). EM-1 is available from a local company called Weljeje in Debre Zeit. In treating crop residues and other feeds sources this EM-1 will be brewed to effective microbes' solution two (EM-2). This EM-2 solution will be directly used to treat feeds. The following are the procedures to prepare EM-2 solution.

#### Material required

1. EM-1 solution
2. Molasses or sugar
3. Warm water
4. Air tight jerricans

#### How to make the solution

Mix 1 litter of molasses (if molasses is not available it is also possible to use 30 to 50g of sugar) with 18 litters of warm water (body temperature / 35 to 40oC) and stir until it is completely dissolved. In this solution add one litter of EM-1 solution and stir so that the solution is properly mixed. The solution will have a total of 20 litters volume and will be poured in to a 20-litter capacity jerrican and tightly closed or sealed so that it will create anaerobic condition.

The sealed solution should be put under a shed /room and warmer place and will be allowed to ferment for about 10 to 14 days. When the temperatures is 20 to 25oC it could be adequately fermented in 10 to 14 days. The number of days depends on the environmental condition in warmer areas the fermentation can be completed in shorter days but in cooler areas (< 15oC) it can take up to 30 days. In this fermentation process usually, gas could be produced. This gas can be expelled using a small valve fitted to the cap of the jerrycan. This valve needs to allow the gas to get out but prevent any entrance of air. This is usually done for intensive systems and research conditions. However, under smallholder farmers conditions one can remove the gas by slowly losing the cap for short time and recapping properly.

### **Effective Microbes (EM) to improve feeding values of crop residues and other uses**

Effective microbes could be utilized in different ways to improve feeding values of crop residues

1. Directly spraying EM-2 solution on crop residues at the rate of 20 litres EM-2 solution on about 15 kg crop residues and keep it for about 4 hours and ready to feed animals
2. Treating crop residues using EM solutions to make a silage. One can use EM-1 solutions and EM-2 solution to treat crop residues as silage. The procedures are described in detailed. After the treatment the silage will be ready for utilization in 4 to 6 weeks
3. EM could also be included in drinking water of ruminant animals. The EM-2 solution should be added at 0.2% (100 ml EM solution to 50 litres of water). Properly mix and allow animals to drink ad libitum.
4. EM could also be used to treat concentrate feeds like wheat, rice and maize brans, poultry litter and other organic concentrates feeds. The treated cereal brans are called Bokashe.
5. Effective Microbes is also used to avoid or reduce bad odour of barns and poultry houses when sprayed on barn floors.

### **Crop residue treatment using EM-2 solution**

The EM-2 solution will be used to treat crop residues that will be use to feed animals. The EM-2 solution should be used in few numbers of days but it is advised not to store more than 30 days. The EM2 solution could be used to treat crop residues in two ways. Crop residues particularly stovers (maize, sorghum and peril millet) should be chopped (in 2 to 3 cm size) and shred. This makes the treatment very effective. It is also always an advantage that straws like wheat, barley and oats are chopped for efficient treatment.

### ***Spraying crop residues and feeding animals***

The simplest way of using of EM-2 solution in treating crop residues is just spraying the solution and feed to ruminant animals after few hours. In this process you need to have, EM-2 solution, water, chopped crop residue, water can, and plastic sheet.

1. Depending on the scale of farming one can treat different amount of crop residues at a time as required. First mix 1 litre of EM-2 Solution with 20 litres of clean water and stir it to mix properly. This solution is enough for about 15 kg of straw/ stover. This is equivalent to one bale of straw. If balances are available, one can weigh about 15 kg. The amount of solution could be prepared proportionally to the quantity of crop residue to be treated.
2. Spread the crop residue on a plastic sheet. Using a watering can or similar materials spray the solution on the crop residues. Try to spray uniformly by turning over the crop residues.
3. After spraying cover the straw / stover with a plastic sheet and keep it for about 4 hours.
4. After four hours the treated strow / stover could be fed to ruminant animals

### ***EM treated crop residue silage***

This is basically the same procedure and a similar method of ensiling urea treated crop residues. EM treatment for ensiling crop residues could be done using both EM-1 and EM-2 solutions. The materials required are similar when one treats crop residues with urea. The procedures are as follows:

- Prepare an ensiling facility either a pit silo, or large volume barrels and other similar materials. For pit silo if it is not concrete one can use plastics and plant leaves like ensen leaves to protect the soil contact. The size of the silo or containers depends on the capacity and plan of the farm.
- Chop the crop residues with a size of 2 to 4 cm. This increases surface area and proper exposure for the solution. Chopping is generally very important for all crop residues but necessarily important for stovers
- Prepare the EM solutions – you can use EM-1 solution (unfermented) or EM-2 solution fermented
- If one wants to use EM-1 then mix 1 litre of molasses (if not available, one can use 30 to 50 g of sugar) with 18 litres of warm water (Body temperature) and stir it to mix very well. Add EM-1 solution and stir to mix properly. This solution is ready to treat the crop residues to be ensiled.
- If one wants to use EM-2 – prepare 20 litres of EM-2 solution
- The above prepared EM solution (EM-1 and EM2) is enough to treat About 50 to 70 kg of dry crop residues in silage making
- The crop residues to be treated with EM will be sprayed very well with water and kept for overnight. Use 2 litres of water for 1 kg of crop residues.
- Fill the rinsed crop residue to the silo or barrel to a height of about 20 cm and spray the EM-solution, fill again the rinsed crop residue for about 20cm and spray the EM solution. Continue like this until the crop residue is finished. Please try to estimate uniform distribution of the EM solution to the total crop residue. Another option is also spread the straw on a large plastic sheet spread the crop residue uniformly and spray the EM solution uniformly and put into the silo or ensiling container.
- When filling the treated crop residue to the silo and container please make all possible compaction so that there is no any air inside to create anaerobic conditions



- At the end seal the EM treated crop residue with plastic sheet and put heavy things on it and leave for 4 to 6 weeks.
- The EM treated straw will be ready to be used as feed for ruminant animals after 4 weeks in warmer areas and in about 6 weeks in cooler areas.
- A good EM treated crop residue smells very nice, with light yellow to light brown colour and no any decay or fungus on it.



Effective microbes (EM) solution (left), processing EM1 solution to EM2 solution (right). Photo credit: ILRI)



Crop residues treated with effective microbes (EM) smells very attractive and normal color (right). Photo credit: ILRI)

### ***Feeding EM to animals with drinking water***

Feeding of EM to ruminant animals through drinking water is the simplest method that could be applicable to most smallholder farmers. The type of EM to be used is EM-2 solution which is prepared from EM-1 and fermented for 10 to 14 days. Assuming an average daily water consumption of cows to be 50 liters of water about 100 ml of EM-2 solution is enough. Which means 1 litre EM-2 solution could be mixed in 500 liters of water and enough for 10 cows.

The EM in the drink of water helps to facilitate digestion of fiber (crop residues) in the rumen, enhance intake of feed and overall improvement of productivity.

### **Other uses of EM**

Besides treating crop residues, EM could also be used to treat concentrate feeds like wheat, rice and maize brans, poultry litter and other organic concentrates feeds. The treated cereal brans are called Bokashe. It is prepared by treating the cereal bran with EM and keep it for 4 to 5 weeks under anaerobic condition similar to the silage making. This has nutritional advantages such as improving digestibility.

It is also used to reduce bad smells in barns and poultry houses when EM solutions are sprayed on barn floors.

### **Improved use of crop residues through supplementation**

Supplementation of crop residues with high protein and energy feeds is one of the best methods of maximizing the efficiency of its utilization. Normally for productive animals both the untreated and treated crop residues are not nutritionally adequate to support meaningful production. Therefore, crop residues need to be supplemented with quality feeds like green fodder or concentrate feeds, which have high crude protein and energy contents. The level of supplementation, however, is lower for treated straws relative to the untreated crop residues.

Many smallholder farmers may have limitation to afford concentrate feeds. Under such condition cultivation of forages especially those with high crude protein contents and higher biomass yields like alfalfa and elephant grass are alternative options. Cultivating forage crops by smallholder farmers have multiple advantages. 1) farmers can easily access quality feed in their vicinity 2) It gives farmers to use the forage in different forms such as in cut and carry, or conserved forage at the time of need 3) could be cheaper source of high-quality feed 4) have an advantage to conserve the natural resources and improve soil fertility and many other functions.

Farmers may also have challenges to cultivate forage crops for various reasons, such as shortage of land and other resources and supply. However, forage could be produced in different strategies targeting to address different forage production problems. For those who have land they can conventionally cultivate forage crops under rainfed or irrigation. While others could produce forage in their backyards, under-sow in their crops like maize and sorghum, or cultivate in rotation, grow as part of natural resources conservation activities or other methods. Details of forage production practice in and the different production niches are described in the cultivated forage production and utilization section of this manual

## **CHAPTER SUMMARY & KEY TAKEAWAYS**

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- Crop residues are the major feed resources used as livestock in the crop livestock mixed production systems in Ethiopia. The major sources of crop residues are from cereals (Maize, Sorghum, tef, wheat and barley).

- Crop residues are generally fibrous poor-quality roughages and their nutritional values as livestock feed is low. They are especially very low in crude protein and energy contents. Though the total production is low the quality of legume crop residues is better compared to cereal residues.
- Proper selection of crop species and varieties, appropriate agronomic practice, harvesting at appropriate stage and time, and proper storage are good practice to get quality and high crop residues.
- There are different physical (chopping and rinsing), chemical (urea treatment), and biological (use of effective microbes) methods to improve nutritional quality of crop residues.
- Physical processing of crop residues like chopping and rinsing improves nutritional value of crop residues in terms of intake and digestibility and efficient utilization.
- Urea treatment of cereal crop residues primarily improves crude protein content. It also improves intake, digestibility and efficient utilization
- Effective microbes produce different enzymes, hormones and other chemicals, which helps to improve the flavor, intake, digestibility and overall nutritional efficiency of crop residues.
- Crop residues even after treatments they may not be nutritionally adequate to feed for productive animals. Therefore, depending on the level and type of production (milk or meat) crop residue basal diets need to be supplemented with quality green forages or concentrate diets.

## PRACTICAL EXERCISES

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Identify a certain rural locality you are familiar?

- List out the major crop residues produced in the locality in the order of their estimated total production?
- Indicate average or range of the crude protein contents mostly reported for each of the crop residue?
- Based on the prevailing situation in your locality which crop residue quality improvement method is appropriate and why?

What are the nutritional benefits of processing or treating cereal crop residues by

- Chopping and rinsing
- Urea treatment
- Essential Microbes
- Supplementing with quality forage or concentrate feed

Indicate the procedures of making EM2 (Effective Microbes solution 2) from EM1 (Effective Microbes solution 1).

Mr Kebede is a dairy farmer he feeds his animals with untreated crop residues. The extension worker, Tesfaye advised Mr Kebede the benefits of treating his crop residues with urea and effective microbes. Mr Kebede was convinced with the idea and agreed to treat his crop residues to feed his animals. Mr

Kebede has planned to treat 200 kg wheat straw with urea and 200 kg barley straw with Effective Microbes. Tesfaye has agreed to demonstrate how to treat the crop residues.

Please workout the following questions to treat Mr Kebede's crop residues

- When treating the wheat straw with urea
- What are the different inputs, materials and facilities required?
- What will be the quantity of each of these inputs required (urea, size of silo, water, molasses, etc)?
- Clearly describe the procedures of treatment?
- How long shall he keep the treated crop residues before it gets ready for utilization?
- How do Mr Kebede feed the urea treated crop residues feed his animals, and what are the precautions ne should made before feeding?

When treating the barley straw with EM1 and EM2 (Effective Microbes solution 1 and 2)

- What are the different inputs, materials and facilities required?
- What will be the quantity of each of these inputs required (EM1, or EM2, size of silo, water, molasses, etc).
- Clearly describe the procedures of treatment, show the different treatment options using EM1 and EM2
- How long shall he keep the treated crop residues before he starts utilization
- How do Mr Kebede feed the treated crop residues to his dairy animals

# Chapter 3 : Methods of Planning Livestock Feed Requirements

Getinet Assefa\*

## LEARNING OBJECTIVES

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*This chapter intends to achieve the following objectives.*

- *To give highlights on the benefits of feed planning in a given farm, village or district level. It will give also the principles and the information required and the procedures to follow in planning feed requirements for a given period of time.*

*At the end of this chapters, learners will be able to:*

- *Understand how planning of feed requirements and acting accordingly are essential in a given farm to keep the farm productive throughout the different months of the year and more profitable.*
- *Know the basic data / information required to estimate and plan feed requirements of animals*
- *Be able to estimate live weight of animals, which is the basic information used to estimate feed requirements, using different methods,*
- *Understand how to estimate daily feed requirements of different classes of animals*
- *Will be able to estimate dry matter / residues yields of the major feed sources (forages of different species, crop residues from the major crops and natural pasture)*
- *Understand the different feeding systems of livestock in the mixed crop livestock production system in Ethiopia*
- *Will be able to estimate feed requirements (daily, quarterly, biannually, annually or any given period of time) for individual farmers, villages, woredas, zones or even at broader perspective.*

## INTRODUCTION

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Planning on feed requirements of a given livestock farm is the main and essential activity for successful husbandry. The scope of the planning could stretch from traditional system to well-organized commercial farms. Planning feed requirements for commercial livestock farms are simpler and follows established guidelines. Moreover, these farms have required updated information that helps the planning. These plans are more precise and normally done professional to make the farm profitable.

On the other hand, traditional livestock systems, like in Ethiopia, as pastoral, agro-pastoral and crop livestock mixed systems, planning feed requirements is a very difficult task. It is generally done as routine practice and done through traditional way, which lacks precision and effectiveness. For example, pastoralists plan to have feed and water through moving from place to place in annual basis.

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This movement has a pattern over the locations and seasons to get adequate and good quality pasture and water. Planning for crop-livestock mixed systems is better than the pastoral systems but still feed requirements are not clearly known and farmers try to manage whatsoever feed available and mostly not planned based on requirements. There are always difficulties when one tries to plan feed requirements for such traditional livestock production practice. This is because the basic information for planning are not available or very crude estimates, and it is common to see feed shortage as the main challenge problems in some months and weight loss of animals are very common. Under such circumstances the best way of planning is through experiences which is an established good practice through trial and error. Moreover, if one properly uses different tools to estimate the required data and information that helps for planning of feed requirements, performance of the farms will improve very well.

Basic tools and information required for planning of feed requirements focusing on crop livestock mixed systems under Ethiopia condition are described as follows.

## **BASIC INFORMATION ON YOUR LIVESTOCK, THE MANAGEMENT AND RESOURCES AVAILABLE**

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Basic data or Information on your livestock need to be well documented periodically to properly plan the management of the farm such as the feed requirements for a given period of time. Planning on feed requirements could be done at different levels, from national, village and individual farm level. It could also be planned annually, biannually or on quarterly basis. The most common and effective is planning at individual farm levels on annual basis. Feed planning or sometimes called feed budgeting in a given farm has the following purposes.

- It ensures animals are fed properly, so we can reach the set production targets.
- It ensures minimisation of feed wastage.
- It helps to predict feed surpluses and deficits and act accordingly.
- It helps to design a strategy of acquiring the required feed including roughages in time
- The supplement feed requirements can be foreseen a long way in advance and therefore purchased at the lowest possible price.

In planning the feed requirements of a given farm or herd, one has to critically look in to three major components

### **The animals**

In planning feed requirement, the first thing to know the details of animals in the farm.

- a. Which type and number of animals are in the farm? (Cattle, Goats, Sheep, mixed, etc)
- b. What is the main purpose of the animals (milk, meat, power)
- c. How many are there in the different categories (milking cows, growing animals, heifers, steers, bulls, calves, etc)
- d. Good if one has individual liveweights periodically

Knowing the details of the herd structure will help the feed requirements for a given period of time. Feed requirements could be expressed in many ways, in terms of total dry matter, or in terms of roughages, concentrate supplements, and total mixed rations (TMR) or all details of nutrients (protein, energy, vitamins, minerals and water) based on the level of intensification of the farm.

Feed and nutrient requirements of individual animals could also further disaggregate as for maintenance, production (milk, growth/meat, power/traction, etc) and pregnancy. This makes estimation and planning of feed requirement precise and increase productivity and profitability of the farm.

## The management of the animals

The management of the animals could be classified in different ways. One can broadly categorize as pastoral, agropastoral and sedentary (crop-livestock mixed systems in Ethiopia) production systems. The other classification could be the extensive, semi-intensive and intensive systems. It could also be classified as traditional and commercial production systems. In dairy it could also be categorized as rural, peri-urban and urban systems. Most of these classifications are based on the level of feed availability and feeding systems. Hence, if a farm has clear farm management practice one can have a practical plan the annual feed requirement.

In all the management systems the main challenge is lack of uniform supply of feed over the seasons. Seasonality of feed availability is very crucial in the tropical livestock production systems. It is sever in the pastoral and agropastoral systems. This seasonality of feed supply has also a huge influence on feed and products (like milk) price-variability over the seasons. It is important to look months of peak feed supplies, times of feed scarcity and associated feed related matters. Therefore, in planning we may need to clearly identify which months have critical feed scarcity, or good supply, in which seasons are feeds cheaper and the supply is good. This helps the farm to maintain production levels consistent throughout the year and makes it more profitable.

## The available feeds

The other side in planning feed requirements is looking the feeds required and available for livestock. Therefore, one has to clearly list out the feed available around the area and the additional feeds to be purchased or produced. These includes:

- The area and expected grazing land and estimated productivity. In countries like Ethiopia where communal grazing practiced, it might be very difficult to estimate for individual farmer or animal.
- The estimated feed from the crop aftermath grazing
- The amount of hay produced and conserved annually
- The amount of crop residues produced annually by crop type
- The area and total production of cultivated forages (either in cut and carry systems, conserved hay or silage)
- The concentrate feeds (formulated feed, grains, agro-industrial by products, etc) available or to be purchased

- Prices of roughages and concentrate supplements over the months of the year
- Any other feed available that could be quantifiable or estimated
- Average quality profiles of the feeds for major nutrients like protein, energy, digestibility, etc

## ESTIMATING FEED REQUIREMENTS OF ANIMALS AND A GIVEN FARM

In the modern livestock production systems calculations of feed requirements are done using computer soft wears or manually calculated with established procedures. In these systems the main required information are live weight of animals, physiological stages, product types and levels, price of feeds and other relevant information. However, most Ethiopian livestock production practice are still traditional.

The main data required to determine (estimate) feed requirements of an animals is weight of each animal, physiological stage and production levels. Annual feed requirements of a given farm will be the sum of daily feed requirements of all the animals in the farm multiplied by the 365 days.

Hence first determine or estimate the weight of each animal. Under smallholder farmers conditions, getting liveweights of animals specially for large animals is very difficult or not usually available. More precise estimate of feed requirements is normally derived from a good estimation of liveweights of animals. There are different alternatives to estimate liveweight of animals as follows. However, their level of precision is different.

- Using appropriate balances to weigh animals
- Estimating weight through body heart girth measurements
- Estimating using conversions factors as tropical livestock units (TLU) which is about 250 kgs

The use of TLU is mostly applicable for most smallholder farmers as weighing and measuring facilities are not available. The conversion factors are indicated in Table 4. But still close supervision and use of the proper conversion factor makes the estimation mor precise.

Table 4 – Conversion factors of different livestock groups into Tropical Livestock Units (TLU)

No	Description of animals	Conversion factor to TLU*	No	Description of animals	Conversion factor to TLU
1	Calf	0.20 - 0.25	10	Sheep Young	0.06
2	Crossbred calves	0.40	11	Goats Young	0.06
3	Weaned calf	0.34	12	Sheep mature	0.10 - 0.13
4	Heifer	0.50- 0.75	13	Goat mature	0.10 - 0.13
5	Local Cow	0.8 - 1.00	14	Donkey Young	0.35
6	Local Oxen	1.00 – 1.10	15	Donkey mature	0.50 - 0.70
7	Crossbred cows	1.80	16	Camel	1.25
8	Crossbred oxen /bulls	1.9	17	Chicken	0.013
9	Crossbred Heifers	0.70	18	Horse	0.8- 1.10

TLU – Tropical livestock unit which is equivalent to 250kg; Sources: Storck et al, 1991 and Greyseels, 1988

## Example

If a farmer has 2 crossbred cows, 3 local oxen, 2 crossbred calves, one crossbred heifer, 1 mature donkey and 15 sheep. The total TLU the farmer has will be calculated as follows:

Table 5. Example on how to convert the type and number of animals a farmer has to TLU

No	Animal description	Number of animals	Conversion factor to TLU	Estimated TLU
1	Crossbred cows	2	1.80	3.60
2	Local oxen	3	1.0	3.00
3	Crossbred calves	2	0.40	0.80
4	Crossbred heifer	1	0.70	0.70
5	Mature donkey*	1	0.5 - 0.7	0.60
6	Sheep*	15	0.10 - 0.13	1.73
	<b>Total</b>			<b>10.43</b>

Average conversion factors used.

As indicated in Table 5 the farmer has about 10.43 TLU animals, which is equivalent to

$10.43 \text{ TLU} \times 250 \text{ kgs} = 2,606 \text{ kgs}$

Therefore, the farmer requires for his all animals (herd), which totally weighs about 2606 kgs for a given period of time. Note that if the actual weights of individual animals are available feed requirements are calculated for each animal and sum up to estimate for the farm.

Exercise: Eg. TLU conversion exercises

## Estimating feed requirement of animals in terms of dry matter and nutrients

Once you know the total number of animals and their live weight estimates the next step is to assess the daily feed requirements. Feed requirements could be expressed in terms of total dry matter (TDM) or in terms of nutrients including, crude protein (CP), energy, minerals, vitamins and water. Detailed feed requirements could be planned for specialized farms, however for smallholder farmers like in Ethiopia requirements in terms of TDM, CP and energy is usually doing well for planning

The very crude estimate of daily TDM requirement is just using established multiplication factors. Normally an animal will consume about 1 to 4% of the live weight. Large animals like cattle consume about 2.5 to 3% while small ruminants like sheep and goats can consume 3 to 4% of their live weight. The level of intake is also highly determined by the quality of the feed (Table 6). Based on this intake estimation factor;

A farmer who has 10.43 TLU = 2606 kg liveweight will require as follows

Daily feed requirement (TDM) =  $2606 \text{ kg liveweight} \times 3\% = 78.2 \text{ kg}$

Here if we know the daily feed requirement, we can calculate for any length of time required. If it is a fattening, we can calculate 3 or 6 months as planned or if it is dairy we can plan for a year

Annual feed requirement (TDM) =  $78.2 \times 365 = 28,543 \text{ kg} = 28.5 \text{ tons of TDM}$

Add about 20 % allowance for feeds that may be wasted as refusal and others.

Total annual feed requirement =  $28.5 \text{ tons} + (28.5 \times 20\%) = 34.2 \text{ tons TDM}$

Table 6. Forage intake guidelines as percentage of body weight for cattle

No	Animal types	Straw and poor forage	Medium quality forage	Very good quality forage
1	Growing and finishing cattle	1.0%	1.8 to 2.0%	2.5 to 3.0%
2	Dry mature cows and bulls	1.4 to 1.6%	1.8 to 2.0%	2.3 to 2.6%
3	Milking cows	1.6 to 1.8%	2.0 to 2.4%	2.5 to 3.0%

Exercises: EG annual feed requirement calculation

## ESTIMATING FEEDS WHICH ARE AVAILABLE OR TO BE PURCHASED BASED ON THE PLAN

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According to the above example the total feed required is 34.2 tons TDM. This total dry matter feed could come from different feed sources available including from grazing, crop residues, hay, cultivated forage crops, agro-industrial by products, formulated concentrates and others. Therefore, the next step is to determine the proportion of the total estimated annual total dry matter (TDM) in terms of the different feed components.

When one calculates or estimate the proportion of these feed components it is essential to consider the following.

- Availability of feeds in the area
- Nutritional value of the feed in relation to the nutrient requirement and targeted product
- Price of the feed if it is to be purchased
- Ease of production and its productivity and quality if it is to be produced

### The required feed types usually determined based on the livestock production systems

There are three major husbandry practices in the crop livestock mixed systems in Ethiopia. The feed resources for these systems are basically different. These systems are:

1. Livestock under grazing systems – such production system under Ethiopia condition is very extensive. It is usually traditional and not market oriented.
2. Semi intensive in which animals are partly grazing but supplemented at home
3. Indoor feeding



Hence the proportion of feeds for the annual TDM estimated for the farms will be disaggregated depending on the above broad livestock production practices.

Exercise Eg. Assess feed availability and estimate purchasing needs

## Livestock based on entirely on grazing

In this system animals allow to graze on natural pasture, browse in forest areas, graze after maths and on threshing grounds. Animals do not provided with any supplement feed at home or around the barn. One of the big challenges for farmers is to estimate the amount of feed the animals consumed from these feed source. Moreover, in areas where communal grazing is practiced, estimation of consumed feed from such grazing systems is very difficult. The question here is, do the animals fed adequately and produce according to the expectations. Do animals fed to their requirements in the different seasons. Such systems require close supervision and check if the grazing is adequate or additional feed is required or not. In most parts of the country animals are suffered from feed shortage in some months of the year specially during the dry season. Therefore, interventions on efficient feed utilization and introduction of additional feeds should be looked to meet requirements and improve productivity. The available feed should be estimated in terms of quantity and quality and the deficits need to be fulfilled from other sources. This is crucially important in most farming systems.

## Livestock partly grazing and complimented with additional feed

In the crop livestock mixed systems, the majority of livestock production is based on grazing and supplemented with different feed resources available. The amount and quality of additional feed required depends on the amount of grazing feed available, season and productivity level of the farm. If the grazing lands are good the additional feed is low. In many parts of Ethiopia, the grazing lands are highly degraded and the area is small relative to the number of animals and its contribution is seasonal and limited in amount and poor in quality.

There are techniques to estimate the productivity of a given grazing lands and the amount of feed daily consumed by animals. But this is not an activity that could be done as a routine. Moreover, the grazing lands in many parts of Ethiopia are communal, which makes estimation very complicated and very difficult. Therefore, the recommended way is to roughly estimate the proportion of feed a given livestock farm obtained from grazing. The best estimation is obtained from experience. Though productivity of the grazing lands varies over the different years, those experienced farmers know how much the grazing contribute to the annual feed budget. In addition, it is also very important to consider the quality of the feed from grazing lands. In most parts of the crop-livestock mixed systems in Ethiopia, grazing lands contribution is estimated up to 50% of the annual feed supply.

If the farmer estimates 50% of the feed budget from grazing, then the next step is what would be the rest of the feed resources to full fill the annual feed requirement. Here one has to consider critical facts

- Crop residues are very poor in quality especially the cereal crop residues which are the major feed sources available. If the farmer has only these feed resources, it might be very difficult to expect products like milk and meat.
- If the farmer is producing milk or fattening animals. Then he/she needs to have quality feed sources like cultivated forage crops, agro-industrial by products or formulated concentrates in addition to the poor roughages (grazing and crop residues)

In crossbred dairy animal feeding, there is a blanket feeding recommendation of 70 % roughages and 30 % concentrate feeds for a milk production level up to 8 liters per day per cow. The roughages could come from grazing, hay, and the concentrates could be from agro-industrial by products, formulated feeds or could be replaced by good quality cultivated forages or green feeds. Therefore, it could be recommended to full-fill the feeds according to the following ranges of proportion (Table 7).

Table 7. Example on how farmers estimate the proportion of the different feed components required for a livestock farm

No	Feed sources	Contribution of the feeds in ranges	Example proportion	Actual feed required (tons, TDM)
1	Grazing	30 - 60 %	50%	17.1
2	Hay	Up to 5%	5	1.71
3	Crop residues	20 - 30%	25	8.55
4	Green feeds and cultivated forage crops	5 -10%	10	3.42
5	Concentrate and other feeds (like atela)	10%	10	3.42
	Total required (34.2 tons)		100	34.2 tons

Note that depending the actual situation of each farm and location on the ground, the availability of the different feed types and the purpose of the livestock farming, one can rearrange the proportion of the feed sources.

The quantity of crop residues available or produced from the farmers' fields could be estimated from the grain yield by established conversion factors as indicated in Table 8. Example if a farmer produces 10 quintals of tef from his farm, the total amount of straw he can obtain is  $10 \times 1.5 = 15$  quintals = 1.5 tons of tef straw).

Hay produced from the protected pasture lands will be estimated either from quadrats or number of bales produced (usually a bale of hay weighs 15 kg in Ethiopia) or directly weight the total yield or estimate in different established systems like a bundle of donkey loads, cart loads, piles etc.

Purchased hay, concentrates, grains, agro-industrial by products are usually purchased based on weights and could be easily quantified.

Yield of cultivated forage yields will be calculated by measuring the area cultivated and its average forage yield (or reported yields for the area). Note that perennial forage crops like elephant grass

could be harvested 2 to 4 times under rainfed conditions and up to 6 times when irrigated. Annual yields will be the sum of the total cuts in a year.

Table 8. Multipliers used to estimate crop residue from grain yields of different crops

No	Crop type	Multiplier
1	Tef	1.5
2	Wheat	1.5
3	Barley	1.5
4	Oats	1.7
5	Rice	1.3
6	Maize	2.0
7	Sorghum	2.5
8	Millet	2.2
9	Faba Bean	1.2
10	Field Pea	1.2
11	Chickpea	1.0

Sources: FAO, 1987

## Livestock husbandry in indoor feeding systems

Indoor feeding is generally a practice of market oriented commercial farms under intensive management. Such feeding systems in dairy production, fattening (cattle and small ruminants) and poultry production. In Intensive systems of livestock production more than 70% of the cost is incurred for feed. The implication is that any effort for efficient use of feed makes the farm more profitable. In Ethiopia most urban and peri-urban dairy production and fattening activities and in some rural areas farmers follow indoor feeding practices. Now a days such feeding systems with improved dairy breeds becomes popular in many parts of the country. In such production practice planning annual feed requirements is not as such complicated, it only needs to follow the basic principles of diet formulation. However, unlike other countries, the productivity level are still far below, moreover we don't have our own established feeding standards and the ration formulation is less efficient.

The procedures are:

- Determine the feed requirements of your animals – The feed requirement in terms of TDM should be estimated for each and every animal based on their liveweight. If it is difficult to individual animals then animals could be grouped and TDM should be calculated for the groups. The groups could be like milking cows, dry cows, heifers, calves, bulls, fattening animals, etc. Consider 3% of lives weight for cattle to estimate TDM requirements, with 10 to 20% allowances.
- Determine the nutrient requirements and/or recommendations especially in terms of protein and energy, for the different groups of animals. Nutrient requirements standard tables are not available for tropical systems, but one can use the nutrient requirement standard tables for the temperate areas.

- Identify the available feed types and ingredients in the area, with their nutrient content and current prices. If actual nutrient composition of feeds not available average values from existing data could be used.
- The feed sources could be categorized as basal diet and supplement. The basal diet could be natural or cultivated pasture hay or crop residues. Normally the basal diet is offered ad libitum. But the quality is the most important factor that determines the level of intake. If the quality is poor, it may have filling effect and remarkably affect productivity.
- Formulate the ration for physiologically grouped animals as milking cows, dry cows, heifers, calves, bulls, etc. In the formulated ration proportion of the different sources of feeds will be determined. During the formulation consider the price of different ingredients, and time of purchase
- Then calculate the amount of feed from each ingredient for the required period of time. Based on prices trends over the months, purchase the feeds required at the time of lowest prices in the year.

## PLANNING FEED REQUIREMENTS AT VILLAGE, DISTRICT AND ZONAL LEVELS

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Planning feed requirements at different levels have many advantages to lead the livestock production better. Generally, the planning is always more precise at individual farm level and as the level increase from individual to village or, district and zone the precision and variability increases. However, it is possible to plan feed requirement at all levels.

The principles and procedures are generally following the procedures used for individual farm described above.

1. The first thing one need to have is well organized data on livestock population for the targeted village, district, zone or region. The data need to be presented in different categories including different species (cattle, sheep, goat, equines, etc), classes (mature, young, milking, local crossbred, etc). The availability of data is usually the main difficulty for proper estimation of requirements.
2. The available livestock data will be organized and converted to a standard unit of tropical livestock units (TLU) and the daily feed requirements in terms of dry matter will be estimated from the TLU. The annual requirement is extrapolated from the daily feed requirement.
3. The available feed is also estimated from the targeted village, zone or district. Feed from the grazing is estimated from the total area of grazing lands (or the contribution estimated from practical experiences). If hay is produced, the total hay is estimated, crop residues of the different crops estimated from the grain yields using the established conversion factors. If cultivated forages existed the area and expected yield will be calculated. Moreover, feeds of different types, including agro-industrial by products, formulated feeds, feeds from enclosures or forest areas, and any other feed sources in the targeted area will be estimated. All the estimated available feeds in dry matter will be sum up and considered as the total feed produced annually. Note that all feed produced should be considered for the period of one year, if there are multiple cuts they have to be summed up.
4. By balancing the feed requirement and produced one can crudely see if the feed is adequate, deficit or extra. Based on these findings the feed plan will be developed. If it is deficit, feed may be purchased, cultivated or other actions will be considered.

5. Planning feed requirements should be done by experienced personnel. otherwise, the planning will be biased. This is because, pasture productivity is very variable, you have to know the locations, they are variable over the months one has to be familiar. Almost all the feed resources are highly variable and hence the estimation need to be supported by experience.

## General principles in planning feed requirements

During planning of feed requirements, it is very essential to consider the dynamic nature of animals. In a farm there are new births, there are deaths and callings. Moreover, feed requirements could vary depending on weather conditions. The best planning in feed management is achieved over time and from experience.

All groups of animals under traditional systems requires macro and micro minerals. The minerals have crucial roles in the health of the animals, proper physiological functions and efficient use of feeds for more production. Reports showed that in many parts of the country mineral deficiencies are a common problem. Therefore, provision of required minerals are very important.

When feeding is not well-planned animals may under or over-fed, in which both of them have negative consequences. Therefore, target to feed animals based on their requirements to make the farm more profitable.

Farmers could produce cultivated forage crops in their vicinity with reasonable prices. These forage crops could support a good amount of production levels. If a good quality forage provided in sufficient amount crossbred cows could produce up to 10 litres of milk a day. Such practices are sustainable, environmentally attractive, economical and produce quality products and hence should be encouraged.

The productivity of animals is remarkably affected if they don't have access to clean and adequate water. Dairy animals and poultry should have free access to clean water other yields would be dropped. Therefore, water should always be considered in planning livestock feeds.

## CHAPTER SUMMARY & KEY TAKEAWAYS

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- Proper planning is the means for leading a successful livestock production. The major input / expense in livestock production is feed and effective feed planning helps to keep the farm more productive and profitable.
- For planning feed requirements, there is a need to have information or data on the type of animals (the number of animals in the different classes, their weight, their physiological condition or productivity) is required. In addition, the feeding management of the animals, the quantity, quality and price of the available feed resources. Should be known or estimated
- The livestock feeding systems in the mixed crop-livestock production systems are 1) free grazing without any supplement at home 2) grazing and supplement of hay, crop residues



and other available feeds at home and 3) Semi intensive or intensive livestock production usually in the urban and peri-urban areas based on improved feeding using roughages and concentrates usually purchased feeds

- In Intensive livestock production systems, the basic data and information are usually available. However, in extensive production systems the data like the liveweights of animals are not available. Hence liveweight of animals, feed requirements will be estimated but usually they are not precisely estimated.
- Tropical Livestock Units (TLU) which is equivalent to 250 kg liveweight is a standardized measurement for weights of animals in the tropics. A conversion factor is established to estimate liveweights of the different species of animals and classes of animals.
- Crop residue yields of major food crops (mainly cereals) is estimated from the grain yield by an established conversion factor.
- Daily dry matter feed intake of ruminant animal's ranges from 2 to 4% of their liveweight
- Planning of feed requirement are estimated from the daily requirements of animals and available feeds which will be extrapolated for the given period of time (but annual planning is the most common), in a given farm, village, district, zone and country level. However, as the area increase the estimation becomes very crude. Usually, estimations are very good when done based on experience and at farm level.

## PRACTICAL EXERCISES

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Mr Mohamed is a farmer in the mixed crop-livestock production system in Ethiopia. He has 7 cows, 3 calves, 2 heifers, 4 oxen, 1 horse, 1 donkey, and 10 sheep. He also cultivates crops, including 0.5 ha of tef, 0.25 ha of barley, 0.4 ha of maize, 0.25 ha of wheat and expects grain yields of 8 quintals of tef, 5 quintals of barley, 16 quintals of maize and 7 quintals of wheat. Farmers in the community have communal grazing lands. Mr Mohamed animals graze in the communal grazing area and supplemented, with crop residues, green feeds during the wet season, and usually conserves some hay from field borders at home. According to Mr Mohamed the contribution of the communal grazing land is about 40% of the feed (dry matter) requirement of his animals.

Please exercise the following questions based on Mr Mohamed's farming practice

1. Convert all the animals, Mr Mohamed owned in to tropical livestock units (TLU) and estimated total live weights of his animals in Kgs. Use the conversion factors from the table indicated in this manual.
2. Estimate the total amount of crop residues Mr Mohamed can produce. Use the conversion factors from the table indicated in this manual
3. Estimate the daily feed (dry matter) requirement for Mr Mohamed's total herd? What will be the annual feed requirement? (Please assume the average dry matter daily consumption of the animals is 2.5% of their liveweight)
4. Sum up the total amount of crop residues produced, and roughly estimate the amount of hay he may produce and the green forage he may obtain during the wet season or any feed available. As it is assumed 40% of the feed is from grazing, all the other feeds should make up 60 % of the total requirement of his animals
  - Is the feed available adequate to fulfil 60% of the requirements of Mr Mohamed animals?

- If the feed available is less than what is required what would be your advice to Mr Mohamed to fulfil his feed deficits for the year?
5. What would be the scenario if Mr Mohamed wants to change his 7 cows with 3 crossbred cows each of them producing 15 litres of milk a day. (brainstorm)

# Chapter 4 : Techniques of Ration Formulation for Smallholder Dairy Farmers

Melkamu Derseh\*

## LEARNING OBJECTIVES

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*This chapter intends to acquaint learners with a mobile application ration formulation tool that can be used to guide optimal feeding practices for dairy cows. At the end of this training, trainers will:*

- *Appreciate the importance of using feed advisory tools to reduce feeding costs, increase productivity and income of farmers*
- *Be able to practice dairy cattle ration balancing in their localities and provide scientific advice to individual farmers*

## INTRODUCTION

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Smallholder dairy production is constrained by not only feed shortages, but also by inability to feed animals according to requirements. Feeding animals according to their production, growth and reproduction requirements is vital to increase productivity and reduce feeding costs. This requires knowledge on the nutrient requirements of animals, the nutritional qualities of locally available and purchased feed resources as well as the price of these feed resources. In addition to meeting the energy and nutrient requirements of animals, it is highly important to make sure that the rations formulated are the least cost options possible.

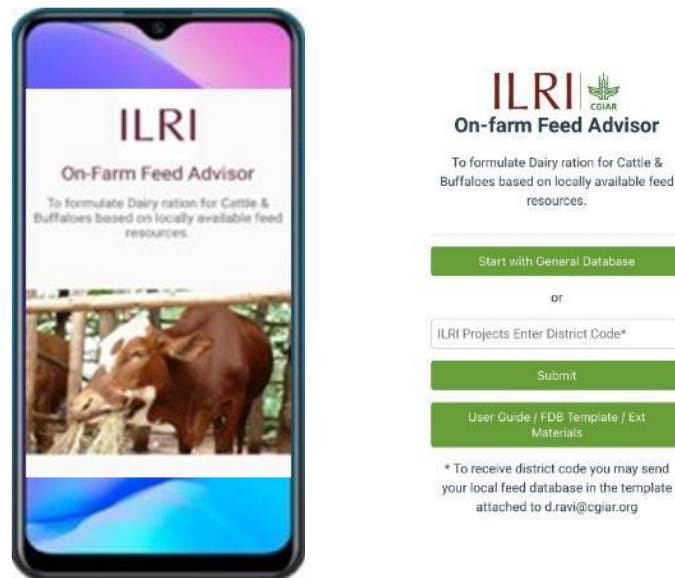
In the mixed farming system, generally farmers feed their livestock with whatever is available on their farm in the form of crop residues such as straw, stover, haulms, and other agricultural by-products. This basal feed is later supplemented with home-grown or purchased forage and concentrates, but with minimal understanding of the nutrient composition and actual nutrient requirements of the animal. This may, in many cases, result in over or under supply of key nutrients such as protein or energy relative to the level of production. In some instances, by not choosing the most cost-effective feed, the feeding costs are higher than they need to be.

To address mismatch of nutrient requirement and availability in the smallholder system, the International Livestock Research Institute (ILRI), has developed a feed advisory tool called 'On-farm Feed Advisor' that helps to formulate a balanced dairy cattle or buffalo ration. This is a mobile based nutrient balancing application downloadable from Google Playstore (<https://play.google.com/store/apps/details?id=org.ilri.ilrifeedadvisor>) or Appstore

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(<https://apps.apple.com/in/app/on-farm-feed-advisor/id1570480676>). The tool works well with an android /iOS smartphone. When users install the tool on their smartphone, the following app icon will appear on the mobile screen.



The tool guides users to input data into the app and apply it to formulate a customized balanced ration. As the tool has provision to self-populate nutritional and feed database including price of feeds, it can be used in any situation where mixed farming is practiced.

## HOW TO USE THIS TOOL?

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- First users will be prompted to choose from two options and click: 1) Start with a general data base, or 2) ILRI projects Enter district code. Users should choose the first option as there are no ILRI project districts, whose feed database have been uploaded to this software.
- Then users will be able to edit the general feed database already available in the system. Adding new feed type, deleting/blocking the ones that do not apply to the local situation are possible. Review the nutritional qualities and prices of the feed types. Update and exist the feed database.
- Then click animal, enter farmer name, village name and animal details such as animal type, stage of pregnancy (in months), animal girth (in inches) or weight (kg), milk quantity (in kg), fat content (in %) and price (per kg) and submit
- After that click Add Feed, enter the feeds farmer offer to the animal in a day
- First select feeds from the drop-down menu by typing the first few letters (all forage names start with 'green' and other feeds with the crop name). Then enter 'quantity' (in kg) and indicate whether 'own' or 'purchased'. Then submit.
- When the screen with the entered feeds appears, click "CALCULATE GAP"
- See the GAP and click "BALANCE THE FEED"
- It will give you a solution on what feeds to be used, indicating the quantity/

- It will also give additional information such as cost of purchased feed before & after balancing, total feed cost including own feeds, additional milk & income after balancing, metabolizable energy density, Crude protein density, NDF% etc.
- Then click “ADVICE MEMO”. The memo with the solution along with other advice to improve the overall quality of feeds, reduce feeding cost and increase productivity will be presented

## WHO CAN USE THIS TOOL?

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This advisory tool can be operated by extension workers, progressive farmers and farm managers who have some basic understanding of animal nutrition to formulate least-cost dairy rations following the above procedures. For the tool to be of support, updated information on the feed types, qualities and prices and animal production potentials and milk composition are important.



# Chapter 5 : Forage Seed Production and Management Techniques

Aberra Adie\* and Melkamu Derseh

## LEARNING OBJECTIVES

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*As chapter one explains the agronomic and seed production potential for selected annual and perennial forages, this chapter aims to equip forage seed growers with technical knowledge and skill of forage seed production process in general. It also intends to raise the level of their understanding that forage seed production requires special attention and preparation before engaging into the business.*

*At the end of this chapters, learners will be able to:*

- *Ascertain the different forage seed production approaches pertaining to his/her environment and specific interest or plan*
- *Clearly understand the different elements of site selection and plant the forages where they can produce maximum quality seed*
- *Have a better knowledge of planting time, planting material preparation and effective planting*
- *Properly manage the planted material at field level including assessment of germination, weeding, disease/pest control*
- *Understand forage crop seed maturity stage and time to ensure maximum quality seed harvest*
- *Effectively carry out appropriate post-harvest seed management practices including threshing, cleaning, grading, seed quality tests, packaging and storage*
- *Ensure cost effective and quality seeds production and sustainable market for the product*

## BACKGROUND

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Use of cultivated forages to feed livestock in the Ethiopian crop-livestock system is gaining attention by both the government and livestock keepers at all levels. Adoption of cultivated forages in the small holder and peri - urban livestock producers is promoted by various research and development programs. One of the challenges for rapid adoption and scaling of forage technologies is the supply of quality seed in a consistent manner. Following this, associations and individuals interested in production and supply of forage seeds are emerging across all regions in Ethiopia. One of the impediments for the supply of quality forage seed is the lack of technical skill to produce and manage forage seeds. This manual is intended to equip producers with knowledge of site selection, planting methods, weed management, harvesting and post-harvest management of forage seeds or planting materials.

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## **FORAGE SEED PRODUCTION APPROACHES (FORMAL AND INFORMAL)**

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Unlike for the food crops, the seed production and dissemination system for forage crops is at a very infant stage in Ethiopia due to many factors. There are various initiatives and projects attempting to engage different models of forage seed production. Some examples among others include Ethiopian Fodder Roundtable, Feedseed project, Africa RISING project and ILSSI project all ILRI projects which have been attempting to bring along interested partners to work around establishing viable forage seed production and supply system in the country. Some of these models include commercial seed production, small scale businesses, individual farmers, cooperatives (unions), community seed production (FTCs), and research centers. The first two approaches may be classified as formal approaches while the latter four could be classified as informal approaches.

### **Commercial seed production**

This is a formal approach whereby seed growers are organized in a form of large enterprise (regional enterprises like Oromia seed enterprise, Amhara seed enterprise, etc.) initially formed to grow and disseminate food crop seeds to Ethiopian farmers. Though there is no such enterprise formed so far to produce forage seeds exclusively, these food crop seed enterprises are approaching to include forage seeds in their program if there is viable market for the forage seeds.

### **Small scale forage seed businesses**

There are many private firms emerging around forage seed production and trading businesses in Ethiopia. Some of these firms have their own pieces of land or use outreach farmers to produce forage seeds and need to be provided with technical training and quality basic seeds. Recently, an association (Ethiopian Forage Seed Producers' Association) comprising some of these firms has been formed legally and launched its operation. This could be very instrumental to strengthen the forage seed sector in Ethiopia.

### **Farmers' cooperatives (unions)**

Farmers' cooperatives and unions established for the production and supply of food crop seeds or dairy products can also be used to produce and supply forage seeds if they are equipped with relevant training and basic planting material. Members of the cooperatives can produce seeds in their individual farms with the supervision of the coops management. The coops management can play the role of distributing the planting material and collection of the harvested seeds with prior agreed price or profit margin from the member farmers. They then sell the seeds to the available market within their locality or elsewhere in the country.

### **Individual farmers seed production**

Some forage seeds require less technical skills and can be produced at individual farm level. For example, forages like lablab, cowpea, oats, vetch, etc. require similar cultural practices like for food crops and farmers can produce their seeds with limited training and supervision. Cuttings and root splits could also be produced at individual farm level using traditional cultural practices. However, attention must be given for the quality and reliability of the source material and final product. The

final product can be used by the farmers themselves or could be sold to neighboring farmers or others through extension, NGOs or private businesses. However, the market outlet has to be thought right from the beginning if selling of surplus is intended.

## Community seed production (FTCs)

This is another informal approach where community structures like FTCs are used to grow and disseminate forage seeds. In this approach, the farmers training centers (FTCs) which were basically established at each kebele for practical training and demonstration purposes can be used to grow forage seeds and disseminated to farmers at least on a cost recovery basis. The development agents can take the role of supervision and monitoring of the production and dissemination process of the seeds.

## Research centers (ILRI, EIAR, Regional research centers)

Research centers are mandated with collecting and maintaining forage genetic materials from various sources. They carry out field and laboratory experiments until they release suitable varieties for different agroecology. They also multiply planting materials in limited quantities for dissemination to researchers, seed growers and extension work on not-for-profit basis. Currently, research centers serve as the sole source of reliable pure seeds to the rest of the seed producing sectors mentioned above.

The government extension system in collaboration with relevant stakeholders is expected to facilitate the overall process right from the acquisition of the planting material to marketing of the final product. This is important particularly for the informal seed growers though the formal enterprises also need the attention and support of the government.

## SITE SELECTION

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Identification of proper site for forage seed production is crucial to have good expression of the cultivars or varieties, highest seed harvest and quality. Site selection criteria includes climate, soil type, history of the plot, drainage or slope, proximity to road, presence of pests or rodents, access to grazing of wild or domestic animals, human disturbance, etc. Climate factors pertinent to crop growth include rainfall, temperature, both affected by the elevation of the site, light (day length).

### Rainfall (moisture)

The productive life of many forage species is influenced by moisture supply. Seed crops require ample water in the vegetative phase followed by relatively dry period for the reproductive phase.

Rainfall influences the water supply to the roots and to the atmospheric humidity. Different crops may have different requirements for rainfall or water. In Ethiopian highlands, the main rains commence in June and mostly last up to September. 4-6 months of wet season allows the plants to produce the necessary strong vegetative framework for heavy seed crop. 800-2000 mm of rainfall is required for effective seed production. Depending on flowering behavior and species adaptation, grasses can grow within a rainfall range of 600 to 1500 mm while most legumes can grow within an average rainfall

of 800-2000 mm. More rain in the reproductive phase means increased risk of diseases and hence less viable and inadequate seed production. Moisture stress promotes vigorous reproductive growth.

Supplemental irrigation is necessary to ensure reliability of seed production. Irrigated forage seed production has an advantage in regulating water required for optimum crop and seed production. Irrigation requirement depends on climate condition and related soil moisture level, species planted and method of irrigation. Crops require more (ample) water during the herbage growth stage until close to flowering stage and seed development stage. Less water is needed during the flowering stage and no water is needed during ripening stage of the seeds. Hence, irrigation helps to regulate these periodically. There are different irrigation techniques including surface irrigation (furrow irrigation, border irrigation, basin irrigation), sprinkler irrigation, drip irrigation, etc. Each technique can be employed to different species depending on the nature of the plants, plot arrangement, topography of the land, availability of water and irrigation equipment. Water lifting and conveyance equipment selection needs in-depth analysis and experience/lesson from other users who have prior knowledge and experience. Expert advice is also very important before engaging in any of the irrigation techniques or choosing irrigation equipment. Sources of water for irrigation could be water collected from roofs, ponds, shallow wells, deep wells, rivers or lakes. In any case, the health and purity of the water needs to be verified as some water sources may be saline or contaminated with industrial by-products.

## Temperature

Temperature is one of the determinants for crop growth and seed production right from sowing time to maturity and harvest of the seeds. Some crops require low temperature (chilling) while most other crops require moderate temperature. Too high temperature may inhibit the development of ovules and fruits. It may also cause shedding of flower buds or young fruits in pulse crops or legumes.

Though it is difficult to give a generalized temperature range for seed growth and flowering, optimum or suitable temperature is very important for good soil texture during seed bed preparation and planting. Good temperature is also required to enhance growth during the vegetative stage of the plants. Temperature also influences the switch from the vegetative stage to the reproductive stage of the crops. The lower the temperature the slower the switch process and vice-versa. For successful harvest operation, we need open weather accompanied by optimum temperature. Flowering, pollination, seed setting, and ripening are all favored by warm weather.

## Soil type and history

Soil is one of the major factors influencing plant growth. It provides physical conditions for root development and anchorage and supplies nutrients and moisture. Most forage crops need neutral soil or slightly acidic or slightly alkaline soil.

Most forage crops require deep well drained fertile soil for vegetative growth. However, for seed production, nutrient supply needs to be reduced towards seed maturity to discourage vegetative growth and maximize seed yield.

Soil types or environment unfavorable for crop growth or forage seed production include inadequate moisture, deficiencies in nutrients, water logging (poor aeration), low pH (acidity), high pH (alkalinity), salinity, shallowness, poor texture (crusting, hardening, stoniness).

History of the soil including previous crop is important to manage and reduce contamination (disease) or weed infestation from regrowth of shattered seeds from previous crop. If possible, clean fallow land is preferred to grow forage seeds. The soil on which forages are planted for seed production need to be well drained soils, laying on a gentle slope. Steep slope and water logging must be avoided. If possible, the farm has to be easily accessible from all-weather roads and well protected from the disturbance of wild or domestic animals.

## Elevation above sea level

Plant growth and yield (both biomass and grain/seed) are heavily affected by agroecological factors like altitude of the area. Massive research is done by research centers to identify suitable varieties or species for the different agroecology. In Ethiopia, national research centers like EIAR and international research centers like ILRI spend much of their time in experimenting and screening varieties and finally varieties are released through the national variety release process for Ethiopian farmers. So, seed growers are advised to use the officially released varieties for seed production and dissemination. List of released varieties at national level is annexed to this manual.

## PLANTING

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### Seed bed preparation

Clean seed bed preparation by frequent ploughing or tilling of the land is very important for free soil particles and for moisture, temperature, and nutrient movement. Plant roots can easily penetrate in a well-prepared seed bed. A good seed bed means a clean seed bed, a firm seed bed and a fine seed bed. To attain this quality, land preparation (ploughing, harrowing, raking, etc.) should be performed during a good weather. Wet weather or excessive moisture during land preparation may result in a sticky soil which will be difficult for planting, germination, and plant growth.

### Isolation

Isolation is very important to minimize or avoid genetic contamination of seeds due to cross pollination of similar species of different varieties and contamination of diseases. Cross pollination may be triggered by bees, wind and other agents like humans or animals including birds. Due to this, species that pollinate openly need to be isolated 200 m and those which are pollinated by insects like bees and other need to be at least 100 m apart. Isolation for disease control need to be at least 100 m apart from the feared plot.

### Physical seed treatment before planting

Seed treatment is not normally required for most forage seeds, but certain seeds may require physical treatment to break the hard cover before planting. Such treatments include hot water, acid treatment, sandpaper (scarification), knife, machine. Expert guidance is necessary when using these options at least for the first time.

## Inoculation

It is the addition of nodule bacteria to the surface of legume seed or directly to the soil just before planting to enhance nodulation or production of more nitrogen (N). The inoculant can be adhered to the seed by different mechanisms including gum Arabic solution, skim milk, or sugar solution. Inoculant could be prepared in a form of slurry, pellets, or dust. If inoculation is planned to be performed during planting, there should be help from skilled personnel at least for the first time.

## Time of planting

Forage seeds must be planted during a good weather (sunny but with adequate moisture in the soil) during the main rainy season if it is not irrigated forage seed production. Most species are planted between mid-June and mid-July. However, species that mature early can be planted later to avoid bad weather (rains) during seed maturity and harvest.

## Types of planting materials

Planting materials could be seeds (most herbaceous legumes and grasses) or vegetative parts like stem cuttings or root splits (big grasses like Napier grass, desho grass, cenchrus, etc.) or seedlings (browse trees).

### Cuttings or root splits

Alike the seed materials, vegetative planting materials also need to be properly prepared to ensure effective establishment. Grass varieties like Napier grass, desho grass, brachiaria and panicum can be propagated better by cuttings or root splits. This makes them easy for establishment though the amount of material required to cover a given plot is larger and transportation of cuttings or splits is heavier and more costly than transporting seeds. Special care is required to prepare cuttings or splits in a manner they will emerge easily from the stem or root parent. When stem cuttings are prepared (for example in the case of Napier grass) cuttings have to be made with at least three nodes and 2 internodes. When root splits are prepared, they have to bear some soil from the original plot for use during transportation and early establishment of the roots.

### Seedlings

MPTs or fodder trees can be established from direct sowing of the seeds or seedlings. Seedlings can be raised by individual farmers' backyards, community nurseries, or government nurseries. In any case, the seed bed for raising seedlings must be prepared ahead of time. Most of the time, seedlings are prepared during belg season (March-May) with the support of small rains so that they are ready to be transplanted during the meher season. The seedlings can be raised in a polythene tube or bare plot depending on the amount of materials to be raised and availability of polyethene tube and labor. The soil to be used for raising seedlings must be fertile loam soil (forest soil) mixed with well decomposed manure and sand in the proportion of 3:2:1 respectively. The moisture content of the mixed soil has to be moderate as some plants like tree Lucerne are not happy with excessive moisture. Planting either on bare plot or in polythene tubes has to be done with due care so that seeds are not deeply buried or left uncovered. Once planting is done, there should be a thin mulch (mostly grass mulch) on top of the plot or polythene tubes for increased temperature to allow fast germination of the planted seeds. Germination has to be checked after 7-10 days of planting and replanting has to be done if the germination is viewed to be weak. Some varieties like tree lucerne take longer days for



germination so there should be patience in checking for germination. Within 2-3 weeks of germination, the mulch has to be raised up and redone in a form of roof (40-50cm high) to allow aeration and sunlight for the emerged seedlings. This has to be monitored closely and the roofs can be removed totally once the seedlings are strong. Watering of the plots or the tubes has to be done as necessary (after every other day or 3 days) by regular checking of the moisture condition of the soil. Most often, this is done during evening times or early morning to reduce loss of water by evaporation. Presence of rodents and disease has to be checked and measures have to be taken timely if they occur. The seedlings have to be checked for nutrient deficiency symptoms and supplemented with appropriate nutrients if necessary.

## Seeds

Most legumes and grass varieties are multiplied by direct sowing of the seeds. Seeds could be acquired from local sources (research centers or accredited producers) or imports. In all cases, seeds should be certified true to type and of minimum quality standard including purity, germination, or viability. Seeds should be received in sealed, weatherproof sacks or small cloth bags with printed labels on each sack or bag identifying the species, cultivar, source, date of harvest, lot no., site of harvest and recommended storage conditions.

In all cases appropriate procedures like recommended seed rate, plant and row spacing and time of planting has to be maintained during planting.

## Fertilizer Application

The fertility level of the soil must be assessed before planting to plan calculated fertilizer application. Representative soil samples must be taken for analyses of the soil for the important major nutrients (N, P, K) and macronutrients (Calcium (Ca), Magnesium (Mg), Sulfur (S)). Micronutrients or trace nutrients for consideration include Iron (Fe), Copper (Cu), Zinc (Zn), Manganese (Mn), Molybdenum (Mo), Boron (B), and Chlorine (Cl). Based on the results of the analyses, appropriate fertilizer rate and type need to be applied for all (grasses and legumes) and during planting tillering stage for grasses.

As there are limited laboratories for soil analyses and they may not be affordable for many small-scale businesses, it is important to refer to national fertilizer recommendations for a given area or soil type where forages are planned to be planted. The recommended nutrients could be obtained from various sources including organic sources (compost, manure) or factory products (Urea, DAP, NPS, etc.) Caution is necessary to reduce weed infestation when applying organic fertilizers as they may emerge from hidden weed seeds in the fertilizer.

## POST-PLANTING FIELD LEVEL MANAGEMENT

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### Assessment of germination

Some forage seeds germinate within 7-10 days after planting while other may take long time (months depending on seed dormancy). Rate of germination may be affected by seed viability, condition of the soil at planting (muddy and stick soil may inhibit faster germination), soil moisture (too much and too low moisture reduces germination rate), waterlogging, bird or ant picking and the condition of the

seeds at planting. In any case, the possible reason of any poor germination has to be assessed properly before deciding to replant to avoid repetition of the same error or reason.

Reserve seeds should be retained during planting for replanting in case of any poor germination to offset any possible loss of plant population. Uniformity of the plot may be affected due to different planting dates, resultant germination and maturity but harvesting them differently could be manageable if the plot is small. If the plot size is big, decision has to be made either to maintain the original planting or to remove it all and replant depending on the percentage of original germination.

## Weed control

One of the major factors contributing to the low productivity and low seed purity is weed infestation. Weed infestation is caused by various factors including plot history (previous crop), purity of the seeds planted, erosion from adjacent plots, etc. Some of the measures to control weeds are taken before planting while other measures are taken after the emergence of the crop. Pre-planting measures include proper site selection, method of planting (row planting for easy weed removal), ensure cleanness of seeds and seed bed. Post-emergence weed management include timely monitoring and eradication of the weeds using different means including hand picking and chemical application. If chemical application is used, caution to be made for the source of chemicals, method, and rate of application. The frequency of weeding depends on the type of the forage crop and level of infestation by weeds. Some forage crops require only one major weeding at the initial stage of plant growth and hand pick some emerging weeds before flowering of the crop. In any case, weeding must be done as early as possible before the flowering stage of the weeds once it is possible to detect the weeds from the planted forages.

## Pest and disease management

Pests and diseases contribute at large to the reduction in yield and poor health of the crop, or the seed produced. Common pests include mammals, birds, snails, insects, mites, and nematodes. Diseases could be fungal, bacterial, viral, or environmental. The prevalence of diseases could be observed by field inspections and possible symptoms include wilting (dying), growth disorders, blotchy patches, discoloration, broken stems, holes in pods or leaves.

Pests and diseases could be controlled by cultural or chemical means. Cultural methods may include crop rotation, manipulating planting date, cutting / grazing, soil burning, deep ploughing, irrigation, crop sanitation / rogueing, sowing resistant varieties. Chemical measures could be insecticide or fungicide. Special care is required when applying chemicals.

## HARVESTING

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### Planning for harvesting

Seed ripening and harvest require calm dry weather and even sunny conditions. Damp or cloudy weather has to be avoided during ripening or harvest. Windy weather and heavy rainfall during crop growth and seed maturity may cause crop lose by shattering of seeds and lodging of the vegetation. Planning for harvest must be made right before the planting time. This may entail choosing the site

with the best weather at the time of seed ripening and harvest; adjust the date of sowing so that ripening, and harvest operations coincide with dry weather; consideration of supplemental irrigation if changing the date of planting is mandatory to suit to dry weather for seed ripening and harvesting. Cutting or grazing in the early part of the season or early vegetative growth delays flowering and this way one can manipulate the harvest dates of biennial and perennial forage grasses.

Harvesting consists of two operations: Cutting or picking operation in which the inflorescence together with some stem and leaf is detached from the basal part of the plant and threshing operation in which the seeds are separated from the rest of the cut material. Both operations may be carried out manually or by machine depending on the size of the farm and availability of labor or machine. Determination of the time for harvest is usually assisted by personal experience and changes in the plant physiological development.

Generally, indicators of ripeness for both grasses and legumes include the following factors:

- Grasses: moisture content of the seeds, % seed shed, head colour change, ease of seed removal, presence of caryopsis
- Legumes: moisture content of the seeds, % of seed shattering, pod colour change, proportion of (flowers, ripe pods, and green pods)

Manual harvesting methods may vary depending on the nature of the plant and may include picking, sweeping, cutting, shaking, stripping.

## Problems associated with forage seed harvest (mainly grasses)

In tropical grasses, there are wide differences between flowering times of individual plants. Thus, flowering followed by ripening of seeds in forage crops is spread over a long period. As a result, a single harvesting operation contains a mixture of ripe and immature seeds.

Forage crops may be perennial or annual and the form of growth is indeterminate. Each plant has many stems, either the inflorescence arises on lateral branches leaving the terminal bud to continue vegetative growth or if the terminal bud produces an inflorescence, vegetative growth continues from the lateral buds. Therefore, expert judgement has to be employed to make choice of harvest date by estimating the amount of seed lost or gained if a certain date of harvest is chosen. Too early or too late harvest dates may both contribute to the reduction in yield and quality of the seeds harvested.

## POST-HARVEST SEED MANAGEMENT

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### Pre-threshing management

The harvested seed crop must be handled carefully in the field until threshing to reduce crop loss and ensure maximum level of quality. Grass seeds can be left in the field for some days after harvest to ascertain further seed maturity and effective threshing. Stooking or sweating, windrowing, or keeping the harvested (cut) material in a form of sheath or bundles are useful to facilitate effective and uniform drying and uniform seed maturity.

## Threshing

Threshing is the operation in which the seeds are separated from the rest of the cut material or the straw. This can be done manually, by animals or machine (drum thresher or belt thresher). Care must be taken to reduce seed damage during threshing. Some forage seeds like vetch can be shattered on the plot during harvest and threshing and may become invasive weeds for subsequent crop. Therefore, maximum care has to be taken to reduce seed shattering during these operations.

## Drying

Most seeds moisture content at harvest is 40-70%. The required final moisture content is 5 -10%. This can be attained by drying the seeds under the shade, using the sun and naturally forced air by spreading out the seeds in a thin layer on a smooth earthen floor or matting with good ventilation to dry the seeds.

## Cleaning

A lot of other materials (up to 20%) could be mixed with the forage seeds during harvest. Some of these materials may include stone, soil particles, rodent faeces, weed seeds etc.) and immature seeds, damaged seeds of same variety. Successive cleaning operation must be employed to get rid of these materials and prepare a clean seed product. If cleaning is done manually or traditional materials, then this has to be done with utmost care. There are various machines to undertake this operation in the research centers like ILRI or well - developed seed producer companies. Some of these machines present at ILRI include pre - cleaner, air screen cleaner, indented cylinder, gravity separator, band grader, velvet roller, spiral separator. Three different stages of cleaning are undertaken using these machines. These are: conditioning or pre-cleaning, basic cleaning, separation and grading.

- **Pre-cleaning:** involves removing the bulkiest material and the rubbish that choke up sieves. These are chaff, awns, long pieces of stem and leaves and fibrous pods. This process of removing large particles is known as scalping (blowing). It is also known as hulling or shelling for some crops.
- **Basic cleaning:** with more refined air-screen cleaner, air blast removes light materials. These are weed seeds, other crop seed, and broken seeds.
- **Separation and grading:** A special machine sizing operation removes seeds larger or smaller than the required size. Grading is the removal of seeds which are cracked, damaged, or otherwise defective.
- **Seed size and uniformity:** large seed size is an indication of vigor. The bigger the seed, the greater the size of the seedlings and the area of green leaf capable of photosynthesis. Large seeds produce seedlings which grow more rapidly in the field. Every seed lot is to some extent a mixture of large and small seeds. Therefore, a lot should be thoroughly blended before it is packaged so that the contents of every bag are the same.

## Seed purity and viability

The final seed material must be checked for purity and viability in laboratory tests. This is done by taking a homogenous representative sample to test for purity and germination and viability. Acceptable germination levels or percentage vary from variety to variety. However, germination percentage less than 75% is not suggested for effective establishment of the crop.

## Seed treatment

Seeds must be treated with pesticides (fungicides) in a form of powder or liquid before packaging or storage. This prolongs the shelf life of the seeds. The pesticides destroy pathogenic organisms on the surface of the seeds to protect the emerging seedlings against insects and fungi in the soil at sowing time or absorbed by the seeds at the sowing time thus destroy organisms that were within the embryo.

## Seed storage

Keep seeds out of direct sunlight in a cool spot that maintains a consistent temperature (15-17°C). Consider a cold closet, a basement, or a room that remains cool year-round. Freezing isn't necessary for short-term storage, but you can refrigerate seeds, provided they are sufficiently dry.

## Seed packaging and labeling for dissemination

This is the final stage of seed management process and must be performed with due care. Proper seed packaging is expected to reduce seed damage, seed contamination and seed loss. The packaging material should be moisture proof or moisture resistant. The label should include species name, cultivar / accession number, lot number, harvest date, site, owner/organization.

## Forage seed quality assurance

Quality can be explained as a level acceptance of a given product or service relative to a nationally or internationally set standard. Seed quality inspection and assurance has two phases. The first phase is pre-marketing phase and the second is marketing phase. The premarketing seed quality inspection and assurance phase involves variety illegibility, seed source, field inspection for absence of weeds and uniformity of the crop, seed sampling, laboratory testing and seed labeling and certification. Seed quality inspection and assurance activities during the marketing phase involve seed sampling for laboratory analysis to check its viability and germination at the point of sales.

There is no formal quality assurance system so far for forage seeds in the country. This may be attributed to lack of qualified facilities or laboratories, inadequate trained personnel, lack of policy regarding forage seeds. Various research and development projects have been trying to initiate the establishment of a formal quality assurance regulation. Currently, ILRI with other interested local and international institutions is trying to develop a quality declared seed (QDS) policy manual for forage seeds. Once this effort is fruited and got approval, it is expected to serve as an interim legal document to declare forage seed quality until a formal certification system is established. Therefore, forage seed growers must consider the quality declared seed (QDS) protocol (which is to come soon) while producing forage seeds.

## FORAGE SEED MARKETING

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One of the limitations of forage seed system in Ethiopia is its weak market structure. As cultivated forage development is slow in general in the country, the market system is also under-developed. The major market outlets of the forage seeds currently are NGOs and government extension. Most of the

small-scale farmers are provided with free of charge seeds by the NGOs and government extension system. This has weakened the interest of farmers to pay for forage seeds from other sources and blurred the clear understanding of the potential market for the forage seed growers. For the increased adoption of cultivated forages and associated demand for forage seeds, extension efforts must increase to build farmers' capacity about the multiple benefits of the forages. Free hand out of forage seeds to the farmers is one of the major impediments for the adoption of cultivated forages in the country and it requires the attention of policy makers to discourage it.

In the case of business-oriented seed production however, initial market survey (supply -demand relations) is needed before embarking on the business. Business firms must plan their operations carefully and make market linkages using various marketing channels. Demand for forage seeds can be influenced by massive awareness creation, promotional works including use of local media, promotion of quality seed, using various distribution systems for easy access and affordable price. To ensure sustainable forage seed production and marketing, seed producers/marketers have to work with all partners along the value chain including input suppliers, forage and livestock product output market, researchers, development projects and policy makers.

## CHAPTER SUMMARY & KEY TAKEAWAYS

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Ethiopia's livestock sector is growing commercially followed by increased urbanization and urban population and associated demand for animal source foods. Production and supply of quality forage seeds to livestock producers is critical to meet the growing demand to grow and feed quality forages in adequate amount to the livestock. Forage seed growers are emerging at various scales and need technical support. Growing quality seed and marketing it effectively requires relevant skill and knowledge of forage seed production and management. The various steps that need attention in the process of producing and marketing quality seeds have been discussed in this chapter.

Key messages:

- In the current Ethiopian context, there are various forage seed production approaches exercised by different practitioners. Feasibility and sustainability of any of these approaches need to be verified by in-depth analysis of each approach. Seed producers need to choose among the approaches most suitable for their situation based on critical analysis.
- Effective forage seed production starts with clear understanding of the sites and the forage varieties intended to be produced in a particular site. There are released varieties from research centers through the national variety release system for the different agroecological zones in Ethiopia. In addition to agroecology, site selection criteria also include specific niches required for the different forages. These may include soil types, landscape, history of the plot, etc.
- Planting forages for seed production is different from planting for forage production. Seed production requires special attention during planting material preparation, land preparation, planting, field observation and management
- Determining appropriate harvest time for forage seed production requires in-depth knowledge of the features of the varieties and field experience of the farmer. Seed growers



need to familiarize themselves with the varieties and their developmental stages by paying experience sharing visits to the research centers or other senior forage seed producers

- Post-harvest seed management is very important to reduce crop loss and ensure quality produce. This includes pre-threshing handling of the harvested crop, care during threshing, cleaning and grading the seeds. Apart from the research centers, there are various seed producers and traders who supply forage seeds to the existing market. However, sometimes the quality and viability of the seeds they supply could be impure or even a different variety. Therefore, knowledge of post-harvest seed management is crucial for the sustainability of the business and the development of the sector. Seed producers and suppliers should be accountable for the seeds they supply to the market.
- The available market for forage seed producers is mainly NGOs and government extension services who provide free of charge seeds to the farmers. For the forage seed business to develop, there should be a strong policy intervention to cease free offer of seeds to the farmers. Forage seed producers must scan their existing and potential market before engaging into the business. They also need to work closely with all actors along the value chain for effective and sustainable business.

## PRACTICAL EXERCISES

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1. Among the different approaches of forage seed production mentioned in this chapter,
  - a) which approach/es are the best? And which are the least according to you to ensure sustainable seed supply system?
  - b) Please mention your reasons in both cases.
2. What are the different elements of site selection, and which ones matter most to you and explain the reason?
3. In this chapter, it has been mentioned that 'a good seed bed means a clean seed bed, a firm seed bed and a fine seed bed'. What do you understand by this and why do you think this is necessary particularly for forage seed production?
4. A farmer has planted Alfalfa for seed production. The germination was above 85% and establishment was fast. However, when the plant continued to grow, the farmer observed that the vegetation looked like a different forage variety. He invited an extension worker to look at it and the extension worker found out that it is Melilotus and not Alfalfa. 1) Why do you think this happened? 2) What advice do you provide to the farmer to manage this crisis? 3) What advice do you give to other co-farmers, seed suppliers, extension workers so that such error doesn't occur to again?
5. I have a well-established vetch field for seed production. The pods are about 75% ripe, ready for harvest but the remaining 25% is with unripe green pods. Do you advise me to just go ahead harvest the whole field or wait for the remaining part to ripen? What are your reasons in either case?
6. A well-to-do businessperson may have a cold room with a recommended temperature range to store forage seeds until they are sold out or used for subsequent planting. Jaleta, a traditional farmer doesn't have such facility, but he wants to engage in small scale seed production and marketing business. What advice do you offer him to store his seeds for about 4-6 months until he finds viable market for his seeds?

# Chapter 6 : Scaling of Feed and Forage Innovations

Million Gebreyes\*, Birhan Abdulkadir, Kindu Mekonnen and Peter Thorne

## LEARNING OBJECTIVES

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*This chapter intends to achieve three objectives. At the end of this chapters, learners will be able to:*

- *Describe scaling, scaling types, scaling principles and basic concepts in scaling assessment*
- *Appreciate the importance of systematic and deliberate approaches for scaling of agricultural innovations*
- *Describe the steps involved in scaling assessment and scaling strategy development*
- *Undertake preliminary scaling assessment and scaling strategy development for selected forage innovations*

## INTRODUCTION

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**Question:** What do you understand by the term scaling? Why do you think is scaling of agricultural innovations an important concern for decision makers?

Scaling is a major pre-occupation of many feed and forage innovations or for that matter any agricultural innovation. Often innovations are generated in relatively controlled environment with small number of ultimate beneficiaries during the initial phases of innovation generation and testing process. Innovations are then taken to more promotion and diffusion through various pre-extension and extension methods such as demonstrations and field days. Scaling involves a deliberate and systematic effort to increase the number of beneficiaries and the geographic coverage of use of an innovation. In scaling, we want to expand and widen the impact of innovations.

Despite the growing desire to scale innovations, the science and practice of scaling is still nascent. Many innovations struggle to move from the small pilot stage to wider diffusion and impact at scale. The struggle to scale may come from various sources. Often times, it arises from a narrow technology transfer model that is still pervasive in many agricultural innovations' generation and dissemination. In technology transfer models of innovation generation and dissemination, demand and market orientations are often downplayed, and technical experts dominate the innovation generation and diffusion process. Such innovations face scaling problem as they have to deal with demand and market failures.

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Even in innovations generated through a more complex approaches and with involvement of diverse set of stakeholders, systemic constraints may hamper scaling. Understanding these systemic constraints and devising appropriate strategies to overcome them is essential to steer deliberate scaling. A recent paper by Africa RISING team indicated the need for flexible, reflective and long-term partnership-based approach for scaling of agricultural innovations (Gebreyes et al 2021). The International Livestock Research Institute (ILRI) developed a scaling framework to guide scaling of livestock innovations. In this chapter of the training module, we will present an abridged version of ILRI's scaling framework, together with insights from practical examples of scaling practices from Africa RISING project experiences.

## SCALING TYPES

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Scaling is often a multi-dimensional concept. The different dimensions of scaling, also called scaling types, are essential to address the interrelated social constraints of scaling. The first two and the most used concepts of scaling are scaling out and scaling up.

- **Scaling out** is increasing the number of beneficiaries reached out with innovations: In Africa RISING project, scaling out meant increasing the number of beneficiaries of innovations generated.
- **Scaling up** is institutionalizing mechanisms to increase the number of beneficiaries reached out with innovations: In Africa RISING project, this meant, for example, inclusion of AR introduced innovations in annual plans of public extension systems.

Efforts to scale out and to scale up innovations, however, may face resource, capacity and regulatory constraints. Those involved in scaling initiatives need to understand and respond to these constraints. Some of the spatial strategies in this regard are scale jumping, scaling down and scale bending.

- **Scale jumping** is expanding decision making power on scaling in order to avoid scale traps resource, capacity and political legitimacy related constraints. In Africa RISING project, this meant, for example, taking evidence on local fertilizer application to a national level fertilizer recommendation reform.
- **Scaling down** is devolution of power which higher level scaling actors engage local actors to get sufficient space and support to implement scaling actions. In Africa RISING project, this meant finding local partners for implementation of an improved fertilizer decision support tool generated based on evidence from Africa RISING research.
- **Scale bending** is finding alternative mechanisms for surmounting or even resisting market, regulation and policy related constraints of scaling faced by local communities. In Africa RISING, this meant, in some instances, by-passing stringent seed regulations that limit the possibility of seed production from limited supply of available early generation seeds.

**Exercise:** From your practical experience, state examples of scaling out, scaling up, scale jumping, scaling down and scale bending.

## SCALING PRINCIPLES

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Scaling is not about tools alone. It is important to note several principles that underpin the proposed approach to scaling.

- Scaling of innovations requires a balanced focus on technical requirements and associated social dynamics surrounding scaling targets, actors involved and their social relations
- The processes follow flexible approaches that use a combination of complimentary tools that have been carefully reviewed.
- Attention is given to practical, implementation-oriented needs. These needs are supported by scaling coordinators to ensure smooth implementation and communication, as well as collection of required data needed for reporting, M&E and decision support information.
- Scaling strategies need to be flexible, stepwise, and reflective. Hence, an agile approach that can be adapted and iterated quickly needs to be followed
- The approaches need to be designed to promote the close involvement of project teams feed and forage value chains and ensure ownership and a shared understanding and commitment to scaling objectives.

Very few, if any, feed and forage innovations have been systematically assessed with a scaling lens; fewer still have detailed scaling plans based on such assessments. The suggested model below looks to address this in a gradual and practical manner. Considering innovations are at various stages of the research cycle, the process below provides the choice to conduct light or in-depth analysis for scaling, as well as a process to ensure required human and managerial support is met.

**Exercise:** In your practical experiences of scaling of agricultural innovations what are the key lessons you think those who are designing new scaling initiatives should learn from? Describe the lessons in brief.

## SCALING ASSESSMENT

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### Key definitions

#### Scaling coordinator

The first thing that needs to be done in scaling agricultural innovations is assigning a dedicated scaling coordinator. The scaling coordinator is assigned to the scaling initiative and work closely with all relevant stakeholders to support the whole scaling process. The main tasks include:

- Collect firsthand data through interviews and surveys and secondhand data through literature review of existing reports and documents
- Support and organize scaling workshops with key scaling stakeholders as major facilitators
- Follow-up and validate data for the initial scaling report
- Conduct data analysis and draft reports for scaling workshops
- Support the use of other selected tools for detailed analysis
- Assist in drafting the final scaling plan

- Assist the implementation and monitoring, evaluation, and learning (MEL) of the scaling plan

### Scaling champion(s)

A scaling champion is a person within the scaling initiative, preferably with a senior role. For feed and forage scaling initiatives, these could be team leaders of feed and forage subject matter specialists at district, zonal or regional levels, depending on the level that the scaling initiatives is initiated. The champion needs to be someone with a broad knowledge base of the feed and forage issues in his/her jurisdiction and act as a direct conduit between the scaling coordinator and the rest of the feed and forage subject matter and extension team in the organization, linking with people or resources who can facilitate information and data flow.

### Core scaling group

The core scaling group comprises the scaling coordinator and scaling champion(s) from a particular feed and forage innovation scaling initiative. They are the scaling initiative focal people and as such understand the technological innovation. The core scaling group also includes the scaling overseer, preferably the head of district, zonal or regional bureau of agriculture or someone with higher-level decision-making power, who supervises and coordinate the scaling initiative. The purpose of the core scaling group is to focus and coordinate scaling efforts from commencement to conclusion of the initiative.

### Key scaling stakeholders

The key scaling stakeholders include a broad range of people- key development partners among the technology value chain, direct and indirect beneficiaries, sectoral representatives from both government and private sector, market experts who are familiar with the enabling environment and anyone else who is willing and able to add value to aspects of scaling in the project.

**Exercise:** Identify potential core scaling group members and key stakeholders for selected feed and forage innovations in your district/zone/region.

Once the scaling coordinator, the scaling champion(s), the core scaling groups and the key scaling stakeholders are identified, the next steps are undertaking a scaling assessment and scaling strategy development.

There are five steps listed below for developing a scaling strategy through an introductory workshop and analysis.

#### **Step 1. Understand the context of the project/technology and operating environment**

Before conducting an initial scaling workshop, it is important to identify the organizational strategy, existing partnerships and available resources to accurately determine the purpose and goal of the

scaling initiative. This step helps to identify scaling priorities, select pilots for potential technological interventions and establish key individuals and organizations involved.

In the context of feed and forage innovations, there are often two types of technological innovations identified as target for scaling assessments; it can either be a specific technology, such as an improved forage crop cultivar, or it can be a package or “basket” of innovations that consists of core (for example new forage crop cultivar) and complementary technologies (for example feeding methods for introduced cultivated forage) along a specific value chain and market system.

The outcome of this step is a draft statement of realistic scaling ambition. A scaling ambition is a description of what you want to scale. A good statement of scaling ambition includes description of the innovation, the target group, the intervention area, the size of the target group, the leading organization for the scaling, the time to reach the desired scale and the system change that you want to contribute to.

**Exercise:** Set a scaling ambition for feed and forage innovations in your area of jurisdiction.

## Step 2. Preliminary data review

After identifying the target for scaling, the scaling coordinator together with the scaling champions and the core scaling group need to conduct preliminary data review. The preliminary data review process aims to capture and document existing knowledge as much as possible in preparation for the scaling workshop. This will also help the scaling coordinator to understand the context and previous scaling efforts. The review can also include a summary of the innovation (package), models and theory of change, and a list of proposed scaling workshop participants and their experience with scaling.

Review methods can include desk research, literature review and online surveys conducted by the scaling coordinator. The scaling champion will collaborate with the scaling coordinator to collect reports and other evidence—technology or innovation summary, reports on research design, value chain mapping documents, monitoring and evaluation reports, etc. They will also select scaling workshop participants and familiarize stakeholders with relevant materials ahead of the workshop.

The two outcomes of this step are descriptions of systems check and responsibility check. The system check describes what changes in the sector are required to reach your scaling ambition. The responsibility check describes the positive or/and negative implications of the scaling work on society and the environment. The social responsibility check needs to address potential negative side effects on women and youth farmers and other disadvantaged groups and identify potential losers and winners due to the scaling initiative. The environmental responsibility check needs to assess the potential negative side effects of the scaling ambition on natural resources such as land, water, biodiversity, and the climate.

**Exercise:** Write down System Check and Responsibility Check statements for feed and forage innovations scaling in your area of jurisdiction.



### Step 3. Initial scaling workshop: setting the scene

At this stage, key scaling partners are brought in on board in a workshop format, together with the core scaling group, the scaling champion, and the scaling coordinator. This workshop is at the core of the process. It's a light, in-person workshop that will take 1–3 days depending on the availability of staff, previous exposure of participants to scaling work, project lifecycle and timelines, available budget and the scaling scope of the initiative. The workshop aims to bring key scaling stakeholders together to review the scaling ambition and key challenges for scaling efforts, agree on core components of the scaling strategy and seek directions for implementation. A clear scaling pathway based on the scaling goal can be one of the workshop outputs, which we recommend includes an evaluation of the sectoral willingness and capacity to implement the scaling pathway(s).

The workshop is aided by a scaling assessment tool called Scaling Scan. With the scaling ambition set and system check, and responsibility checks in place, the next step is to further assess the innovation planned to be scaled against a set of criteria that would provide the opportunities and challenges of scaling innovations. The 10 issue and close to 40 questions assessment tool is available at (<https://ppplab.org/2018/11/3223/>). It is recommended that you use the spreadsheet available on the website as this would allow you to make automatic calculations and visualization of your results. It is important that the scaling coordinator encourage maximum participation from the core scaling group members and the key scaling partners as the genuine deliberations are as much important as the final rank given to a particular question. Equally important is to maintain a detailed and clean note of discussions during the workshop.

The major expected output from this workshop is an increased awareness of scaling principles and a change in how key partners perceive dimensions of scaling in their work. A synthesized workshop report needs to also be prepared after the workshop and shared with all participants for documentation and reporting reasons.

**Exercise:** Undertake innovation scaling ingredients assessment for feed and forage innovation in your areas of jurisdiction using the Scaling Scan spreadsheet available at <https://ppplab.org/2018/11/3223/>.

### Step 4. Post-workshop follow-up: getting to a scaling plan

After the scaling workshop, it is important to follow up with workshop participants and newly identified stakeholders or partners to independently confirm assumptions and ensure the accuracy and validity of the information obtained in the workshop. This is a key step in reducing reporting bias that may emerge in group workshops, which should be undertaken in any case (even for the light scan process) to ensure that pathways proposed in the workshop are feasible. The process can be conducted through calls and interviews by the scaling coordinator with the help of the scaling champion.

The core scaling group might need to meet again shortly after the workshop (some teams find it easier to add an extra day immediately following the workshop in step 3) to verify scaling ambitions within the target timeframe and the feasibility of proposed solutions from the workshop based on the

resources and capacity of the research team. If the scope is too broad, it might need further revision and prioritization before developing the scaling strategy or any action plan.

For projects planning to complete the in-depth process, it might not be required to be as thorough as the process described above in the initial scaling assessment. However, the core innovation(s) should be identified before commencing the analysis using the scaling readiness tool. Scaling readiness provides integrated, science-based options for assessing and accelerating scaling of innovations. Through the five steps defined in the scaling readiness tool, the target innovation (package) will be characterized and diagnosed based on existing evidence for its readiness and current usage status. A large amount of information will be obtained through literature review, online survey and interviews with key informants. Based on the detailed analysis and validation, a scaling strategy will be formed and approved by stakeholders. As an iterative “deep drive” approach, scaling readiness provides a much more thorough examination of the known challenges to achieving desired impact. This will help draft a detailed plan to inform decisions towards scaling. It also provides guidelines for implementation with explicit feedback loops.

At this stage, the scaling team will have the needed information to prepare a detailed scaling plan that incorporates findings from overall analyses and assessments, clarifying a clear scaling pathway, areas of concern, as well as recommendations that can help enhance the scaling outcome. This is the main deliverable of the assessment process.

**Exercise:** Based on the results in step 1-3, prepare preliminary scaling strategy for feed and forage innovations in your jurisdiction.

### **Step 5. Beyond a scaling plan: ongoing implementation and monitoring, evaluation and learning (MEL)**

The detailed implementation process will be specific to each scaling plan. It includes periodic reflection on scaling activities to check if all tasks are proceeding as planned. A set of monitoring and evaluation indicators will be designed to facilitate this process through standardized and traceable measurements for progress.

**Exercise:** Prepare MEL approaches and tools for your scaling initiative.

### **Africa RISIG Ethiopian Highlands Project Experiences with Scaling**

In its first phase of operation (2011– 2016), through participatory action research, Africa RISING (Africa Research in Sustainable Intensification for Next Generation) Ethiopian Highlands Project, USAID funded research for development project, was able to generate scalable innovations which were tested and validated in different agro-ecological settings. The technically sound innovations generated by the project were well received by local actors because of the trust and cordial relationships between project coordinators and scaling partners. The second phase of the project kicked off in 2017. The scaling strategy adopted by the project in the second phase has been i) identification of scaling partners, ii) developing the capacity of scaling partners to set scaling targets and integrate Africa RISING validated innovations in their regular work plans and iii) providing backstopping research to help scaling partners achieve their scaling targets.

- i. Identification of scaling partners: Scaling partners were drawn from a pool of partners who contribute to research prioritization through participation in the first phase diagnostic studies and planning meetings and were able to observe the research process and its results. In the second phase of the project, the project needed to strengthen the spontaneous scaling which was already happening during the first phase and shift towards a more deliberate scaling. Partnership have been dynamic. Some of the local partners such as the public extension system continued to work with the project throughout the project period. Other partners, however, dropped off along the line. Other partners such as farmer cooperatives and unions were brought on board in recent times.
- ii. Capacity building of development partners: Before each planting season, Africa RISING organizes capacity building and planning workshops in each intervention region. These workshops were used to prioritize innovations for scaling and set scaling targets. The outputs of the workshops has been used by Africa RISING project coordinators to plan and execute scaling support strategies such provision of starter planting materials, capacity building in the form of trainings, exchange visits, demonstrations.
- iii. Backstopping research to support scaling partners: Africa RISING empirical experience showed that scaling may not be strictly planned. Instead, it requires research backstopping to refine innovations to fit local contexts, build functional relationships with key partners, and build trust.

## CHAPTER SUMMARY & KEY TAKEAWAYS

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This chapter brought to you the issue of scaling. Deliberate scaling initiatives could help you reach out to many farmers with feed and forage innovations. The chapter brought you some of the basic principles of scaling, the types of scaling and the deliberate process of scaling assessment. The last aspect, scaling assessment, is essential to device scaling plans and strategies for your feed and forage innovations. In using the guides in this chapter, the following key takeaways are essential.

- i. Scaling feed and forage innovations require dedicated attention and resource. Hence, organizations committed to scale innovations need to dedicate the required resources as well.
- ii. Scaling involves engagement of actors which are often neglected in innovation generation processes such as financiers, marketers, input suppliers and decision makers. Hence, those who want to have successful scaling needs to work on the partnerships required seriously.
- iii. Scaling is a complex undertaking. A full scaling of an innovation often is a multi-year, multi-actor endeavour. Hence, those who want to engage in scaling need to take a phased approach, harvesting simple and 'low hanging fruits' first and proceeding with achieving more complex results.
- iv. Scaling requires flexible and learning based approaches. While scaling tools and scaling targets help to make scaling initiatives, to appear 'deliberate' and 'focused', flexibility and learning based approaches help scaling initiatives achieve concrete results.

# Chapter 7 : Media Communications on Livestock Feed Development

Getinet Assefa\*

## LEARNING OBJECTIVES

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*This chapter intends to provide the media people on the overall role of livestock to farmers livelihoods and national economy, current production conditions, the major challenges, and opportunities in the mixed crop-livestock production systems for promotion of improved livestock production specially focusing cultivated forage crops*

*At the end of this chapter learners will be able to*

- *Understand the role of livestock in the livelihoods of smallholder farmers*
- *Know its contribution to the national economy.*
- *Understand the current status of livestock production in the mixed crop-livestock production systems?*
- *Know the major challenges that has limited transformation of the livestock sector*
- *Understand the different feed resources and major challenges of feed as the main input limiting livestock productivity*
- *Understand the roles of cultivated forage crops as feed for livestock and their production challenges and opportunists*
- *Will identify the major agendas to be addressed by media targeting the different stakeholders of the sector including farmers, extension workers, policy makers, input suppliers, traders, etc.*
- *Will know the main sources of information and their contacts.*

## INTRODUCTION

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In Ethiopia a number of proven technologies has been developed in the areas of livestock feeds and feeding systems. These include, improved management of grazing lands, efficient use and treatment of crop residues, productive forage varieties/species with their agronomic practices, recommended use of agro-industrial products, and efficient conservation practice of different feeds. However, these technologies have very little adoption mainly due to poor extension systems and promotion. Therefore, use of media to create awareness and introduction of these technologies to different actors in the livestock production value chains is crucially important. If transformation of the livestock sector to a viable and meaningful sector of the economy, crucial interventions in the area of feed improvement and promotion should be among the top agendas.

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In this process it is very compulsory to design a clear and focused strategy of promotion using media that consists of the most important elements.

In media promotion of improved practices, new technologies and innovations in the development of livestock production, journalists at different levels (producers, editors, camera persons and other technicians) are very instrumental. Successful promotion is essentially depends on the capacity and level of awareness of the journalists. Hence, an important area to be seriously addressed to promote the targeted livestock development interventions is training of the media people (journalists and others) on the basic concepts, objectives and envisaged goals are important. Motivation, and incentives on competitive basis are also often good and is an area to address.

In this particular area of intervention, the main areas to address for media people are described as follows. It includes livestock production and role in the economy and livelihoods in Ethiopia, existing policies and opportunities, the major challenges, available practices to improve feed supplies and feeding practices and emerging approaches in feed development such as irrigated fodder production.

## **THE ROLE OF LIVESTOCK PRODUCTION IN THE ECONOMY AND LIVELIHOODS IN ETHIOPIA**

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Livestock production is an integral component of the agricultural system that contributes about 15% of the total GDP, 45% of the agricultural GDP and 31% of the total employment in Ethiopia (Getachew, 2003; IGAD, 2010). Livestock has significant contribution to the national development goals such as food security, poverty reduction, livelihood improvement and finally to the overall socio- economic growth and transformation.

The role of livestock in the livelihood of most Ethiopian smallholder farmers and pastoralists is all rounded. Livestock provides food for the family, plow the land for crop production, it is source of income and social prestige, provides manure to improve soil fertility, it is sources of fuel for cooking, It provides transport services for goods and human beings, when all these services finished the skin and hides provide clothing and shoe.

On the other hand, despite having the largest livestock population in Africa, its contribution is still very low. Good indicators are the low milk and meat consumption in Ethiopia, which is far below Africas average. Accordingly, the Government of Ethiopia (GoE) has set an ambitious target for livestock sector development in terms of increasing production and productivity and thereby contributing to poverty reduction, attainment of better food and nutrition security, national income growth and foreign exchange earnings as outlined in the 10 years strategic development plan of the ministry of agriculture. These targets can only be met through securing year-round supplies of good quality feeds and efficient utilization of the available feed resources through improved feeding management.



### **Important elements to design a clear and focused strategy of promotion using media**

- **Target audiences:** in this context target audience means particular group of people to which a message is aimed at or directed to. Your message might be targeted to smallholder farmers, extension workers, policy makers, feed industries, traders etc, and need to be fine-tuned accordingly
- **Communication objectives:** This means what to be achieved by communicating with the targeted audience. This is like do we want to scale up technologies, is there a need to improve or have new policies, etc
- **Messages:** Message in this context means a statement tailored to different audiences that define the issue, state solutions and describe the actions that need to be taken.
- **Channel of communication:** In this context channel of communication means those tools/ platforms by which a message is delivered to the various target audiences. The medium or channel of communication we choose varies according to the target audiences identified. For example most smallholder farmers may have no televisions and hence radios might be appropriate. For policy makers social medias like Facebook might be more suitable
- **Implementation plan:** this map out specific tasks and roles of different actors at various levels. It is also equally important to focus on key critical areas of intervention.
- **Monitoring and Evaluation (M&E):** Monitoring and Evaluation is a process that helps to track progress that helps to improve performance and achieve results. In other words, monitoring will help as a checkpoint of whether the implementation is on the right track or needs any adjustment. Evaluation is a process of gathering and analysing information to determine if the communication objectives have been achieved or not.

## **MAJOR CONSTRAINTS FOR LIVESTOCK SECTOR TRANSFORMATION**

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Constraints to the livestock productivity are generally associated with traditional / poor agricultural practice together with man-made and natural environmental degradation. Among the various constraints limiting livestock productivity, the first and foremost one is inadequate availability and poor-quality of animal feeds. A good indicator of this fact is, critical feed scarcity for more than 9 months a year and average annual feed deficit of 35% of the requirement (maintenance plus production) has been noted in the study on the status of feed resources in the central highlands of Ethiopia (Tadesse et al., 2007). The feed situation in the pastoral and agro-pastoral situation is even worst as it is entirely dependent on grazing unlike the highlands in which crop residues remarkably

contribute to the annual feed budget. Moreover, the environment is more fragile compared to the highlands.

The other major challenge is use of local breeds especially cattle and poultry, which are remarkably low in productivity. The number of crossbred cattle in Ethiopia is less than 2% of the total population. In the crop-livestock mixed systems, farmers keep cattle primarily for traction purposes. The oxen traction animals are reported to be used 60 days per year. During the rest of the months these animals are feed and kept idle and produce nothing. It is realized that the available feed is not efficiently utilized.

The increasing human population is also one of the problems. The food demand is ever increasing and never fulfilled. This resulted in encroaching the available grazing lands for crop production and worsens the feed scarcity. On the other hand, the demand for milk and meat is becoming very high and prices are ever increasing.

In Ethiopia there are many economical important livestock diseases, which significantly affecting productivity. Young stock mortality almost in all species is high, in addition there are seasonal disease outbreaks in different places. Despite strategies developed and efforts going on, transboundary diseases, weak quarantine procedures, over all weak animal health services are the main challenges in the sector. The presences of these important disease have also affected the export market. Besides zoonotic disease like, tuberculosis, brucellosis, anthrax, salmonellosis, rabies, and east cost fever are common problems affecting public health.

The national livestock marketing systems are poorly developed. Livestock producers are not well benefited due to the poor marketing systems. It is more of traditional, and systems and infrastructures are not well developed. This poor marketing system is also remarkably affecting the export market. The supply is inadequate, and the quality of animals is not to the required standards. The country is also highly affected by the illegal trade of livestock almost in the borders of all neighboring countries.

## **MAJOR LIVESTOCK POLICES AND OPPORTUNITIES**

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Ethiopia has a conducive environment for livestock production such as dairy and meat. Most of the highland areas have suitable for dairying. Moreover, there are variety of forage crops well adapted to these ecologies. In the mid and low land areas there are many irrigable areas which is suitable specially for meat production from cattle, small ruminants and camels. Generally, the suitable agro-ecology, the high demand for the livestock and its products marketing and availability of cheaper labour are attractive opportunities for livestock production

There are different polices developed by the government targeted to develop the livestock sector such as in the area of investment, quarantine, health, feeds, importation of genetic materials, local and export market and the like. However, most of these polices are not well functioning at the grass root level. This has remarkable affects the sector. Despite that there are some developments such exemption of VAT in livestock feeds, encouraging developments in livestock investment like dairying.

Under the current condition of the livestock sector, there are many issues that should be given by the government which might requires police guidelines. These includes

1. Land use policy – the land use is specific to livestock production. Most of the livestock farms are usually confined in small places. Most dairy farms are in small places. But almost all livestock farms do not have land for feed production therefore, livestock investment needs to consider this.
2. Credit services – Investment in livestock should be treated with its peculiarities. However, insurance systems and many criteria set are discouraging to have investment in the area.
3. Free grazing / Communal grazing systems are hindering the livestock development in many ways, hence such practice should be guided and encouraged to be a form of controlled systems.
4. Marketing systems for live animals, dairy and its products, export market, illegal trades should be legal structured and guided, otherwise its negative impacts on the economy, public health and related matters will be very high

## **AVAILABLE LIVESTOCK FEED AND FORAGE TECHNOLOGIES**

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### **Grazing lands (natural pasture)**

In the mixed crop-livestock system of the highland agro-ecology, the contribution of the grazing lands declined from 80-90 % in the early 1960's to 30-50% during the last decade of 2000's. The area coverage, productivity and quality of natural pasture is dictated by various biophysical and management factors among which agro-ecology accounts for the major variation. Currently, with the rapid increase of human population and increasing demand for food, grazing lands are steadily shrinking being converted to arable lands, and are restricted to areas that have little value or farming potential such as hill tops, swampy areas, roadsides, and other marginal lands. This is particularly evident in the mixed highland and mid altitude farming systems.

Annual pasture yield assessments on the highlands and mid altitude areas have shown 1-2 tons on average pastures and 4-6 tons DM/ha on very good and well managed pastures. But with increasing natural degradation and over stocking productivity is also declining. In addition, the forage biodiversity is threatened and many pasture species are lost and the remaining are endangered. According to on-station research findings (Zinash et al., 1995) the natural pasture in the highlands is just adequate for live weight maintenance and weight gain during wet seasons and would not support maintenance for the rest of the year. Under maximum herbage intake, protein supply was adequate for maintenance only for three months of the year. Grazing trial conducted in the highlands indicated that optimal carrying capacity of natural pasture is 1.5 TLU per ha per year and well managed natural pasture could support up to 2.5 to 3 TLU/ha during the main growing seasons.

Fertilization, legume over sowing and bush control were some of the major interventions studied to improve productivity and quality of natural pasture. According to studies on highland pastures, higher herbage yield was recorded with an increase in the levels of N and P fertilizers. Phosphorus is also useful to improve crude protein content of the total herbage by enhancing the growth of native legumes through its positive effect on nodulation and root development. Suitable time of fertilizer application is suggested to be at the beginning of the rainy period. Split application has been found

to result in better yield and quality than single application. Cattle manure applied at the rate of 10 t/ha on natural pastures has also been found to improve yield and quality of native pastures. The grazing lands are most commonly used in a free grazing system. In some places grazing lands are managed privately, however, communal grazing is widely utilized in the majority of the months of the year.

Limited amount of hay is produced in the country. Most of the produced is used at home, while limited amount is baled and supplied to the market. Almost all the hay produced is from natural pasture. In very few areas hay from oats, rhodes grass, and others are produced. The market niches for hay are peri-urban and urban livestock producers (dairy and fattening), livestock traders, quarantine sites and during the time of emergency. There are established hay traders, who purchased the pasture on the field, in which they harvest, bale and transport by themselves. The price of hay is becoming very expensive and rapidly increasing over the years. The quality of the hay produced is poor. This is mainly due to over maturity and lack of good practice of effectively harvesting, collecting and baling at the right time.

## Rangelands

For pastoralists the rangelands are the main and practically the only sources of feed for their livestock. As pastoralist livelihood is entirely dependent on livestock, the rangelands are everything for them. On the other hand, the agro-pastoralist, dominantly rely on the rangelands for their livestock, however limited amount of crop residues is also used as feed for their livestock. Pastoralism is the source of employment for 12% of the population of Ethiopia and it is potential resource for capital investment and savings. In Ethiopia there are huge area of rangelands in the different regions, the estimated area of rangelands in the different regions is about 623,620 sq kms which is about 67% of the countries land area (PADS, 2005). Abule et al (2018) has summarized the main challenges of rangelands in pastoral agropastoral systems as follows:

1. **Drought, climate change and variability:** Periodic drought is a common phenomenon globally and a characteristic of the arid pastoral production system. Currently, drought has been more pronounced, and its frequency has become short recurring every 2 to 3 years in Ethiopia. It has brought about significant effects resulting in the decline of rangeland resources, productivity and survival of livestock that eventually caused changes in the size and composition of livestock herd sin affected areas (Solomon, 2002). In severe cases, it resulted in widespread disruptions of food supply and emigration owing to loss of livestock and other factors
2. **Bush encroachment and other invasive plants:** Bush encroachment is the process of open grassland savannas being transformed into thick bushes and is one of the major problems of the rangelands in pastoral areas. The lack of prescribed burning, accompanied by severe overgrazing, and the expansion of farming in the dry-land were among the main problems associated with bush encroachment in Borana rangelands. There are no accurate data as to the area covered and amount of encroacher plants in the Afar region, however, rapid expansion of *Prosopis juliflora*, *Acacia seyal*, *Acacia melifera* as well as *Acacia senegal* are major concerns (Beruk, 2008). Currently, the rapid expansion of *Parthenium hysterophorus* commonly known as congress weed is another threat encroaching in both the rangelands and crop farming areas.

3. **Contraction of the pastoral territories:** this is the losses of rangelands (pastoral land) to other non-pastoral land uses in the pastoral agropastoral areas of Ethiopia. Over the last three four decades, the pastoral areas lost millions of hectares of their prime grazing territories to other non-pastoral uses including rain fed agriculture, irrigated agriculture, national parks, etc in Afar, Somali, Borana, South Omo, Gambella regions. These changes may have displaced millions of breeding cattle, posing significant impact on the lives and livelihoods of pastoral households and their environment
4. **Human and livestock population increase:** As compared to neighboring east African countries, human population in Ethiopia has increased substantially since the 1960's. Increased demand for livestock products is evident in developing countries owing to rapid population growth, urbanization, income growth and the increased production is also associated with increase in animal numbers which is also true for Ethiopia (Thornton, 2010). Aggravated by land use changes (increasing size of crop land and declining grassland size and productivity), population growth has been another challenge in the development of pastoral areas.
5. **Conflicts, weakening traditional pastoral system and others:** Conflicts of different kind (inter and intra clan) and weakening of the traditional pastoral system is very evident in Ethiopia (Abule and Alemayehu, 2015). The other major problems associated in this regard include the lack of adequate knowledge of the pastoral and agropastoral production system, shortage of appropriate research technologies and extension services, shortage of qualified human power and facilities. Although there are some improvements, inadequacy of basic social services, infrastructure and communication facilities, poor veterinary and market services in terms of area coverage, human power and facilities as well as lack of appropriate land use plan are also bottlenecks to the system

All the above-described challenges are threatening the rangelands in Ethiopia. The situation is aggravating over time and threatens the pastoral way of life and the overall livelihoods of the pastoral and agropastoral people and hence there is a need to address the challenges and appropriate interventions to be in place

## Crop residues and aftermath grazing

Crop residues are the second most important feed resources for livestock. There are different types of crop residues produced in the country. The major ones are cereals, followed by legumes, horticulture crops, oil crops etc. The cereal straws account the major proportion. Their crude protein content is lower than the threshold required for maintaining the N balance of an animal in the positive side. The fiber content is also higher than the value suggested to limit intake of animals. Digestibility of crop residues is also low and varies with the crop type from which the residue is produced. In general, nutritional quality of crop residues is influenced by several factors like morphological fractions of the residue and varietal difference of the crop (Seyoum et al., 1996). Fekede et al., 2015 also showed that nutritional quality of crop residues is also highly affected by storage method and storage duration as investigated in tef and wheat straws. Legume haulms are good quality residues. Farmers are well aware of that, and they usually give high attention. They feed these residues in mixture with cereal residues or alone mostly for fattening animals.

Strategic supplementation of crop residues and poor-quality native hay substantially increases the palatability and digestibility of the total diet thereby improving body growth and productivity of animals. High quality fodder legumes both from herbaceous and browse trees have been selected to meet the need for quality supplementary fodder well adapted to the various climate and soil types of the various regions.

Digestibility and intake of straw can also be increased by treatment (physical, chemical and biological), and if accompanied by supplementation, better animal responses can be attained. Among various chemicals globally used to treat crop residues, application of fertilizer-grade urea has been explored locally. Results suggested that depending on the type of crop residue, crude protein content can be improved by about 5.5% and digestibility by 8.4% through urea treatment (Seyoum, 2007)

Aftermath grazing is an important feed sources after crop harvest. Aftermath grazing is usually privately utilized by the owners of the crop. During the old time, aftermath grazing was providing good quantity of forage from crop fields. However, over time as feed scarcity becomes critical, farmers tend to collect as much crop residue as possible for conservation and the left over in the field is becoming less and less. Once the aftermath grazing is exhausted normally it is open for free grazing. This condition aggravates a lot of land degradation.

## Agro-industrial by-products and other concentrate feeds

The main agro-industrial by products available in Ethiopia are, flour mill by products (wheat brans, middlings, etc), sugar mill by products (molasses), brewery spent grains, oil mill by products (oil seed cakes) are the main once. In terms of potential the sugar mill by products is very high, however, due to accessibility and transportation difficulties it is not adequately utilized as feed for livestock. In some area's molasses mixed with urea, and other concentrates made into MNB (multi nutrient blocks) and used as emergency feed supplements. However, it has been proved that use of MNB has substantially increased milk production of dairy cows. Additionally, potential use of MNB in fattening animals' diet was also validated on-farm as a preferred supplement in central highlands of Ethiopia (Mesfin, 2012; Seyoum et al., 2008)

The most widely utilized agroindustry by-products are flour mill by products, oil seed cakes and brewery spent grains. However, they are limited in supply.

In many countries grains like maize and soybean are important ingredients of concentrate feeds. In Ethiopia these grains are insufficient in supply and usually prioritized as food grain for human being. These grains are very high in price, moreover, transportation costs where most of the mixers are found are very high. The majority of soybean produced is also exported to Asian countries. Generally, currently the use of food grains as livestock feed in the country is insignificant.

Feed industries in the country are concentrated in the central part of the country. These industries mix and produced formulated rations for dairy, beef, small ruminant fattening, poultry and other groups of livestock. Most of the inputs for these feed industries are agro-industrial by products and very limited food grains. The industries are currently performing under capacity. They reported the demand is very low, while the livestock producers are complaining with the very high and ever-increasing prices. The prices are increasing due to very limited supply raw materials, high



transportation cost for the long distance to travel, taxes and sometimes double taxations. It is also reported that most often the quality of these compound feeds is poor or not as expected or prescribed.

In addition to the above indicated feeds there are non-conventional feed sources which are widely used all over the country. These feed sources have high crude protein and energy contents enough to be used as concentrate supplements for livestock. Atela (the local brewery byproducts), local flour mills byproducts like pulse hulls (field pea, grass pea, faba bean, lentil and chick pea hulls) are the common once.

The available concentrate feeds are mainly used by urban and peri-urban livestock producers. These are market-oriented dairy, fattening and poultry producers. These producers use formulated rations or home-made concentrate mixes. Most poultry producers purchase formulated feeds from feed industries. This is mainly because they can't find some basic ingredients of the mixture like the pre-mixes and other additives. However dairy and feedlots partly use formulated feeds and partly home-mixed feeds. Although home mixing is cheaper in terms of price, one has to mix in the right proportion for better use. Therefore, under such condition's extension workers are expected to assist in the preparation of home mixed concentrate feeds. Use of concentrate feeds by pastoralists and smallholder farmers is generally insignificant.

## Improved forage and pasture crops

Cultivation of forage and pasture crops are not traditional practice of Ethiopian livestock producers. Ethiopia has very divers agroecology ranging from cool highlands to very hot desert climates. During the last five or more decades, research has been going on cultivated forage crops. Accordingly, many forage species and varieties were identified and evaluated. Most of the evaluated and recommended forage crops are exotic species. However, the local species had very little attention.

Forage crops provide an excellent quality feed for livestock. They can be produced with the premises of farmers locality with cheaper prices. Access to concentrate feed is one of the major challenges but farmers can grow in their locality and can use it any time they want. Forage has also multidimensional uses, in soil and water conservation, improvement of soil fertility and sequestration of carbon in mitigating climate change.

In Ethiopia about 61 forage and pasture species / varieties are official registered and many others recommended (Annexes 1, 2 and 3). With the current feed scarcity production of forage crops is a feasible intervention to most smallholder farmers and pastoralists. The cultivated forage crops could be utilized immediately or could be conserved and used at the time of need. Agronomic practices focused on various desirable characteristics including adaptation to the prevailing climatic and soil conditions, ease of establishment, persistence, herbage productivity, seed yield, resistance to pests and diseases, forage quality, multi-purpose uses and suitability for integration into the farming system has been developed for well adapted and productive species. Generally, forage and pasture crops are the future livestock feed sources for many reasons and environmentally friendly way of livestock production.

Details of the cultivated forage production practice for selected widely popular species and different strategies of forage production is described in forage crops production and utilization section in this manual. Similarly details of seed production methods are also available in this manual.

## **EMERGING APPROACHES FOR FEED AND FORAGE PRODUCTION**

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With the increasing human and livestock population, resources such as land for crop farming and grazing becomes limiting. The extensive way of livestock production, which has been the case for many years in Ethiopia becomes extremely challenging. The emerging scenario in many places is intensification of livestock production. This is especially pertinent in highly populated highland crop livestock mixed areas. The intensification is generally focusing in use of improved productive breed such as in dairy and poultry and remarkably on the production, management and utilization of feeds. The main inputs in such semi-intensive commercial livestock farms are feed and the prices of feed is high and increasing and hence farmers try to maximize the use of available feeds and look various options to produce additional feeds. These include:

- a. Efficient conservation, conservation and use of crop residues and feeds from grazing lands.
- b. Integrated production of cultivated forage crops in different farming practices
- c. Cultivation of forage crops on arable lands under irrigation

Currently almost all farmers timely collecting properly conserving crop residues. Almost all aftermath grazing practices are on private bases. Farmer's practice feeding value improvement practice of crop residues like chopping, rinsing with water and salting. Hay making from exclusion areas farm boundaries, school and church compounds becomes very common in many places.

Successful and integrated forage production is becoming popular in different parts of Ethiopia. Forage crops mainly legumes are grown through intercropping and under-sowing with cereal crops especially maize and sorghum. This practice does not require additional land, do not affect food grain production moreover, the forages minimize soil erosion and improves soil fertility. Forages are integrated in the natural resource conservation practices. They are planted on terraces and soi bands. This provides dual functions; farmers produce forage for their livestock and at the same time conserve water and soil. Semi intensive dairy farms start produce forages in the backyards. They plant highly productive forages like elephant grass, desho grass, alfalfa and brachiaria.

Conventional cultivation of forage crops both under rainfed and irrigation is the current emerging scenario for Ethiopian livestock producers. This is usually for two main reasons 1) the current demand for livestock products promotes market-oriented systems that motivates farmers to produce forage with the available land both under rainfed and irrigation schemes, 2) in dryland areas and drought prone areas moisture often don't support forage and crop growth. Hence, many government and project supported small scale dams and irrigation systems are developing. In these areas farmers produce high value crops such as vegetables and generate quite good amount of income. In addition, forage crops are also produced under irrigation. Farmers produce one or two crops per year under irrigation. In this system forages are used as break crops in the irrigation system. In producing

cultivated forage crops and irrigation systems it is very important to properly consider practical condition for successful forage production. The main points are summarized as follows.

### **Production of cultivated forage crops in arable lands under irrigation, and rainfed main points to consider**

1. Decide the size of the farm based on the total feed required for the targeted purpose and the productivity of the forage species to be planted.
2. Identify the recommended forage crop types to be planted and prepare the inputs (seed and fertilizer) and make ready for planting at the right time. Primarily look into adaptability, productivity and quality of the forage to be planted.
3. Use the recommended establishment practice, and agronomic practice of the selected forage crop that suit to the targeted locality.
4. Plan the mode of utilization and conservation ahead of time and act timely
5. Know the farming system in the targeted area and align the management of the forage production activities. In areas where communal grazing is practiced, forage crops in arable lands may be problematic. If there are communal after-math grazing then forage crops cultivated should preferably be annuals like Sudan grass, lablab, cow pea, oats, vetch, etc. When produced under irrigation, targeting highly productive forages are preferable. Forage crops could be partly used in cut and carry in the growing season and conserve the remaining forage as hay and used during the time of scarcity.
6. Cultivation of perennial forage crops may create difficulties to keep them during the off-season unless and otherwise it is grown in a fenced and well protected areas from free grazing livestock.
7. Consider all the above precaution when forages cultivated under irrigation in arable lands

## **CHAPTER SUMMARY & KEY TAKEAWAYS**

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In promotion of improved practices, new technologies and innovations in the development of livestock production, the role of media is very instrumental. Hence, journalists at different levels (producers, editors, and other media experts) need to be well aware the major issues and agendas to be promoted

The media people need clearly scrutinize and understand livestock production and its role in the economy and livelihoods in Ethiopia, existing policies and opportunities, the major challenges, available practices to improve feed supplies and feeding practices and emerging approaches in feed development such as irrigated fodder production

The traditional farming practices, the genetic make of the animals, prevalence of different animal diseases, critical feed shortage and its seasonal variability, poor extension efforts and marketing setups remarkably affected livestock production in Ethiopia.

Feed is the main input and the major cost in livestock production. Depending on the farming systems there are different sources of feeds including; rangelands /grazing lands, crop residues, cultivated forage crops, agro-industrial by products, formulated concentrates and other different non-conventional feeds. However, most of these feeds are generally in short supply affecting livestock productivity.

Cultivated forage crops have diverse functions in the farming system and hence promotion of the best practice and addressing the challenges are crucially important in transforming the livestock sector.

Forage crops could be cultivated under irrigation in integration with other high value crops and could play different function such as in tackling climate change

Media should play a key role on promoting effective feed utilization practice focusing improved feed production and utilization focusing on cultivated forage crops.

## PRACTICAL EXERCISES

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1. List out the major challenges of livestock production in the crop livestock mixed systems area in Ethiopia?
  - What are also the major opportunities in tackling these challenges?
  - What would be the main interventions that should be done to improve productivity
2. Write three priority agendas that could be primarily address by the media
3. Write two topics and the appropriate channel (radio, TV, social media, etc) to be addressed by the media targeting
  - Smallholder livestock farmers
  - Extension workers
  - Policy makers
  - Input suppliers like feed suppliers or drug suppliers etc
4. Discuss the main institutes or organizations who will be the major source of information in media promotion with regard to:
  - Animal feeds
  - Animal Health
  - Animal genetic improvement
  - Livestock marketing (local, import and export export)
  - Livestock related polices

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# Annexes

## Annex 1. List of species and varieties of forage Crops Released and Registered by the Ministry of Agriculture, Ethiopia

### Annex 1.1 Species and varieties of forage grasses released and registered by the Ministry of Agriculture, Ethiopia

No	Species	Variety	Common Name	Altitude (masl)	DMY (t/ha)	Year registered	Institute / Breeder Center	
	<b>Grasses</b>							
1	Andropogon gayanus	Dirki Ayifera	Andropogon	Up to 2000	8 - 10	2009	EIAR Pawe	
2	Avena sativa	CI-8237	Oats	1500-3000	10 - 13	1976	EIAR Holetta	
3	Avena sativa	CI-8251	Oats	2000-3000	8 - 12	2013	EIAR Holetta	
4	Avena sativa	Bonsa	Oats	2300-3000	9.7 - 10.8	2011	OARI Sinnana	
5	Avena sativa	Bona-bas	Oats	2300-3000	9.8 - 10.3	2011	OARI Sinnana	
6	Avena sativa	SRCPX80Ab2806	Oats	1500-3000	12.0 - 15.0	2015	EIAR Holetta	
7	Avena sativa	SRCPX80Ab2291	Oats	1500-3000	11.5 - 16.0	2015	EIAR Holetta	
8	Avena Sativa	Bate (ILRI - 5453)	Oats	2000-3000		2018	OARI Bako	
9	Avena Sativa	Was (CI - 1506)	Oats	2000-3000		2019	EIAR Holetta	
10	Avena Sativa	Walgaa (SRCPx80 AB2596)	Oats	2000-3000		2019	EIAR Holetta	
11	Avena sativa (grain type)	Sorataf (79Ab382(Tx) (80SA.94))	Oats	2300-2900		2017	EIAR Holetta	
12	Brachiaria hybrid	Mulatto II	Signal grass	< 1800	13-20 t/ha/cut	2018	EIAR Melkassa	
13	Brachiaria mutica	DZF-483	Para grass	< 2000	13.3	2015	EIAR Debre Zeit	
14	Chloris gayana	Massaba	Rhodes grass	1000-2400	7 - 12	1984	EIAR Holetta	
15	Cynodon aethiopicus	DZF-265	Qola Serdo	< 2000	12.2	2015	EIAR Debre Zeit	
16	Panicum coloratum	Panicum	Colored Guinea	1000-2400	6 - 10	1984	EIAR Holetta	
17	Panicum maximum	Local panicum	Guinea grass	Up to 2000	9 - 14	2014	EIAR Pawe	
18	Pennisetum purpureum	ILCA-14984	Elephant grass	< 2004	10 - 15	1984	EIAR Holetta	
19	Pennisetum glaucifolium	Areka / DZF-590	Desho grass	500 - 2500	21.7 t/ha/cut	2017	EIAR DZ, H, WG, K,	
20	Pennisetum glaucifolium	Kindu Kosha / DZF-591	Desho grass	1000- 2000	23.4 t/ha/cut	2017	EIAR DZ, H, WG, K,	
21	Pennisetum glaucifolium	Kulumsa / DZF-592	Desho grass	>1000	20.7 t/ha/cut	2017	EIAR DZ, H, WG, K,	
22	Pennisetum Hybrid	Maralfalfa	Elephant grass			2018	EIAR Holetta & Werer	
23	Pennisetum polystachion	Nech Sar	Netch sar	900-1500	7 - 12	2014	EIAR Pawe	
24	Pennisetum purpureum	ILRI - 16791	Zehone 02	1500 - 2500	12 to 16	2017	EIAR Holetta	

No	Species	Variety	Common Name	Altitude (masl)	DMY (t/ha)	Year registered	Institute / Breeder Center	
25	Pennisetum purpureum	ILRI - 16819	Zehone 03	1500 - 2500	8 to 12	2017	EIAR	Holetta
26	Pennisetum purpureum	Bako-04 (ILRI-16804)	Elephant grass			2019	OARI	Bako
27	Pennisetum purpureum	Bako-02 (ILRI - 16801)	Elephant grass			2019	OARI	Bako
28	Pennisetum sphacelatum	Shebela Sar	Bebeqa Sar	< 2000	13.2	2014	EIAR	Debre Zeit
29	Phalaris aquatic	Sirossa	Phalaris	2400-3000	6 - 8	1982	EIAR	Holetta

## Annex 1.2 Species and varieties of herbaceous forage legumes released and registered by the Ministry of Agriculture, Ethiopia

No	Species	Variety	Common Name	Altitude (masl)	DMY (t/ha)	Year registered	Institute / Breeder Center	
	<b>Herbaceous legumes</b>							
30	Lablab purpureus	-	Lablab	1000 - 2004	3 - 5	1984	EIAR	Holetta
31	Lablab purpureus	Gebisa - ILRI-14417	Dolichos lablab	1500 - 2100	8.43	2016	OARI	OABako
32	Lablab purpureus	Beresa - ILRI-14455	Dolichos lablab	1500 - 2100	8.37	2016	OARI	Bako
33	Lablab purpureus	Doli -I (ILRI-11640)	Dolichos			2019	EIAR	Melkassa
34	Lablab purpureus	Doli -II (ILRI-147)	Dolichos			2019	EIAR	Melkassa
35	Lupinus angustifolius	Welela	Seewt Lupine	1800 - 2600	13.3 qt/ha gr	2016	EIAR	Holetta
36	Lupinus angustifolius	Sanbor	Sweet blue Lupin			2014	ARARI	Andassa
37	Lupinus angustifolius	Vitabor	Sweet blue Lupin			2014	ARARI	Andassa
38	Medicago sativa	DZF-552	Alfalfa			2014	EIAR	Debre Zeit
39	Medicago sativa	Alfalfa-1086	Alfalfa	750 - 3000	3-5 t/ha/cut	2016	EIAR	ELFORA / Holetta
40	Medicago sativa	Alfalfa-ML-99	Alfalfa	750 - 3000	3-5 t/ha/cut	2016	EIAR	ELFORA/ Holetta
41	Trifolium quartianum	(Native)	Clover	1500-3000	3 - 6	1976	EIAR	Holetta
42	Vicia dasycarpa	Lana	Vetch	1500-3000	5 - 7	1976	EIAR	Holetta
43	Vicia narbonensis	Abdeta	Narbon vetch	2300-3000	3.1 - 3.4	2011	OARI	Sinnana
44	Vicia sativa	ICA-61509	Vetch	2200-2004	5 - 6	2012	EIAR	Holetta
45	Vicia sativa	Gebisa	Vetch	2300-3000	4.3 - 5.1	2011	OARI	Sinnana
46	Vicia villosa	Lalisa	Vetch	2300-3000	6.6 - 8.4	2011	OARI	Sinnana

No	Species	Variety	Common Name	Altitude (masl)	DMY (t/ha)	Year registered	Institute / Breeder Center	
47	Vigna unguiculata	Sewinet	Cow pea			2009	EIAR	Pawe
48	Vigna unguiculata	Temesgen	Cow pea			2014	TARI	Humera
49	Vigna unguiculata	Adulala (ILRI 9352)	Cow pea			2018	EIAR	Melkassa
50	Vigna unguiculata	Melka (ILRI 9334)	Cow pea			2018	EIAR	Melkassa

### Annex 1.3 Species and varieties of browse trees released and registered by the Ministry of Agriculture, Ethiopia

No	Species	Variety	Common Name	Altitude (masl)	DMY (t/ha)	Year registered	Institute / Breeder Center	
	<b>Browse trees /shrubs</b>							
51	Cajanus cajan	Dursa	Pigeon pea			2009	EIAR	Melkassa
52	Cajanus cajan	Kibret	Pigeon pea			2014	TARI	Humera
53	Cajanus cajan	Tsigab	Pigeon pea			2014	TARI	Humera
54	Cajanus cajan	ILRI - 11575	Pigeon pea	1000 - 2000		2017	TARI	Maitsebri - Bako
55	Cajanus cajan	ILRI - 16527	Pigeon pea	1001 - 2000		2017	OARI	Bako
56	Chamaecytisus palmensis	Lattuu (CI - 15052)	Tree luceren	2000 - 3000		2018	EIAR	Holetta
57	Chamaecytisus palmensis	MOA	Tagasaste	2000 - 3000		1992	EIAR	Holetta
58	Sesbania dummeri	DZF 386	Sesbania			2018	EIAR	Debre Zeit, Werer / wondogenet
59	Sesbania macharanta	ILRI0342	Sesbania			2018	EIAR	TARI / Shire
60	Sesbania sesban	Nubica chior	Sesbania			2018	EIAR	Debre Zeit, Werer / wondogenet
61	Sesbania macrantha	DZF-092	Sesbania	400-2000		2012	EIAR	EIAR / Debre Zeit

# Glossary

To be worked out and incorporated in the second version



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