Producing and Using Alternative Feeds to Crop Residues

User Manual

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Ethiopian Institute of Agricultural Research
Producing and Using
Alternative Feeds
to Crop Residues

Efficient use of Crop Residues: Animal Feed Vs Conservation
Agriculture Research Project

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Contents

Introduction 7
Feed resources in the Highlands 8
  Natural pasture 8
  Crop Residues 11
  Agro-industrial byproducts 13
Alternative Feed Resources 14
References 23
Introduction

Livestock feed supply in the highlands is based on natural pasture and crop residues. The area of grazing land has been significantly declining owing to the expansion of cropping to meet the food grain demand of the ever-increasing human population. Moreover, expanding urbanization and use of arable land for housing, recreation, and industrial development is diminishing grazing lands. Generally, the available grazing lands in the highlands are highly fragmented and limited to areas where conditions are adverse for cropping due to topographic, edaphic, and climatic limitations. As a result, ruminants depend largely on crop residues as their basal diet. Crop residues form the main constituent of roughage feed resources particularly during the dry season. Although the dominant use of crop residues is as livestock feed, they have also other alternative uses such as for construction, fuel and as sources of cash income under Ethiopian context. Furthermore, it is recommended and expected that some 30% of the total crop residues produced on a given plot of land should be left on the land for soil amelioration and protection from erosive losses. However, this aspect is less prioritized by farmers as the prevailing practice depicts almost complete use of crop residues mainly as
livestock feed. This in turn has injurious effect on the soil and may lead to the connotation that livestock production is unfriendly to the environment.

Livestock production will become harmonious with or even beneficial to the environment when appropriate feed production and utilization systems are in place. This manual highlights the major livestock feed resources and describe important features of some selected improved forage crops as alternative feed resources to complement the available feed resources in the highlands of Ethiopia. The intention of the manual to promote the production and utilization of promising forage crops so that some portion of crop residues is left on the field to amend soil fertility and also protect the soil from erosive forces. This manual has been prepared with the initiative and support of the crop residue project.

Feed resources in the Highlands

Natural pasture
Natural pasture refers to naturally occurring grasses, legumes, forbs, shrubs, and tree foliages used as livestock feed. Previous records indicate the availability
of vast grazing lands accounting for about 57% of the Ethiopia’s total land area and more than 70% of the livestock feed supply. However, the current scenarios indicate significant reduction in both area and productivity of grazing lands especially in the highland mixed farming systems due to the following factors:

- Expansion of cropping to meet subsistence needs of the ever increasing human population
- Expansion of urbanization (housing and recreation areas, industrial development, various development investments) at the expense of grazing lands
- Poor management and utilization systems (over grazing) leading to land degradation

As a result, pasturelands have been significantly dwindled with the consequent severe feed shortage in the highland crop-livestock mixed farming system where about 80% of both the human and livestock population of the country are concentrated. In the highlands, the available grazing lands are highly fragmented and limited to areas where conditions are adverse for cropping due to topographic, edaphic, and climatic limitations. In general, the grazing lands available in the highland mixed farming systems could be into three categories:
- Up land/sloppy grazing areas
- Arable land grazing areas
- Valley bottom land grazing areas

**Upland grazing areas**
These areas represent highly degraded lands available in sloppy areas that are liable to erosion and degradation. They are characterized by very shallow soil profiles and low plant nutrients. As a result, pasture productivity in these areas is very low and on average could not exceed 0.5 – 1t DM/ha on an annual basis.

**Arable land grazing areas**
These include intermittent fallow lands between cropping cycles, roadsides, crop boundaries, and stubble grazing after crop harvest. The average herbage productivity of these areas could lie within the range of 1 – 3 t DM/ha.

**Valley bottomland grazing areas**
These areas are characterized by frost especially at higher elevations, waterlogging and seasonal flooding. They have comparatively better fertility due to deposition of debris washed up from highly eroded sloppy areas. As a result, there average herbage productivity could reach up to 3-5t DM/ha. These areas are inaccessible to livestock during the rainy season due
to waterlogging consequently used for hay production by farmers.

In general, the quantity and quality of native pasture varies with altitude, rainfall, soil type, and cropping intensity. About 12% of the total grazing land is found in the highland mixed farming systems. The majority of native pasture available in the mixed farming systems is concentrated mainly parts of North and West Shewa Zones of the Oromia Regional State where fodder conservation in the form of hay is a common practice. The urban and peri-urban dairy, feedlots, and small scale fattening operations mainly depend on the hay produced in these areas as source of roughage feed.

**Crop Residues**

With an increase in human population, more and more land will be devoted to crop production and only fragments of marginal lands will be left for feed production. Consequently, ruminants feed largely on crop residues as their basal diet. Crop residues refer to the portion of the harvested crop, which remains after the grain, or marketable portion of the crop is removed. The major components of the crop residue isolated in this way include stems, leaves, and chaff. The other
dimension of crop residue known as the crop aftermath constitutes the above ground plant biomass left in the field after harvest. However, in some parts of the highlands the crop aftermath of barley, wheat, and oats is harvested from ground level and used for roof thatching. Major Field crops produce large quantities of crop residues (straws, stovers, and haulms) in addition to grain. The types of crop residue available in the country vary with agro-ecology or the farming systems prevailing in different areas. Maize, sorghum, and millet crop residues are dominant in the mid and lowland agro-ecologies. On the other hand, small cereal crop residues like tef straw, wheat straw, barley straw and oats straw are mainly dominant in the medium and highland parts of the country. There are also different pulse crop residues in the different agro-ecologies. In the highlands, the principal crop residues used for animal feeding are the straws of tef, wheat, barley, oats, faba bean, field pea, and chickpea.

Although they are mainly used as livestock feed, crop residues have also other alternative uses such as for construction, cash income, fuel and some are returned to the soil as an amendment to soil fertility. However, most farmers in the highlands do not purposively retain crop residues on the field for soil conservation purpose due to the high pressure of feed shortage. Moreover, farmers
obtain considerable amount of cash income through sale of some crop residues such as tef straw both for feed and construction purposes.

**Agro-industrial byproducts**

Natural pasture and crop residues are naturally of low quality and do not fulfill the nutrient requirement of animals. Hence, high producing animals such as dairy cattle and fattening animals should be supplemented with high energy and/or protein concentrates. The most commonly concentrate feeds in Ethiopia belong to different agro-industrial byproducts including:

- Milling byproducts such as wheat bran
- Noug cake, cottonseed cake, peanut cake, linseed cake, sesame cake, sunflower cake
- Molasses from sugar factories
- Whole cotton seed
- Brewery byproducts
- Occasional surplus grain or grain damaged during processing

Although they are nutritionally superior, agro-industrial byproducts have been used at a very minimum scale due to high cost, unreliable supply, and poor access by smallholder farmers. Establishing market oriented
livestock enterprises such as dairy and fattening around the processing plants could be highly essential for efficient utilization of agro-industrial byproducts. Smallholder dairy farmers could also be organized into cooperatives, which help to facilitate the procurement of agro-industrial byproducts and other inputs.

**Alternative Feed Resources**

The feed produced from natural pasture and crop residues cannot fulfill the requirement of the available livestock especially in the highlands where a feed deficit of about 40% is common in any normal year. This situation has led to complete utilization of crop residues mainly as feed disregarding the soil conservation aspect of crop residues with the consequent land degradation and decline in soil fertility. Hence, there is a need to look for other alternative feed resources so that some proportion of the crop residues will be retained on the field for soil conservation.

Ten improved forage species are recommended to the highlands of Ethiopia (Table 1). These species have higher herbage productivity and better quality as compared to natural pasture and other conventional
feed resources available to smallholder significantly to soil nitrogen and provide a break in cereal-dominated rotations. Moreover, some of the species such as fodder trees have various multipurpose uses beyond livestock feed like soil conservation through erosion control, improve soil fertility, and used as live fence and fuel wood. However, most of the improved forage crops have very much limited applications owing to inadequate efforts to demonstrate and popularize the potential species beyond research centers, state/commercial farms and few participants of extension packages.

The Ethiopian highlands is characterized by high human and livestock population which in turn exert a heavy pressure on the natural resource base especially the soil in order to meet the demand for food and feeds. The land is continuously cultivated and all the crop residues are taken away for various purposes, mainly as livestock feed. Hence, there is a need to advise farmers to leave some portion of crop residues on the field by growing promising forage crops as complementary feeds to crop residue. Among the improved forage species recommended to the highlands of Ethiopia, oats, vetch and treelucerne have relatively potential applicability under on-farm conditions to complement the crop residue based feeding system.
Table 1. Productivity of recommended forage species

<table>
<thead>
<tr>
<th>Category</th>
<th>Highland</th>
<th>Mid altitude</th>
<th>Lowland</th>
<th>Yield range (DM t/ha)</th>
<th>Mean yield (DM t/ha)</th>
<th>Increment over native pasture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>8 – 18</td>
<td>13</td>
<td>225</td>
</tr>
<tr>
<td>Herbaceous legumes</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>6 – 10</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>Browse trees</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>9 - 12</td>
<td>10.5</td>
<td>163</td>
</tr>
<tr>
<td>Root crops</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>8 - 10</td>
<td>9.0</td>
<td>125</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>15</td>
<td>10</td>
<td></td>
<td>10.5</td>
<td>163</td>
</tr>
<tr>
<td>Native pasture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seasonally rested</td>
<td></td>
<td>3 - 5</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuously grazed</td>
<td></td>
<td>0.5 – 1.5</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
The production packages and mechanisms of integrating these species into the farming system are briefly presented below.

**Oats (Avena sativa)**

- Life cycle: annual (grass)
- Soil type: well drained soil
- Rainfall: 700 – 1000 mm
- Altitude: 1500 – 3000 m asl
- Sowing date: early to mid June
- Sowing method: broadcast or in rows 20cm apart
- Seeding rate: 80 – 100 kg/ha; 75 kg/ha when grown in mixture with vetch; enormous tillering ability
- Fertilizer: 18/46 N/P2O5 at planting for better establishment on poor soils
- Weed control: once hand weeding based on weed intensity
- Maturity period: 4 months
- Harvesting stage: Milk grain stage for green feeding or hay making; dough grain stage for silage making
- Average forage yield: 8 – 15 t/ha (average of different locations, on station and on farm)
- Average CP content: 5 – 7% on DM basis (average of different varieties)
- Fit into rotational cropping system
- Utilization: direct grazing, cut-and-carry, hay, silage
Vetch (*Vicia dasycarpa*)

- Life cycle: annual (legume)
- Soil type: well drained soil
- Rainfall: 700 – 1000 mm
- Altitude: 1500 – 3000 masl
- Sowing date: late May to mid June
- Sowing method: broadcasting or in rows 30 cm apart
- Seeding rate: 30 kg/ha; 25 kg/ha when grown in mixture with oats
- Fertilizer: 18/46 N/P₂O₅ at planting for enhanced growth and biological N fixation
- Weed control: once hand weeding in the early growth stage
- Maturity period: 3 – 4 months
- Harvesting stage: 50% flowering
- Average forage yield: 6 – 8 t/ha
- Average CP content: 20 – 23% on DM basis
- Fit into rotational cropping system – highly efficient in N fixation (reported to fix up to 163 kg N/ha)
- Utilization: direct grazing, cut-and-carry, hay, silage

Oats/vetch mixture

- Most recommended mixture to produce high quantity of better quality feed which can be used both in green form and also cured into hay
- Sown using seed proportions of 75kg oats : 25kg vetch per hectare
Harvested at dough stage of oats while the vetch is at full flowering/early podding stage for hay making
Average forage yield: 12 – 15t DM/ha with over 10% CP content
Using oats/vetch mixture helps to reduce the costs incurred on expensive concentrate feeds. Moreover, the vetch in the mixture helps to improve fertility of the soil for subsequent cropping.

Treelucerne

An evergreen perennial browse tree legume, grows up to 5 – 6m high
Well adapted to the highlands up to 3000m altitude, and tolerates frost as low as -9°C
Grows better in light well drained sandy soils with a wide pH range (4.0 – 8.5), but is intolerant to saline soils
Established using treated seeds or seedlings in rows 5 m apart and 2.5 m b/n plants within rows, giving a density of about 7000 trees/ha. It is also possible to establish at plant densities of 10,000 – 20,000 seedlings/ha.
Can give edible DM yield of 11t/ha per cut
Good for backyard and alley cropping
Has multiple benefits (fodder, soil fertility, fire wood, live fence, bee forage)
Can stay productive for 5-6 years with good management
Incorporating Improved Forages into the Farming Systems

Since land is one of the limiting factors for the development of improved forage crops, it is very essential to explore appropriate mechanisms in which forage production could be incorporated into the farming system in relatively non-land competitive manner. For annual forage crops such as oats and vetch, the most important mechanisms may include the following:

As precursor to the main crop in double cropping system within a season
This applies in chickpea and lathyrus growing areas where the main crops are grown towards late September using residual moisture. Experience around Gichi vertisol indicated that substantial amount of feed could be produced by growing oats/vetch mixture as precursor crops to chickpea.

As breakcrop between cropping cycles of the main crop
In some highland areas with barely-fallow cropping system, continuous cropping of barley is not effective in
terms of productivity of barley unless the land is either fallowed or grown with other break crops following barley. In such systems, oats/vetch mixture could be grown to produce feed while preparing the land for subsequent barely cropping. This could be introduced in peak highland areas such as Degem area in the Selale area of North Shewa Zone as essential source of feed for dairy cows.

**Intercropping with food crops**
Most of the leguminous forage crops such as vetch could be grown by intercropping with the already established food crops like maize. The vetch should be sown with lower seed rates (20-25kg/ha) than the case of its pure stand. Producing quality livestock feed, forage legumes could also help to improve soil fertility.

**Conventional cropping**
Some adoptive farmers allocate some plot of their prime land for growing annual forage crops like oats and vetch to produce additional feed (Figure 10). When vetch is grown in rotation with annual cereal crops, it helps not only to produce better quality feed, but also provides additional benefits to soil fertility and subsequent crop yield. Traditionally, farmers in the highlands of Ethiopia use to practice fallowing as a mechanism to restore the
fertility of degraded lands. They also use the fallowed lands to produce feed, which will be either directly grazed or used for haymaking. However, studies indicated that growing annual forage legumes like vetch is more feasible than the fallow system both in terms of feed production and in terms of restoring soil fertility. Hence, this could be promoted in the highlands where cereal (barley) –fallow cropping system is practiced.

Backyard and conservation based forage development strategies like forage strips is also feasible mechanisms for the production and utilization of perennial fodder trees such as treelucerne. The trees established on the backyard could serve other multipurpose functions such as live fence and fuel wood in addition to the production of high quality feed.

Forage strips are narrow lines of fodder trees established between arable crops and provide cut-and-carry feed, fuel wood, and help to reduce soil erosion and improve soil fertility. Forage is planted in bunds or on contour strips without bunds. Tree and shrub legumes are used for alley farming and shelterbelts. As the fodder trees stay green year round, they could serve as important supplementary feeds to crop residue based feeding systems.
It is common to observe treelucerne on backyards of many farm households in the highlands. Nevertheless, in some cases, it is overgrown to a big tree stature. This could lead to the loss in feeding value and decline in the edible parts of the plant like the leaf. This calls for the need to aware and train farmers on efficient utilization of the fodder at its proper growth stage. The established recommendation in this regard is that to cut the tree at 50cm from ground and use the biomass as feed any time after the plant has reached a height of 1meter.

References