

## Cultivated forage production in the mid and high altitude areas of Ethiopia

Getnet Assefa, Melkamu Bezabih, Kindu Mekonnen, Aberra Adie, Million Gebreyes, and Haimanot Seifu.

### 1 Introduction

Feed is the main constraint of livestock production in Ethiopia. The major feed resources are inadequate and poor in quality. Grazing lands are shrinking and degraded, and crop residues are very poor in quality. The formulated concentrate feeds and agro-industrial by products are highly inflated in price, and not affordable to most smallholder livestock producers. Under such scenarios transformation of livestock productivity in Ethiopia needs to bring a breakthrough in quality feed production and supply. Cultivated forage crops are the feasible options to increase feed availability and quality, to protect the environment and much more. This brief describes the potential of cultivated forage crops and the basic production practices for selected and recommended forage crops in mixed crop–livestock production systems in Ethiopia.

### 2 Why cultivated forage production is important?

In Ethiopia, more than 60 forage varieties/species have been registered to be used in the different agro-ecologies and production systems. The description of selected forage species for the mid to high altitude areas are presented in Tables 1, 2 and 3. They are ideal for most smallholder livestock producers for several reasons:

1. they can be produced in the vicinity of smallholder farmers

2. with affordable or low costs under alternative means of production, improved forage crops produce high quality biomass to feed animals,
3. some cultivated forage crops provide diversified uses for farmers, in addition to the foliage to be used as feed for livestock forages like cowpeas produce grain for human consumption and browse trees provide woods and branches to be used as fire fuel,
4. cultivated forage crops provide ecosystems services through controlling soil erosion, increasing infiltration and soil fertility, and the quality forage fed to ruminants emits reduced greenhouse gases,
5. when planted in integration with food crops like maize and sorghum forage crops such as elephant grass, brachiaria grass and desmodium, they control the stalk borers which causes up to 15% grain production loss. When planted as break crops forage crops have the advantage of breaking the life cycles of pests,
6. forage crops can be used as cash crops and can be a lucrative business. This is a common practice in areas like Selale (oats), Afar (sorghum), Gode and Jigjiga (Sudan grass).



### 3. Forage production methods

In Ethiopia's mixed crop–livestock production systems, despite the crucial feed shortages, farmers also have many other limiting conditions to produce cultivated forage crops, among which are shortage of land, soil fertility depletion, and erosion are important problems. Hence, according to the specific circumstances, farmers could cultivate forages in two major niches of production:

1. farmers who can produce forages under conventional cultivation practice and
2. others who can produce forages in integration with food crops, soil and water conservation structures and other farm management practices with minimum inputs (Photo 1).

6. Harvesting and/or grazing,
7. Follow up management for perennial forage crops.

#### a) Selecting appropriate forage species or varieties

—When planning cultivation of forage crops the primary thing to do is to properly understand the farming system. This includes, the weather (rainfall and temperature), soil type and pH, the purpose and objective of forage production (dairy, beef, small ruminants, or market), and also exploring the experience of the surrounding farmers practice in forage production. Based on the above information identify or recommend the forage species (annuals, perennials, grasses, legumes or browse trees) to be cultivated in the target location.

Photo 1. Large-scale forage production of alfalfa (left) and elephant grass (right) under conventional management. *Photo credit: ILRI/Getnet Assefa*



#### A) Conventional cultivated forage production

When forage crops are cultivated conventionally on arable lands like other major food crops, the basic practices from land preparation to harvesting and feed preservation should be accomplished. The main activities in this process are:

1. Selecting appropriate forage species or varieties for a given locality or forage production field,
2. Preparing land,
3. Preparing seed,
4. Sowing/planting and fertilizing,
5. Weeding and pest control,

**b) Land Preparation**—Preparation of land will be conditional on the type of forage species to be planted. Many of the perennial grasses and legumes need well prepared and weed free seedbeds in comparison to the annuals. Perennial forage crops often have very small sized seeds. Proper drainage and on-time preparation of land facilitate good establishment.

Table 1. Selected forage crops recommended for high and mid altitude areas of Ethiopia

No.	Forage name	Latin name	Description	Altitude adaptation (masl)	Yield (DM t/ha)
1	Oats	<i>Avena sativa</i>	Annual grass, grows up to 2 m in height	1,500–3,000	8–15
2	Vetches	<i>Vicia species</i>	Annual legume, scrambling and climbing habits	1,500–3,000	5–15
3	Lablab	<i>Dolichos lablab</i>	Mostly annual, legume and vigorously trailing	500–2,100	6–10
4	Cowpea	<i>Vigna unguiculata</i>	Annual legume, climbing—suberect	750–2,000	6–10
5	Fodder beet	<i>Beta vulgaris</i>	Annual tuber fodder crop	2,000–3,000	5–9
6	Elephant grass	<i>Pennisetum purpureum</i>	Perennial, vigorous and giant grass	500–2,400	12–23
7	Brachiaria grass	<i>Brachiaria species</i>	Perennial grass	750–2,000	13–20
8	Desho grass	<i>Pennisetum pedicellatum</i>	Perennial grass	500–2,500	8–18
9	Rhodes grass	<i>Chloris gayana</i>	Perennial grass	500–2,400	6–15
10	Alfalfa	<i>Medicago sativa</i>	Perennial legume	750–3,000	7–16
11	Tree lucerne	<i>Chamaecytisus palmensis</i>	Perennial browse tree	2,000–3,000	4–10

### c) Preparing seed and planting materials

—Forage crops could be established from seeds, stem cuttings or root splits. In acquiring seeds and planting materials for planting, one has to ensure the quality of the seeds in terms of purity from different contaminants pests and diseases, and its viability (due to dormancy, immaturity or other factors). Seeds of some species may require certain treatments either to break dormancy to improve germination, or a specific strain of *Rhizobium* inoculants to improve nitrogen fixation in legumes, to control some seed born disease and pests. It is always advisable to use seeds from known sources, which are certified or quality declared seeds and planting materials.

**d) Seeding rates**—Seeding rates varies with the seed size and nature of the

species, land preparation, purpose of the crop (seed or herbage), environmental condition and other relevant situations. Use of higher seeding rates for herbage production do not have much negative impact in many of the species, it is only for the economy of forage seeds. It is generally advisable to use recommended seeding rate of the forage species/ varieties in the locality and production practice. It is also necessary to use recommended spacing between plants and rows (for both seeds, seedlings, stem cuttings and root splits) to maximize productivity.

**e) Applying fertilizer**—If possible, soil testing helps to determine the type and rate of fertilizer to apply and assess land history and management practices in the preceding years. The common

deficient soil nutrients are N, P and K. Farmers may have access to manure and chemical fertilizers. Hence according to the prevailing situation farmers may use either manure or different levels and types of chemical fertilizers. It is, however, good to follow the recommended levels to the crop and the locality and applying practice like once or split applications. This day's applying micro soil nutrients like boron and sulphur are also becoming important in many parts of Ethiopia.

**f) Sowing/planting**—Seed size is an important factor that dictates the land preparation and depth of sowing. Many of the annual forage crops have larger sized seeds and have vigorous seedlings. While most perennial forage crops have small sized and light weight seeds and seedling vigour is usually poor and slow. Therefore, sowing forage seeds need careful

management and essential to follow appropriate sowing practices not to bury the seeds deep into the soil and having uniform distribution of seeds. Some grass seeds are light weight and uniform distribution is the main challenges as it is affected by wind. Use of soil, sand or fertilizer could be used as filler for uniform distribution. Forage seeds could be drilled by machineries when sown at a larger scale. At smaller scale seeds could be planted manually by broadcasting or in rows. Soil coverage need to be according to the recommended depth. For small sized and fine seeds of forages, very light soil coverage, sowing and dragging tree branches, or even sowing and leaving uncovered may be employed. For seed of smaller size compact seed beds are usually preferred. It is also recommended to follow the traditional practice of teff sowing by driving animals on the

Table 2. General recommendations of major agronomic practices for selected forage crops in the mid and high-altitude areas of Ethiopia

No.	Forage name	Seeding rate (kg/ha)	Spacing between rows (cm)	Grows in mixture with	Weeding	Harvesting
1	Oats	75–100	15–20	Vetches	Hand weeding and herbicides	At the flowering period/full blooming
2	Vetches	20–30	20–30	Oats	Hand weeding	At 50% flowering
3	Lablab	15–25	30–50	Panicum	Hand weeding	At 10–50% flowering
4	Cowpea	15–25	30–50	Panicum	Hand weeding	At 50% flowering
5	Fodder beet	Seedlings	30–50		Hoeing	When wanted
6	Elephant grass	Cuttings or root splits	30–100	Vetch, desmodium	Hoeing/ herbicides	At the height of 1–1.5 m
7	Brachiaria grass	5–10	50		Hoeing/ herbicides	At 50% heading
8	Desho grass	Root splits	50		Hoeing/ herbicides	At a height of 80 cm
9	Rhodes grass	5–10	20	Stylo, alfalfa	Hand weeding and herbicides	At 50% heading
10	Alfalfa	5–10	20–50		Hand weeding	At 50% blooming
11	Tree lucerne	Seedlings	100		Hoeing	6 months regrowth

seedbed before sowing. For successful establishment of forage crops it is always advantageous to sow or plant at the recommended sowing dates, especially when planting under rainfed conditions.

After sowing, continuous follow-up and supervision of the field is vital. It is common that sown seeds are consumed by birds and insects. If rainfall is intensive seeds and fertilizer could be washed out. Therefore, day-to-day supervision and taking actions for any damages including repairing drainage structures or gapping washed-out parts are important. Seed treatments and insecticides could be used to control these problems. Similarly, during germination seedlings could be attacked by insects and may need to take immediate actions.

**g) Weeding**—Weeds are a major problem in perennial forage crops as their growth is slow compared to the vigorous weeds. Agronomic practices such as proper field/seedbed preparation and early sowing dates could help to reduce effect of weeds and pests. Weeding should be done at the right time, when late it remarkably affects the performance of the crop. Depending on the scale of operation, severity of the weed and cost, farmers can use hand weeding or herbicides. When established from seedlings, root splits and stem cuttings, hoeing controls weeding and enhances growth. During establishment of perennial pastures and if weed is a major problem in certain species such as Rhodes and panicum grasses, it is possible to introduce light grazing, hand harvesting both the weeds and seedlings together and feeding to the animals or mowing with machinery are possible means to control weeds.

**h) Harvesting and grazing**—Harvesting of forages is made either to directly feed to livestock as green forage or to conserve it for later use. There are few species which are tolerant to grazing by livestock. However, the grazing needs a

proper follow-up management so that forage productivity is maximized and animal performance improved. Often when productivity or growth of forage crops are poor for various reasons, such as shortage of rainfall and when harvesting is not worse economically direct grazing the forage by livestock is preferable. This practice also applies when food crops failed to fully mature due to a shortage of rainfall. The main parameters to be considered when harvesting forage crops are, total forage (biomass) yield, quality (CP, total digestible nutrient), conservation method, and animal preference (intake and quality). As a rule of thumb, the ideal principle of forage harvesting is to harvest the forage at the stage where one obtains the highest total digestible nutrient per unit area and unit period. The optimum harvesting stage for most forage crops is at early to full blooming. Harvesting should be completed in short period of time.

**i) Follow-up management of perennial forages**—Perennial forages most often have multiple cuts per year. The forage yield from each harvest is dictated by the amount and distribution of, and the use of proper harvesting calendar. The time of harvest affects the productivity of the regrowth and needs keen guidelines. Harvesting the forage at the right time to maximize the preceding and following biomass yield from the regrowth. Strategic harvesting/using forages is important to escape frost occurrence and drought. Make field management such as weeding (usually once a year) or herbicide application. Applying manure and fertilizer as required depending on the soil fertility status. For certain species controlled and light grazing may be considered as an option during the lean seasons. It is also common to harvest opportunistic types of seed production as part of the management.

Table 3. Possible means of forage conservation, recommended use and production of seeds and planting materials for selected forage crops in the mid and high-altitude areas in Ethiopia

No.	Forage name	Use and conservation	Main uses in the diet	Seed/planting material production
1	Oats	Cut and carry, hay and silage	Basal diet	500–3,500 kg/ha
2	Vetches	Cut and carry, hay, silage	Supplement	200–600 kg/ha
3	Lablab	Cut and carry, hay, silage	Supplement	900–2,500 kg/ha
4	Cowpea	Cut and carry, hay, silage	Supplement	900–2,500 kg/ha
5	Fodder beet	Could stay in the soil and harvest when required	Supplement	Set seed at high altitude and cool areas
6	Elephant grass	Cut and carry, silage	Basal diet	Cuttings or root splits
7	Brachiaria grass	Cut and carry, hay, silage, grazing	Basal diet	Cuttings or root splits also sets seed
8	Desho grass	Cut and carry, hay and silage	Basal diet	Cuttings or root splits
9	Rhodes grass	Cut and carry, hay and silage, light grazing	Basal diet	200–500 kg/ha
10	Alfalfa	Cut and carry, hay and silage	Supplement	200–500 kg/ha
11	Tree lucerne	Cut and carry and hay	Supplement	Produce quality seed

## B) Integrated forage production methods

Cultivated forages are feasible options to increase feed availability and quality to transform livestock production in Ethiopia. Although the number of forage varieties and related production technologies are adequately available the adoption is very low. Shortage of land, inputs such as seeds and fertilizer, and labour are indicated as the main reasons. Integrated forage production in different methods in the production system provides multiple advantages. The system economizes the use of scarce resources such as land, intensifies forage production through integration with food crop cultivation,

improves soil fertility through legume forage intercropping, and increases land productivity and environmental sustainability. There are several integrated forage production methods, the main ones are presented in Table 4.



Table 4. Different niches of forage production in integration with food crop production, natural resource conservation and various farming practice

No.	Integration method	Examples of main crops	Examples of forage crops to be grown in integration
1	Under-sowing and intercropping	Maize, sorghum, coffee	Vetch, cowpea, desmodium
2	Rotation (sequential) and relay cropping	Cereal food crops	Forage legumes
3	Hedge row intercropping and alley farming	Barley, wheat	Tree lucerne, sesbania
4	Backyard forage production	Perennial fruit and other crops	Alfalfa, elephant grass
5	Strip forage planting/ establishment	Field crops, grazing lands	Elephant grass
6	Oversowing on grazing areas	Natural pasture	Vetch, stylo, desmodium
7	Integrated feed and pest management	Maize, sorghum	Elephant grass, desmodium

- Under-sowing and intercropping are methods in which two or more crops usually cereals and legumes are grown simultaneously in the same field and growing season. Under-sowing usually involves the planting of crops (forage legumes) into another crop after the main crop is established (Photo 2 left).
- Relay cropping is a sequential cropping but usually the following crop is planted before the preceding crop is harvested or immediately after harvest.
- Hedge row intercropping and alley farming is an agroforestry practice in which browse trees or shrubs are planted as hedge rows in crop fields or other parts of cropping areas to produce fodder or mulch or green manure.
- Backyard forage production is the growing of forages in the residential areas, around the compounds and along the fence lines. Forages like elephant grass and tree lucerne could be planted along the fence lines while highly productive and nutritious forages like alfalfa usually planted in plots in the backyard.
- Strip forage planting are narrow lines of forage established between arable crops, which has a number of uses including: forage for cut and carry, which prevent soil erosion, provide wood for fuel and shelter belts if tree legumes are used, and improve soil fertility (Photo 2 right).
- Degraded natural or cultivated grazing lands or enclosure areas could be rehabilitated by over-sowing suitable forage crops mostly forage legumes to improve productivity and forage quality. It also improves soil fertility.
- Integrated feed and pest management—In areas where maize stalk borers are problems. Such problems are controlled by planting elephant grass in the border and desmodium under the main crops of maize and sorghum. The forage crops have the ability to control the stalk borer (usually called as pull-push technology) while providing the farmers with good quality and a large amount of forage.

Photo 2. Forage lablab production integrated with maize (left) and forage strip established (elephant grass) on sloppy fields (right). *Photo credit: ILRI/Getnet Assefa*



In the different integration methods, careful selection of forage species is important. The selection criteria may vary for the different integration methods, but the most common criteria are easiness for establishment, compatibility (rate of growth, height, days to maturity, nutrient and water requirement, tolerance to

different climatic conditions such as frost, drought and water logging), herbage yield, nitrogen fixing abilities, easiness for harvesting and use and persistence and reseeding ability of perennial legumes when over-sown on grazing lands.

## Summary

- Cultivated forage production is the best alternative and feasible option to improve livestock feeding and productivity under the existing condition in Ethiopia.
- Besides availing high quality forage as livestock feed cultivated forage crops provide different functions, forages like cowpea and pigeon pea could serve as food for humans, they provide ecosystems services through controlling soil erosion, increase infiltration, increase soil fertility and forage crops can be used as cash crops by direct selling of forages.
- There are different niches to produce cultivated forage crops. They can be cultivated conventionally when resources like land are not limiting or for resources poor farmers, they can be cultivated in integration with food crops, natural resource
- Well adapted and registered forage varieties and species for the different agro-ecology and production practices are available in Ethiopia.
- Recommended agronomic practices such as planting, weeding, harvesting etc. for the different annual and perennial forage crops are established.
- Cultivated forage crops have high quality roughages and could be used in different ways, as source of basal diet or a supplement feed through cut and carry systems or conserved forms of hay and silage.



## Acknowledgements

We acknowledge the funding from the International Development Association (IDA) of the World Bank to the Accelerating the Impact of CGIAR Climate Research for Africa (AICCRA) and USAID in Washington, DC to Africa RISING project in the Ethiopian highlands.

## Resources

Bezabih, M., Mekonnen, K., Adie, A., Asfaw, A., Ebrahim, M. et al. 2017. Livestock: Africa RISING science, innovations and technologies with scaling potential from the Ethiopian highlands. Nairobi, Kenya: International Livestock Research Institute (ILRI).

Mekonnen, K., Gebreyes, M., Abdulkadir, B., Seifu, H. and Thorne, P. 2021. Training module on livestock feed and forage innovations. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security.

Mekonnen, K., Bezabih, M., Thorne, P., Gebreyes, M.G., Hammond, J. et al. 2022. Feed and forage development in mixed crop–livestock systems of the Ethiopian highlands: Africa RISING project research experience. *Agronomy Journal* 114: 46–62.

## About AICCRA INFONOTE

AICCRA is supported by a grant from the International Development Association of the World Bank.