OMO International Journal of Sciences
Available online at: https://survey.amu.edu.et/ojs/index.php/OMOIJS/issue/archive
Vol. 5 Issue. 2, *December* , 2022, pages: 36~69
ISSN(Print): 2520-4882 :ISSN(Online):2709-4596

Full-Length Research Article

Improved Forage Crops Research and Development in Ethiopia: Major Achievements, Challenges and the Way Forward

Fekede Feyissa[1], Gezahagn Kebede[2*], Diriba Gelete[1], Getnet Assefa[2], and Alemayehu Mengistu[3]

[1]*Ethiopian Institute of Agricultural Research, P. O. Box, 2003, Addis Ababa, Ethiopia*
[2]*Holetta Agricultural Research Center, P.O. Box 31, Holetta, Ethiopia*
[3]*Forage and Rangeland Scientist, Urael Branch, P.O. Box 62291, Addis Ababa, Ethiopia*
** Corresponding author: gezk2007@yahoo.co.uk*

ABSTRACT

Feed shortage has been the persistent problem hampering livestock production and productivity in Ethiopia. The conventionally available feed resources (natural pasture and crop residues) are not only limited in quantity but also inferior in quality and cannot meet even the maintenance requirement of the country`s livestock resources. Hence, improvement in livestock production and productivity is unthinkable without intensification in feed production using other complementary feed resources in addition to the existing ones. Improved forage crops have untapped potential to resolve the feed shortage problem and lay down the basis for intensification of livestock production if properly promoted, adopted and utilized in the farming systems. This review paper provides an overview of improved/cultivated forage research and development efforts, important achievements, major constraints associated with forage development in the country and recommendations on the way forward.

Keywords: Forage agronomy, forage development, forage production challenges, forage research

Received: September 25, 2022, accepted: Octobe,25 2022, published: December 20, 2022

1. INTRODUCTION

Livestock production constitutes a key livelihood activity for the agricultural, agro-pastoral and pastoral societies which account for over 80% of the Ethiopian population. In the lowland pastoral and agro-pastoral production systems, livestock production is the primary source of livelihood providing multiple economic, social and risk management functions for the estimated 10 million pastoral/agro-pastoral communities. In highland mixed crop-livestock production systems, livestock serve not only as a source of traction power, manure (fuel and organic fertilizer) and rural transportation, but also as a source of income, nutrition and asset for the producers. Livestock is considered as a mobile bank that could be hired, shared, inherited and contracted by rural households. Livestock also plays an important role in urban and peri-urban areas for the poor evoking a living out of it and for those involved in commercial activities (Ayele *et al*., 2002; Halderman, 2005).

Despite the large livestock resource base and importance of the sector to millions of smallholder farmers, pastoral communities and the national economy at large, livestock production has remained underdeveloped and the available potential has not been fully exploited. A number of factors encompassing technical, infrastructural, organizational, institutional, environmental and policy aspects constrain development of the livestock sector with the consequent low productivity in Ethiopia. The major technical constraints include under-nutrition and malnutrition, high prevalence of diseases, low genetic potential of the indigenous breeds for productive traits, poor husbandry practices and weak market infrastructure. Among these, shortage of feed supply, low quality and seasonal fluctuations in feed availability are the overriding problems owing to the fact that feed cost accounts for about 60 to 70% of all costs associated with livestock production. Experiences elsewhere indicate that improvement in livestock productivity is impossible without alleviating the problems associated with feed shortage and low standard of feeding. Hence, meeting the anticipated demand for meat and milk and other livestock products in the coming decades in Ethiopia will require urgent attention to the supply of adequate feed (Tsige-Yohannes, 2000).

Livestock feed in Ethiopia is almost exclusively derived from natural pasture and crop residues, with agro-industrial by-products being used as supplementary feeds by some urban and peri-urban market oriented livestock producers. Previous records (3 decades ago) indicate that natural pasture accounts for about 53% of Ethiopia's total land area (Lulseged and Alemu, 1985). Currently, the Ethiopian population has at least tripled than it used to be 30 years ago necessitating the expansion of arable cropping at the expense of available grazing lands in order to feed the ever increasing population. Moreover, expanding urbanization and use of arable land for housing, recreation and industrial development is displacing a considerable area of grazing land. As a result, grazing lands have been significantly dwindled and the potential for expansion and/or retaining the available grazing areas is limited, as the best pasture lands are lost to expansion of cultivated land, investment and urbanization leading to severe feed shortage. For instance, in the highland crop-livestock mixed farming system where about 80% of both the human and livestock population of the country are concentrated, the area of available grazing lands has been estimated to be only about 5.7 million hectares (Abera, 2006). Furthermore, the available grazing lands are highly fragmented and limited to areas where conditions are adverse for cropping due to topographic, edaphic and climatic limitations. These marginal environments also impose further limitations on the yield and quality of the pasture. Crop residues also form the other main constituent of roughage feed resources particularly during the dry season. However, the quality of crop residues generally is considered inadequate to provide for much weight gain and productivity in animals. In general, crude estimate of the available feed in different parts of the country depicts a deficit of about 35% of the maintenance requirement, which surges up to 70% in bad years such as when prolonged drought occurs.

Hence, improvement in livestock production and productivity requires the concomitant intensification in feed production using improved/cultivated forage crops in addition to natural pasture and crop residues. Improved forage crops have diversified functions and play an important role in sustaining the livelihoods of farmers, mainly as a result of their positive effects on livestock production and contribution to economic and environmental sustainability. Besides producing high amount of better quality forage, they have a number of other benefits in the farming system including improvement of soil fertility through biological N-fixation or when used as mulch (legumes), erosion control when established as conservation structures, fuel wood supply, bee forage and control of weeds, pests and diseases when integrated in crop rotation as break crops. Generally, use of improved forage crops is an important step in supporting and improving livestock productivity while maintaining environmental sustainability in agrarian societies like Ethiopia. This review paper provides an overview of improved/cultivated forage research and development endeavours in Ethiopia, major achievements, important limiting factors and recommendations on the way forward.

2. BRIEF OVERVIEW OF IMPROVED FORAGE RESEARCH IN ETHIOPIA

Forage research in Ethiopia is as old as the establishment of agricultural colleges like Alemaya College of Agriculture (the present Haremaya University) and Ambo College (the current Ambo University). However, forage research as a national program was formally started with the establishment of Institute of Agricultural Research (IAR) in the mid 1960s (Alemayehu and Getnet, 2012; Getnet, 2012). Other governmental and non-governmental organizations especially ARDU/CADU and ILCA (the present ILRI) have also played remarkable roles in supporting national forage research and development efforts. Especially, ARDU which was established in 1967 at Asela has been recognized for its pioneer livestock research and development in the Arsi highlands. The project introduced different temperate and tropical forage species and made significant contributions to the national forage and pasture research by IAR in addition to its development efforts in promoting improved forage crops along with crossbred heifers in its mandate area (Arsi highlands). Generally, forage research efforts over the last four to five decades have been focused on germplasm introduction/collection, evaluation and selection of promising species for the different agro-ecologies, forage agronomic studies, micro-seed multiplication, on-farm demonstrations and promotions to users. Moreover, various forage development schemes have been launched as a component of different livestock/dairy development projects in the country. Highlights of the different activities and major achievements are described below.

2.1 Germplasm introduction/collection, evaluation and selection

A wide range of tropical and temperate pasture and fodder species have been introduced from different parts of the world including South America, North America, Australia and some parts of Africa with the support of Food and Agriculture Organization (FAO) of the United Nations (Lulseged and Alemu, 1985). The aim was to broaden the forage genetic basis for evaluation and selection of suitable species/cultivars for the highly diverse agro-ecological conditions of the country. Some efforts have also been made by the previous Institute of Agricultural Research (IAR); the current Ethiopian Institute of Agricultural Research (EIAR) to collect promising indigenous species from around research stations and substations. Moreover, ILCA (the current ILRI) had played a significant role in introducing various fodder species in addition to its active involvement in collection and evaluation of indigenous species, mainly legumes in the past. The various annual and perennial fodder species introduced and/or collected from different sources were tested in areas ranging in altitude from 600–3000 masl. Both EIAR (ex- IAR) and Regional Research Institutes as the major entities of National Agricultural Research System (NARS) that have been actively engaged in the forage species evaluation and selection works. The various forage species were evaluated for the different desirable characteristics including adaptation to the prevailing climatic and soil conditions, ease of establishment, herbage productivity, seed yield potential, resistance to pests and diseases, forage quality, multi-purpose uses and suitability for integration into the farming systems. To this effect, various adaptable and high yielding fodder species belonging to grasses, herbaceous legumes and browse trees have been identified and recommended for different agro-ecological zones of the country. More than 10 promising forage species have been recommended for each of the highland, mid-altitude and lowland agro-ecologies and the major ones are listed in Table 1.

In terms of choices of alternative forage species/germplasm, suggested species or varieties are too few with respect to herbaceous legumes and fodder trees in the highlands while in the arid and semi-arid low lands, the recommendations are very much limited to few species mainly due to environmental determinants, lack of irrigation facilities and inadequate attention given to this ecosystem in the national research agenda. In the highland agro-ecological zone, there are different environmental determinants which impose limitations to adaptations and overall performances of forage crops. These include low soil temperature and low radiation intensity leading to slow establishment and growth of mainly perennial grasses, seasonal frost (October-January) affecting most of the tropical forage species, drainage problems (water logging) especially on vertisols, sever competition from weeds and relatively low soil fertility. In the highland agro-ecology planting of pasture seeds (mainly perennials) is recommended using the light rains during March to May in order to take advantage of the favourable environmental conditions for better establishment. In situations where the light rains are short and inadequate, planting is done early during the onset of the main rain in June. In the arid and semi-arid lowlands, erratic rainfall, periodic drought and short plant growing periods are the major environmental determinants limiting adaptation of forage species. On the other hand, the mid altitude areas are comparatively favourable for most tropical forage crops.

Table 1: Some important forage species recommended for the different agro-ecological zones of Ethiopia

Agro-ecology	Forage crop category	Annuals	*Perennials*
Highland (>2000 masl)	Grasses	Oats (*Avena sativa*) – different cultivars	*Phalaris aquatica, Phalaris tuberosa, Phalaris arundinacea, Festuca arundinacea, Setaria sphacelata,* *nerata (*Orchard grass*)* *Lolium perenne (*perennial ryegrass*)* *(Chloris gayana, Panicum coloratum, Pennisetum Purpureum)**
	Herbaceous legumes	Vetches *(Vicia dasycarpa, Vicia villosa, Vicia atropurpurea)* Clovers *(T. quartinianum, T. tembense, T. rueppellianum, T. decorum)*	*Lotus corniculatus, Medicago sativa, T. pretense (*red clover*), T. repens (*white clover*)*
	Tree legumes	-	Tagasaste/tree lucerne (*Chamaecytisus palmensis)*
	Root crop	Fodder beet (*Beta vulgaris*)	-
Mid altitude (1500-2000 masl)	Grasses	Oats (*Avena sativa*) – different cultivars *Sorghum Sudanese*	*Chloris gayana, Panicum coloratum, Panicum maximum, Pennisetum purpureum, Andropogon gayanus, Cenchrus ciliaris, Melinus minutiflora*
	Herbaceous legumes	Vetches *(Vicia dasycarpa, Vicia villosa, Vicia atropurpurea)* *Lablab purpureus*	*Stylosanthes guianensis, Desmodium unicinatum (Silver leaf), Desmodium intortum (Green leaf), Medicago sativa, Macroptilium atropurpureum, Centrosema pubescens, Neonotonia wightii*
	Tree legumes	Pigeon pea (*Cajanus cajan*)	*Leucaena spp., Sesbania sesban, Gliricidia sepium, Calliandra spp.*
Lowland (<1500 masl) Usually with supplementary irrigation	Grasses	*Sorghum Sudanese*	*Cenchrus ciliaris, Chloris gayana, Panicum coloratum, Panicum maximum, Panicum antidotale* *Pennisetum purpureum*
	Herbaceous legumes	*Lablab purpureus*	*Stylosanthes guianensis, Neonotonia wightii, Clitoria ternatea, Medicago sativa*
	Tree legumes	-	*Leucaena spp., Sesbania sesban, Atriplex canescens*

* - not suitable in areas >2400 masl in altitude and with high intensity of frost

2.2 Officially Registered/Released Forage Varieties/Accessions

The ultimate objective of improved forage introduction, collection and evaluation is to release superior species/varieties/cultivars for wider utilization mainly as source of feed and natural resource conservation in the farming system within an appropriate agro-ecology. However, forage research works have progressed without formal variety release mechanism for quite a long period of time in Ethiopia. Despite this, various promising forage species/varieties have been promoted via different livestock development projects like the Fourth Livestock Development Project (FLDP) and being developed and utilized under varying scales in different parts of the country. Despite the absence of formal variety release mechanism in the past, about 9 forage species/varieties which were informally promoted and fairly accepted by the different users (ex-state farms, private farms and smallholder farmers) were registered in the crop variety register book of Ministry of Agriculture (MoA). Official variety release procedures and guidelines for forage crops have been established and implemented since 2009 in the country. Between 2009 and 2016, about 29 forage varieties have been released by NARS (EIAR, Regional Research Institutes) following the guidelines. Until 2016, a total of 38 forage species/varieties have been officially registered in the crop variety register book of MoA and their list is indicated in Table 2. It has been perceived that the number of officially registered varieties is still few relative to the number of forage species recommended for different agro-ecological zones of the country. For instance, some forage species like Stylosanthes spp., Desmodium spp., Leucaena spp. and Bracharia spp. which have been found to be promising in the mid and lowland areas have not been officially registered. Moreover, there are various alternative cultivars belonging to some of the widely used species such as oats and Napier grass which need to be subjected to the variety release procedures for official registration purposes. The indigenous Desho grass (*Pennisetum pedicellatum*) which has originally well adapted in southern Ethiopia and being introduced to other parts of the country is also a potential candidate for future evaluation and variety release activities.

Research results have indicated that the improved fodder species generally have higher herbage yield potential than natural pasture. Yield potential of improved grasses usually vary from 8.0 to 15.0 ton DM per ha per annum with a mean of about 13.0 ton/ha. Yield of herbaceous legumes also varies from 6.0 to 10.0 ton DM/ha with a mean of 8.0 ton DM/ha. Productivity of tree legumes also ranges from 9.0 to 13.0 ton DM/ha with a mean of about 10.5 ton DM/ha. These yield potentials have been recorded under rain-fed conditions in which mainly a single cut is possible in a year. If forage evaluation works have been possibly supported by supplementary irrigations, multiple cuts could have been possible and the potential herbage yields could have been by far higher than the figures indicated above especially in the case of perennial forage species. In general, the overall average productivity of the improved fodder crops per unit area has been found to exceed the productivities of seasonally rested and continuously grazed natural pastures by about 3 fold and 10 fold, respectively (Figure 1). Besides their productivity, most of the improved forage crops are also nutritionally superior to that of natural pasture and crop residues, have long growing season and help to extend the green feed period and could provide useful nutrients mainly in the rural areas where availability and accessibility of Agro-Industrial By-Products (AIBPs) is very limited. Moreover, improved fodder crops especially the legumes can complement crop production through maintaining soil fertility through fixation and accumulation N_2, and also help to prevent soil erosion and replenish degraded land when grown as a component of integrated natural resource management.

Table 2: Lists and herbage productivity of officially registered forage species and varieties in Ethiopia

SN	Species	Variety/ Accession	Common name	Altitude (masl)	DMY (t/ha)	Year of register	Breeder
	Grasses						
1	*Avena sativa*	CI-8237	Oats	1500-3000	10-13	1976	HARC
2	*Avena sativa*	CI-8251	Oats	2000-3000	8-12	2013	HARC
3	*Avena sativa*	Bonsa	Oats	2300-3000	9.7-10.8	2011	SARC
4	*Avena sativa*	Bona-bas	Oats	2300-3000	9.8-10.3	2011	SARC
5	*Avena sativa*	CI-2806	Oats	1500-3000	12-15	2015	HARC
6	*Avena sativa*	CI-2291	Oats	1500-3000	11.5-16	2015	HARC
7	*Pennisetum purpureum*	ILCA-14984	Elephant grass	Upto 2004	10-15	1984	HARC
8	*Phalaris aquatica*	Sirossa	Phalaris	2400-3000	6-8	1982	HARC
9	*Chloris gayana*	Massaba	Rhodes grass	1000-2400	7-12	1984	HARC
10	*Panicum coloratum*	Coloratum	Colored Guinea grass	1000-2400	6-10	1984	HARC
11	*Andropogon gayanus*	Dirki Ayifera	Andropogon	-	-	2009	PARC
12	*Panicum maximum*	Local panicum	Guinea grass	Upto 2000	9-14	2014	PARC
13	*Pennisetum polystachion* –Local collection	Nechsare	Mission grass	900-1500	7-12	2014	PARC
14	*Pennisetum sphacelatum* –Local collection	DZF-258	Pennisetum	Upto 2000	13.2	2014	DZARC
15	*Cynodon aethiopicus*	DZF-265	Cynodon	500-1000	12.5	2015	DZARC
16	*Bracharia mutica*	DZF-483	Bracharia	500-1000	13.3	2015	DZARC

	Legumes						
17	*Vicia dasycarpa*	Lana	Vetch	1500-3000	5-7	1976	HARC
18	*Vicia sativa*	LCARDA-61509	Vetch	2200-2004	5-6	2012	HARC
19	*Vicia sativa*	Gebisa	Vetch	2300-3000	4.3-5.1	2011	SARC
20	*Vicia villosa*	Lalisa	Vetch	2300-3000	6.6-8.4	2011	SARC
21	*Vicia narbonensis*	Abdeta	Narbon vetch	2300-3000	3.1-3.4	2011	SARC
22	*Trifolium quartinianum*	-	Clover	1500-3000	3-6	1976	HARC
23	*Lablab purpureus*	-	Lablab	Upto 2004	3-5	1984	HARC
24	*Lablab purpureus*	Gebis	Lablab	1500-2100	8.4	2016	OARI
25	*Lablab purpureus*	Beresa	Lablab	1500-2100	8.37	2016	OARI
26	*Vigna unguiculata*	Sewinet	Cowpea	-	-	2009	PARC
27	*Medicago sativa*	DZF-552	Alfalfa	500-2400	3.88	2014	DZARC
28	*Medicago sativa*	Alfalfa-1086	Alfalfa	750-3000	3-5	2016	HARC
29	*Medicago sativa*	Alfalfa-ML-99	Alfalfa	750-3000	3-5	2016	HARC
30	*Vigna unguiculata*	Temesgen	Cowpea	590-1200	11.4	2014	TARI
31	*Cajanus cajan*	Kibret	Pigeon pea	967-1200	15.62	2014	TARI
32	*Cajanus cajan*	Tsegab	Pigeon pea	590-1000	14.29	2014	TARI
33	*Lupinus spp.*	Sanabor	Lupin	1935-2610	-	2014	ARARI
34	*Lupinus spp.*	Vitabor	Lupin	1935-2610	-	2014	ARARI
35	*Lupinus spp.*	Welela	Lupin	1800-2600	1-3	2016	HARC
	Browse Trees						
36	*Chamaecytisus palmensis*	MoA	Tagasaste/ Tree lucerne	2000-3000	6-10	1992	HARC
37	*Sesbania macrantha*	DZF-092	Sesbania	400-2000	8-10	2012	DZARC
38	*Cajanus cajan*	Dursa	Pigeon pea	-	-	2009	MARC

(Source: Ministry of agriculture and natural resources, crop variety register issue no. 19, 2016)

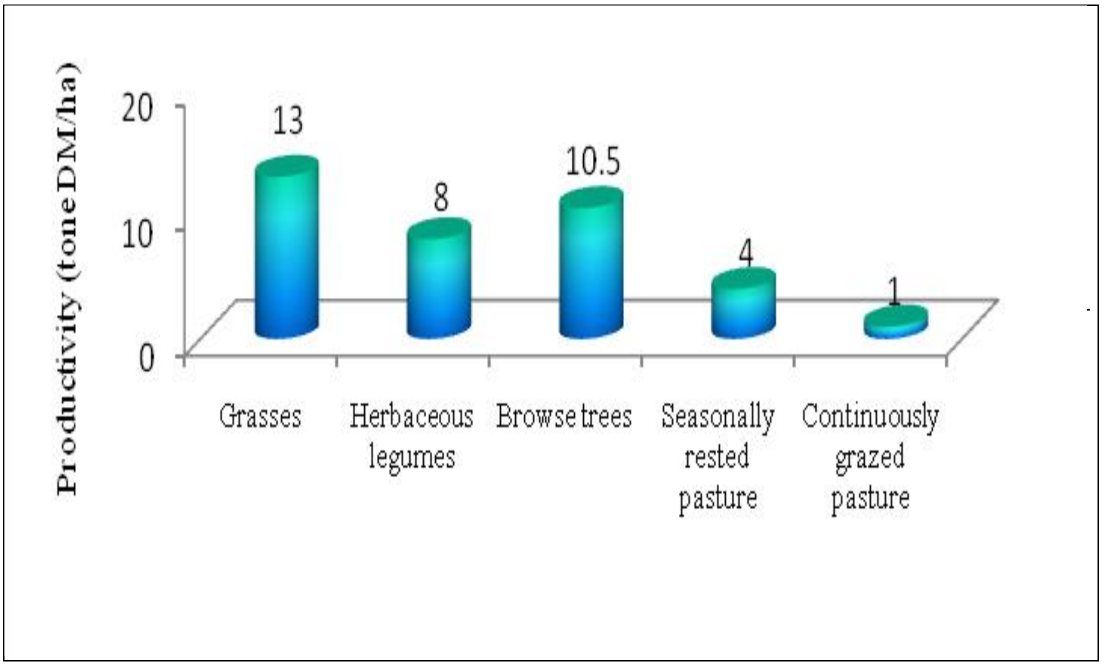

Figure 1: Average productivities of improved fodder crops in comparison to natural pasture in Ethiopia

2.3 Forage agronomic studies

Ethiopia is characterized by a highly diverse agro-ecological setting ranging from the arid lowlands to moist cool highlands. The different agro-ecologies vary not only in moisture (length of growing days) and temperature regimes, but also in soil types and characteristics. The wide diversity of agro-ecological conditions and soil characteristics existing in the country offers various potential ecological niches for the forage introduction and evaluation programs to identify adaptive forages and to encourage their adoption and use by farmers in different farming systems. Nevertheless, the management and agronomic requirements of the various forage crops grown in the different agro-climatic conditions and soil types could vary necessitating the development of appropriate agronomic practices which support better overall productivity and quality of cultivated forages. Agronomic manipulations will help to exploit the desirable characteristics of the forage crops like high herbage production, better nutritional quality, fast/ease of establishment, high competitive ability, persistence, compatibility with other companion forage crop, suitability for forage-food crop integration, tolerance to moisture stress and high seed production. In line with this, various agronomic studies encompassing establishment methods (seed dormancy, treatments), sowing/planting dates, seeding rates/plant spacing, fertilization (types, rates, timing of application), harvesting management (cutting stages, frequency), grass-legume intercropping (seed proportions, compatibility), and forage-food crops integration have been conducted on selected annual and perennial forage species in different agro-ecologies. Summary of the location/agro-ecology, target forage species, main research objectives and major findings of some of the forage agronomic studies conducted by NARS is presented in Table 3.

Table 3: Some efforts and major achievements/findings of forage agronomic research in Ethiopia

No.	Location/ agro-ecology	Target forage species	Main research objective (s)	Major findings & recommendations	Source
1	Holetta/ highland	Napier grass	To evaluate agronomic performances (DMY, plant height & frost tolerance) and nutritive values of local variety of Napier grass and 9 accessions of Pennisetum hybrids, and also to study the effect of cutting height (0.5m, 1m, 1.5m) and accessions on agronomic performance & quality.	• Based on yield performance and nutritional characteristics, the optimum cutting height of Napier grass in the central highlands of Ethiopia is 1m. • Accession No 14984 was found to be the best accession in overall performance followed by accession Nos. 16835 and 16834. • Further studies were recommended on intake and animal response trials in order to develop Napier grass based dairy cattle feeding for smallholder farmers.	Seyoum et al., 1998
		Napier grass + vetch	To assess the effect of under-sowing vetch with Napier grass on the overall herbage productivity both during the establishment year of Napier grass and in the subsequent years.	• The vetches (*V. dasycarpa & V. villosa*) were successfully established when under-sown to Napier grass & found to dominate the grass during the establishment year, but dominated by Napier grass in the subsequent years. • Under-sowing vetch with Napier grass increased total forage production by more than tenfold as compared to sole Napier grass during the establishment year of the grass in the cool highlands, like Holetta. This was realized without affecting subsequent performance of the grass and the overall total herbage production was higher for the vetch/Napier grass mixture than sole Napier grass. • Intercropping vetch with Napier grass during the establishment year of the grass could be an ideal means to produce considerable amount of forage per unit area of land in the cool highlands where perennial grasses are	Fekede et al., 2004

				slow to establish and produce very low amount of forage in the first year. • Further research has been suggested to assess appropriate agronomic and management practices in order to improve the stand and herbage yield of vetches under-sown to the well established Napier grass plots.	
2	Adet/ highland	Napier grass	To study the effect of cutting frequencies (30, 60, 90, 120 and 150 days) on forage yield of Napier grass under rain fed condition	• Harvesting at 150 days interval resulted in higher forage production as compared to the other treatments.	Halima, 2005
		Napier grass	To assess the effect of plant height at cutting as well as different sources and levels of fertilizer on DMY, chemical composition and IVDMD of Napier grass.	• Highest herbage DM was obtained when 92 kg ha^{-1} N was used and at 1m cutting height. • Cutting Napier grass at 1 m height resulted in the production of better quality forage based on chemical composition, IVDMD values and total digestible matter.	Tessema et al., 2002
3	Srinka/mid altitude	Napier grass	To determine the optimum harvesting stage (height) for higher total DMY, leaf proportion and CP yield	• Harvesting at 1.5 m height resulted in higher DMY, leaf proportion and CP yield, and recommended to be the appropriate harvesting stage of Napier grass under Srinka condition.	Samuel & Mesfin, 2002
4	Holetta/ Highland	Annual legumes (Vicia, clovers, oats/vetch) in rotation with barley & wheat	To study the effect of different forage legumes on the yield of subsequent cereal crops & assess the effect of P fertilizer on the establishment & bio-mass yield of the legumes.	• In the first year, oats/vetch mixture gave the highest DMY (16.5 t/ha on red soil & 10.6 t/ha on black soil), while the clover spp. showed better response to P fertilizer than both vetch & oats/vetch mixture. • In the second year, all the plots were planted with barley on red soil & with wheat on black soil, & their respective grain yields were better in response to the preceding forage legumes, mainly clovers. • The study showed that forage legume-cereal rotational cropping has great potential in improving cereal yields	Getnet et al., 1993

				in the highlands where fallowing or continuous cereal mono-cropping is practiced. It can also help to produce better quality livestock feed.	
5	Holetta/ highland	*Chloris gayana*, *Panicum coloratum*	To investigate the best method and date of clearing re-growth for higher seed production of acceptable quality from Rhodes and Colored Guinea grasses under rain fed condition at Holetta.	• Clearing by controlled burning resulted in better re-growth and seed yield than clearing by cutting. • Clearing of re-growths during early June resulted in higher yield of good quality seed than earlier clearing especially when short rains are normal in amount and distribution (about 250 mm). • Peak seed yields were obtained during the second year of establishment and declined then after as the age of the grasses get older.	Getnet et al., 2005
6	Holetta/ highland	*Phalaris aquatic*, *Chloris gayana*, *Panicum coloratum*	To assess the effect of different manure and N-fertilizer levels on the establishment, forage yield and seed yield performances of the three perennial grasses; and to determine the optimum level of fertilizer for the species in the area. - Manure levels used: 5, 10, 15 t/ha - N fertilizer levels used: 23, 46 and 92kgN/ha - Unfertilized plot as control	• Both herbage and seed yields of the three grasses were better in response to high levels of manure and N fertilizer (15 tha^{-1} manure and 92 kg N ha^{-1}) initially applied to the fields. • Rhodes and Panicum were also more responsive to annual N fertilizer application than Phalaris mainly towards the later stage of growth. • The mean seed yields recorded for Phalaris, Rhodes and Panicum in the study were 118.9 kg, 133.3 kg and 94 kg/ha, respectively. • Further study was suggested to evaluate the productivity of the grasses under higher levels of initially applied manure or continuous N application in combination with other management practices such as cutting and the corresponding time of fertilizer application.	Getnet et al., 2003
		Phalaris aquatic, *Chloris gayana*,	To evaluate the establishment & herbage yield performances of the three perennial grasses established as pure stands and	• Intercropping with the perennial grasses did not significantly affect barley grain yield as compared to pure stand of barley.	Getnet et al., 2003

		Panicum coloratum	intercropped with barley and managed as improved grass fallow for three years, and to assess their residual effect on the subsequent barley crop.	• Grasses established in pure stands gave about five times more average herbage yield compared to those intercropped with barley during the establishment year, but the variation sharply reduced then after. • The total herbage yield during the fallowing period was higher for grasses established by intercropping as they stayed longer as a pasture for the same length of fallowing period compared to the pure stands. • Rhodes grass produced significantly higher forage yield followed by Colored Guinea and Phalaris under both as pure stand and when intercropped with barley. • Barley grain yield was significantly increased following Panicum and Phalaris compared to the control (barley–barley mono-cropping), while the highest forage yielder Rhodes grass had significantly depressed the performance of the subsequent barley crop. • The study showed that establishing perennial grasses by intercropping was an advantageous strategy to improve natural fallow land, and the residual effects of the grasses were improved as the fallowing period was extended from 1 to 3 years. • Panicum was found to more suitable for use as an improved grass fallow in terms of both higher herbage production and its better residual effect on the subsequent cereal crop (barley).
7	Holetta/ highland	*Phalaris aquatic, Chloris gayana, Panicum coloratum*	To assess the productivity and quality of the grass seeds as affected by different harvesting stages (1, 2, 3, 4, 5 & 6 weeks after full heading).	• The three species produced seed in the second year of establishment with average seed yields of 149, 85 and 75 kg/ha for Rhodes, Panicum and Phalaris, respectively. • Rhodes & Panicum gave highest seed yields when harvested three & four weeks after full heading with average germination rates of 91 & 32%, respectively.

				Phalaris on the other hand gave high amount of seed towards the later harvesting stages (5 & 6 weeks after full heading). • Seed viability in all the three species was significantly improved with delayed time of harvest after full flowering. • Three to four weeks after full or seven to eight weeks after first heading for Rhodes and Panicum; and delayed harvesting after full maturity for Phalaris were recommended to produce high amount of seeds with better viability from the three grass species. • It was suggested to undertake close follow-up to reduce seed loss due to shattering especially in Rhodes & Panicum.	Getnet and Tadesse, 1996
8	Holetta/ Highland	Tagasaste (*Chamaecytisus palmensis*)	To evaluate the potential of different scarification methods and determine optimum length of treating time to break dormancy of Tagasaste seeds.	• Treatment of tagasaste seeds using boiling water for 7-11 minutes was found to be the best method & resulted in 75% germination followed by dry heat treatment up to 85°C for 1-3 hours and scarification with sand paper also resulted in up to 40% germination. • Complete loss in viability of tagasaste seed was encountered when dry heat treatment was applied at 105°C even for shorter (about 1 hour) and with hot plate treatment for half a minute.	Getnet, 1998
		Tagasaste (*Chamaecytisus palmensis*)	To assess the effect of harvesting frequency/interval on total herbage yield, DM proportions (leaf, edible branch, stem) and nutritive values of the different fractions in Tagasaste. (cutting frequency: 2, 3, 4 & 6 months interval)	• Cutting interval significantly affected annual biomass DMY of tagasaste. The recorded annual DMY was 4.7, 6.2, 7.9 & 10.3 t/ha corresponding to harvesting intervals of two, three, four and six months, respectively. • The proportion of leaf in the biomass decreased with prolonged harvesting interval (67% in two months harvesting interval to 45% in six months harvesting interval). The stem fraction increased from 0.4 to 26%	Getnet and Tadesse, 1996

				with prolonged harvesting interval from 2 months to 6 months; while the edible branch varied narrowly from 27-34% within the harvesting intervals. • The leaf fraction had average CP content of 20% and IVOMD of 67% without much variation among the harvesting intervals. • Harvesting at intervals of 4 to 6 months mainly during the wet season resulted in the production of herbage with high amount of better quality edible matter from tagasaste.	
9	Holetta/ Highland	Oats (*Avena sativa*)	To assess the variation in maturity among 20 oats varieties and its practical implications for integration into highland mixed farming systems.	• There was marked variation among the varieties with respect to the durations required to attain the different growth stages. • Taking the soft dough stage as a reference physiological maturity stage for forage harvest, there was on average a difference of 31 days between the early (117 days: Coker SR res 80 SA 130) and late maturing varieties (148 days: Grayalgeris). • Most of the difference in maturity among the varieties was attributed to differences in the durations of the vegetative growth period (planting to heading) than the grain filling period. • Early maturing varieties could be preferably grown as precursor crops to chickpea/lathyrus, to make efficient use of the small amount of moisture during belg cropping and in cases where cut-and-carry feeding is targeted to curb feed shortage during the main rainy season. On the other hand, late maturing varieties could be the better choice in cases where hay making and conservation for dry season is targeted.	Fekede, 2009

		Oats (*Avena sativa*)	To determine the proportion of different morphological fractions at different growth stages in 20 selected varieties.	• The proportion of leaf blade decreased from 52.2 to 15.6%, while the proportion of stem increased from 19.4 to 57.6% as growth advanced from boot stage to grain maturity stage. The average proportion of leaf sheath decreased from 28.4 to 18% as growth advanced from boot stage to the soft dough stage, but it tended to regain at grain maturity stage (26.8%). The panicle proportion was found to be relatively stable increasing only by 4% units with advance in growth from heading to the soft dough stage. • The different oats varieties also exhibited highly considerable differences in the proportion of morphological fractions suggesting the possibility of improving forage production in oats through proper exploitation of the varietal differences.	Fekede et al., 2008
10	Holetta/ Highland	Oats (*Avena sativa*)	To assess chemical composition and IVOMD of whole forage and different morphological fractions of 20 selected oats varieties harvested at the soft dough stage.	• There were considerable variations in chemical composition and IVOMD among the oat varieties and the different morphological fractions. • Among the varieties, CP content varied from 48 to 76 g kg^{-1} DM, NDF from 586 to 683 g kg^{-1} DM, ADF from 370 to 482 g kg^{-1} DM and ADL from 54 to 83 g kg^{-1} DM. The IVOMD of the whole forage ranged from 43 to 62%. • Among the morphological fractions, leaf blades had the highest CP content and IVOMD, whereas the fiber fractions (NDF, ADF & ADL) were highest in the stems. • The result implied that there are opportunities for improving forage production and quality from oats through appropriate exploitation of varietal differences. However, manipulation of management practices (such as choice of harvesting stage, use of mixed cropping with	Fekede et al., 2008

				compatible legumes and fertilizer application) may still be needed for further improvement.	
11	Sinana/ Highland	Clover – *T. quartinianum*	To assess the effect of wheat/clover seeding pattern on grain, straw & total biomass production of wheat in wheat/clover intercropping system. The treatments used were 1:1, 2:1, 3:1 wheat/clover alternate rows; 1:1, 2:1, 3:1 wheat/clover seed mixtures (row basis) mixed in a row and sole stands of wheat and clover.	• All the intercropping treatments did not significantly reduce wheat grain yield compared to wheat monoculture. But, yield and composition of crop residues were affected by seeding patterns used in intercropping. • The 1:1, 2:1, 3:1 wheat/clover alternate row patterns and the 1:1 wheat/clover seed mixture (row basis) resulted in significantly higher total crop residue yield compared to the sole wheat cropping. • The alternate row seeding patterns compared with the mixed in row treatments, resulted in higher proportion of clover (10% vs 4%) in the total crop residue, and resulted in the production of higher total crop residues compared to the sole wheat.	Tekleyohannes & Daniel, 1998
12	Sinana/ highland	Vetch (*V. dasycarpa*), Clover (*T. quartinianum*), Alfalfa (*cv. Hunter river*)	To investigate the effects of undersowing the three forage legumes, time of undersowing (simultaneously & at first weeding of barley) and fertilization (0/0 and 41/46 N/P_2O_5 kg/ha) on barley grain, straw and DMY of the under-sown forage legumes.	• Undersowing clover & alfalfa did not significantly reduce barley grain & straw yields compared to the control. However, simultaneous barley-vetch intercropping resulted in about 22% reduction in barley grain yield. • DMY of the forage legumes when under-sown simultaneously & at first weeding of barley highest for vetch (17.7 & 1.0 q/ha) followed by clover (3.8 & 0.4 q/ha) and alfalfa (2.0 & 0.1 q/ha). • Both barley grain and straw yields were significantly increased by fertilizer application. • The study showed that small seeded forage legumes (clover and alfalfa) can be simultaneously under-sown with barley without reducing barley grain yield, the large seeded and fast growing vetch tended to reduce barley grain yield when simultaneously under-sown with barley. Hence, time of undersowing should be given special	Tekleyohannes & Worku, 2000

				attention for better results in forage legumes-food crops (barley) intercropping.	
13	Bako/mid altitude	*Chloris gayana*, *Panicum coloratum*, *Desmodium unicinatum*	To evaluate the forage productivity and compatibility of Rhodes-Desmodium and Panicum-Desmodium mixtures grown using different seed proportions of the component species.	• Higher forage yield was obtained when 25% legume: 75% grass seed proportion was used for both Rhodes-Desmodium and Panicum-Desmodium mixtures. • 75% Rhodes + 25% Desmodium mixture gave 65.3 and 15.01 % higher DM yield as compared to the sole Desmodium and sole Rhodes, respectively. • Similarly, 75% Panicum + 25% Desmodium mixture gave 58.7 and 20.3% higher DM yield as compared to the sole Desmodium and sole Panicum, respectively. • In both cases, mixed cropping was found to be biologically advantageous over the sole stands. However, the grass components were observed to be highly aggressive and had superior contribution to total forage DM. Hence, further research has been suggested on development of management techniques that improve the compatibility of Desmodium with both the grass species so as to have desirable botanical composition (30-50%) of the legume component in the mixture.	Diriba et al., 2005
14	Bako/mid altitude	Panicum coloratum, Stylosanthes guianensis	To determine yield and quality of the component species in *Panicum coloratum* (PC) and *Stylosanthes guianensis* (SG) mixed pasture as influenced by seed proportion (75%PC + 25%SG, 50% PC + 50% SG, and 25%PC + 75%SG along with the sole stands of each species).	• Panicum- Stylosanthes mixed culture was observed to offer yield advantages relative to sole cropping of the two components both in terms of yield stability and improved quality of the total stand. • Better complementarities between the two species and higher biological yield advantages as revealed by the relative yield totals were observed when the two species were mixed at 50 PC:50 SG and 25 PC: 75 SG proportions.	Diriba et al., 2005

15	Bako/mid altitude	Vetch	To determine the effects of different supporting structures (A-frame, fence and no support as control) on seed yield and production cost of *Vicia atropurpurea*	• Seed yields of *V. atropurpurea* were increased by more than 318% and 570% over the control (unsupported) plots when it was supported by a structure constructed in the form of A-frame and fence, respectively. • Fence supporting required lower total variable cost than A-frame and gave the highest net benefit of 2802 Birr/ha. • Both in terms of seed yield and net return advantages, provision of supporting structure constructed in the form of fence was recommended for *V. atropurpurea* seed production in the sub humid environment.	Lemma, 1998
16	Bako/mid altitude	*Chloris gayana, Stylosanthes Guianensis, Desmodium intortum, Macrotyloma axillare*	To assess the feasibility of undersowing planted forage crops in maize and its effect on forage, maize grain and residue yields. (pure stands of indicated forage species and mixtures of the three legumes with *Chloris gayana* were drilled b/n the rows of maize 6 weeks after planting of maize)	• Highest grain yield (7.6 t ha^{-1}) was obtained from the maize plots in which Stylosanthes was under-sown, while highest maize stover yield (11.17 t DM ha^{-1}) was obtained from the maize plots in which *Macrotyloma axillare* was under-sown. • Among the forage legumes, Macrotyloma was the highest forage DM yielder (2.9 t ha^{-1}), while natural pasture fallow plots gave the highest (4.68 t ha^{-1}) grass DM followed by Rhodes harvested from the plots in which Rhodes/Stylo mixture was under-sown. • In the subsequent two cropping seasons, highest overall total forage yield was obtained from Rhodes/Stylosanthes mixture plots (16.48 t ha^{-1}) and followed by those plots which were under pure Rhodes. • The plots which were under *Desmodium intortum* gave highest maize grain yield (7.13 t ha^{-1}) followed by the plots which received recommended fertilizer rate which gave maize grain yield of 6.71 t ha^{-1}, and similar trend was observed for maize stover yield. • The study generally revealed the possibility of exploiting short-term forage legume-cereal rotations where the	Diriba & Lemma, 2002

				farmer can gain the benefits of forage legumes to grain production.	
17	Werer/ Lowland	*Chloris gayana*, *Panicum coloratum*, *Panicum maximum*, *Cenchrus ciliaris*	To evaluate the effects of four harvesting intervals (2, 4, 6 & 8 weeks) and two fertilizer levels (0 & 500 kg N/ha per annum) on DMY and nutritional quality of the four grasses under irrigation.	• An increase in DMY was observed with harvesting interval (8 weeks harvesting interval resulted in higher DMY). • Clipping at 2 weeks interval resulted in higher CP content & IVOMD, while NDF content was higher in the 8 weeks harvesting interval. • The study demonstrated that clipping at 4 to 6 weeks resulted in the production of relatively higher DM with better quality in irrigated pasture at Melka Werer. • Fertilizer application did not have significant effect on both herbage yield and nutritional quality of the forage grasses in this study.	Aschalew et al., 1996
18	Adet/ highland	*Chloris gayana*, *Panicum coloratum*, *Phalaris aquatica*, *Desmodium unicinatum*, *Medicago sativa*	To evaluate the herbage yield performances of different grass/legume mixtures and to determine the best combinations of grass and legume under Adet condition.	• Rhodes & Panicum associated well with Desmodium & alfalfa, and contributed to high DMY and reasonable grass/legume proportion in the mixed sward. • Average DM yields of the grass-legume mixtures ranged from 4.51 t/ha (pure phalaris) to 12.09 t/ha (Rhodes/Desmodium mixture) with an overall mean of 9.05 t/ha throughout the trial period. • Rhodes/alfalfa and Panicum/alfalfa mixtures performed better than the other combinations in terms of grass/legume proportion, yield stability and closeness in maturity period of the components. • Rhodes/Desmodium mixtures gave higher DMY than the other mixtures & pure stands throughout the trial period.	Tessema, 1996

2.4 Forage development efforts and challenges

The ultimate goal of cultivated forage research efforts is to avail suitable technologies that help to curtail the feed deficit problem so as to improve livestock productivity and its contribution to the overall wellbeing of the country. However, availing technology alone is not suffice unless the technology is multiplied in sufficient amount, transferred/made available to the grass root users, widely applied and translated in to livelihoods by positively influencing livestock production. Over the past five decades, various livestock development projects (most of them externally funded) have been launched in Ethiopia aiming at curbing the development constraints related to the sub sector including feeds and nutrition. Some of the important projects accomplished with significant contributions to livestock development efforts of the country have been synthesized by Azage et al. 2010 as follows:

- Arsi Rural Development Unit (ARDU)-formerly known as the Chilalo Agricultural Development Unit (CADU) was initiated in 1967 with the financial support of Swedish International Development Agency (SIDA). It has been recognized for its pioneer livestock research and development in the Arsi highlands and also laid the basis for widespread development and use of various cultivated forage crops in the project areas. ARDU had also taken some initiatives in the collection and evaluation of indigenous potential forage species, which had not received attention for a long time. The experiences developed in implementations of this project also helped to establish the Minimum Package Programme (MPP) in 1971. This was regarded as a less expensive approach of reaching more farmers and the Extension and Project Implementation Department (EPID) of MoA was mandated to implement the MPP in two phases, and offered farmers with an integrated minimum agricultural services and inputs.
- First Livestock Development Project (F_1LDP)–also known as the Addis Ababa Dairy Development Project, was established in 1972 with the loan from World Bank. It was designed to establish and support small and medium sized dairy farms in potential milk sheds around Addis Ababa. To this effect, the project has exerted a major effort in introduction and distribution of improved dairy breeds to small-scale dairy farmers in the peri-urban and rural areas of Addis Ababa. Similar projects geared to dairy development like the Dairy

Rehabilitation and Development Project (DRDP) followed by the FINNIDA supported Selale Peasant Dairy Development Pilot Project (SPDDPP) and the Smallholder Dairy Development Project (SDDP) were also implemented in different selected areas.

- Fourth Livestock Development Project (F_4LDP) of MoA-was implemented from 1987 to 1994 with the joint financial support of the Ethiopian government and loan/credit obtained from International Development Agency (IDA) and International Fund for Agricultural Development (IFAD). The project was managed under the Animal Breeding and Feed Resources Development Department of the Ministry of Agriculture and was aimed at increasing livestock and agricultural production by improving animal health and nutrition.
- National Livestock Development Project (NLDP)–emerged from the National Livestock Development Program of 1997 and being implemented throughout the country (both the highland and lowlands) with the loan from the African Development Fund. It had three components including animal health improvement, cattle genetic improvement through strengthening of AI services and forage development.
- USAID supported projects such as the Ethiopian Dairy Development Project implemented by Land O`Lakes; the Sanitary and Phytosanitary Livestock Meat Marketing Project led by Texas A&M University, and the Ethiopian Sheep and Goat Productivity Improvement Project implemented by Prairie View A&M University in Texas and the American Institute for Goat Research of Langston University, Oklahoma.

All the livestock development projects launched in the country during the different periods had improved forage development component with varying extents. Among the various projects, FLDP has made a tremendous contribution to forage development via introduction, multiplication (contract seed scheme) and promotion of promising forage species to smallholder farming systems. The project had initiated and adopted different low cost production strategies to introduce various forage crops into the farming system most of which were readily accepted and implemented by farmers within the project life time. The major forage development strategies implemented by the project (Alemayehu, 2002a) include: (a) Backyard forage production by providing an array multipurpose tree (20 million seedlings) and forage legumes and grasses, (b) Under-sowing, particularly with annual legumes in maize and sorghum fields (17,500 ha), (c) Sowing stock exclusion degraded grazing areas as a conservation measure (9000 ha), (d) Over-sowing with grasses or legume seed by broadcasting on communal pasture and on road sides (11,000 ha), (e) Establishing forage and alley strips (18,600 km), (f) Sowing of pasture with mixed grass and forage legumes (1176 ha), and (g) Growing of forages under perennial plantation trees (82 ha). Moreover, the project has supplied seeds and seedlings to various institutions concerned in forage development and the forage species introduced by the project have been used as useful germplasm sources by the national forage research program of the country. Table 4 indicates the lists of forage species tested and found to be suitable for the various forage development strategies in different agro-ecological zones of the country.

In order to ensure adequate seed supply for the forage development programs, the project also tried to introduce a contractual forage seed production scheme, which not helped the smallholder farmers to get familiarized with improved forage species, but also enabled them to generate substantial income. In this scheme, the project initially imported 94 tons of different forage seeds but eventually managed to locally produce about 160 tons of seeds and 10 million seedlings through participation of farmers.

Table 4: Suitable forage species for the various forage development strategies adopted in different agro-ecologies (FLDP,1988-1994)

Strategy	Lowland (1,500-2,000m)	Mid Altitude (2,000-2,400m)	Highland (>2,400m)
Backyard forage development	Leucaena, Sesbania, Pigeon pea, Rhodes, Setaria, Panicum, Elephant grass, Desmodium, Alfalfa	Tree Lucerne, Sesbania Pigeon pea, Phalaris, Elephant grass, Alfalfa, Vetch	Tree Lucerne, Phalaris, Vetch, Alfalfa, Oats, Fodder-bet
Undersowing forage legumes in crops	Lablab, Cowpea, Siratro, Desmodium (green leaf), Stylo (Verano), Vetch	Vetch, Siratro, Desmodium (green leaf)	Vetch
Forage strips	Leucaena, Sesbania, Pigeon pea, Panicum, Setaria, Siratro, Axillaries, Desmodium (Silver leaf & green leaf), Stylo (Verano)	Tree Lucerne, Sesbania, Pigeon pea, Desmodium (green leaf), Axillaries, White clover, Vetch, Phalaris, Setaria	Tree Lucerne, Trifolium spp.
Forages on livestock exclusion areas	Plicatulum, Buffel, Leucaena, Sesbania, Siratro, Stylo, Axillaries	Tree Lucerne, Sesbania, Axillaries, Siratro	Tree Lucerne, Phalaris

Strategy	Lowland (1,500-2,000m)	Mid Altitude (2,000-2,400m)	Highland (>2,400m)
Oversowing legumes in natural pasture	Stylo (Verano, seca), Siratro, Desmodium	Vetch	Vetch
Conventional forage development	Stylo (Verano), Siratro, Desmodium (Green leaf and Silver leaf), Rhodes, Panicum, Setaria	Phalaris, Setaria, Desmodium (Green leaf and Silver leaf), Vetch, Oats	Alfalfa, Vetch, Phalaris, Cocksfoot, Oats

(Source: Alemayehu M 2002a and 2002b)

3. FACTORS LIMITING CULTIVATED FORAGE PRODUCTION AND UTILIZATION

The availability of improved forage technologies mainly in terms of well adapted and high yielding species/varieties, and the associated agronomic management practices developed by the different NARS entities is apparently undeniable in Ethiopia. Overviews of the various research centers catering for the different agro-ecological zones of the country suggest the availability of a number of productive forage species of great significance in curbing the problems associated with livestock feed supply upon successful promotion and utilization in the farming system. Moreover, various attempts have been made by different livestock development projects like FLDP, government institutions and other development organizations to introduce and promote forage crops into the farming system. Despite these, feed shortage has been continued to be the persistent problem hampering livestock production and productivity in almost all production systems and agro-ecologies of the country. Improved forage crops have tremendous potential to alleviate the problem of feed shortage if properly developed and used in the farming system. However, adoption of improved forage production and utilization by the farming community has been very low with the consequent insignificant contribution to the annual livestock feed budget in the country. A recent study on forage adoption by farmers has indicated that only 0.15% of livestock keepers in rural areas produce improved forages on farm (Tesfaye et al., 2010). Crude estimations on the contribution of different feed resources to livestock feed supply indicated that the share of cultivated forage crops is only limited at 1.5% (Figure 2, EARO 2000). The use of improved forage crops is limited to areas where market-oriented livestock production is practiced such as the case of crossbred dairy production by smallholder farmers and commercial dairy farmers who have access to land. Government institutions like research centres and dairy enterprises also produce and use some forage crops such as oats/vetch and Rhodes grass mainly as conserved feed in the form of hay.

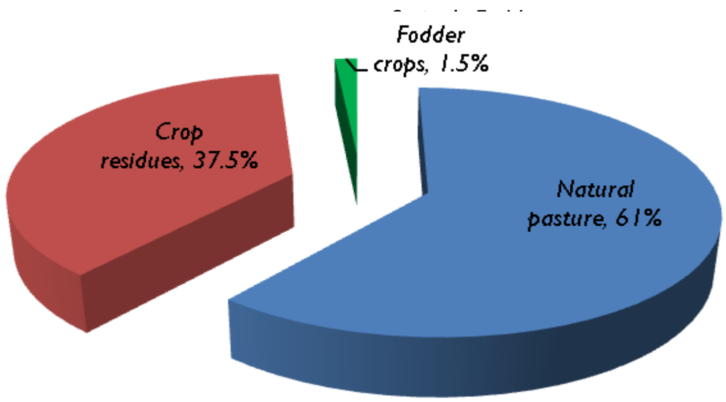

Figure 2: Estimated contribution of different feed resources to annual livestock feed supply (EARO, 2000)

Generally, the use of improved forage crops has been very low and their potential contribution to alleviate the critical feed shortage problem in the country is untapped. Different reasons can be cited for the low adoption of cultivated forage crops of which the major ones include:

- **Lack of market-oriented specialized livestock production to catalyze forage development**–livestock production in Ethiopia is in the hands of smallholder farmers mainly based on low producing indigenous breeds. Farmers` main livestock production objective is also to produce draught oxen for their farming occupation, while the livestock products (milk, beef, etc) are often considered as byproducts to draught. The other factor is associated with the socioeconomic situations of farmers, who operate under high transaction costs and have difficulties in connecting to markets; as their animal production is predominantly linked to domestic needs with only limited market orientation and lack of specialization in livestock production. In such a system where main purpose of livestock keeping is to support crop production, it is unlikely that livestock can be a competitive enterprise to catalyze forage development. Moreover, all the prime land is devoted to food crops and farmers` have low affinity to devote land, labor and capital for fodder development, and livestock are supposed to depend on the crop byproducts and degraded grazing lands as major source of feed.

- **Crop skewed extension system**–livestock production in general and forage development in particular has not been adequately addressed in the national agricultural extension system. Promotion of improved forage technologies has been made sporadically via different externally funded livestock development projects. Externally funded projects usually have a fixed and often limited duration and scope, which may not be suffice for the smallholder farmers to buy in the interventions and take it up in a sustainable manner. Moreover, most of the projects had no proper phase out strategies which ensure sustainability through incorporation of the development initiatives into the government development programs. As a result, most of the project initiatives in promoting improved forage technologies into the farming system have been subject to total collapse after phasing out of the projects. Although the extension system is structurally accommodating livestock production, the actual service is skewed to crop production in terms of input supply and technical support, while the livestock aspect has been remained subordinate. This is further exacerbated by a blanket extension approach followed throughout irrespective of potential suitability of different areas for different enterprises (e.g. we do not have different extension approaches for Selale area which is highly suitable for dairy production vs. other areas which have comparative advantage for grain production). The lack of adequate extension services and demonstration works has resulted in limited awareness by the farming community on the role of improved forage crops.
- **Lack of reliable supply of forage seed/planting material**–the status of forage seed research and development in Ethiopia has been reviewed in the first national workshop on forage seeds, held in May 2011 and proceedings of the workshop has been published by EIAR. In adequate forage seed research, lack of reliable forage seed production, processing and distribution schemes were among the major constraints identified and duly discussed in the workshop. Moreover, the lack of information on the national demand for forage seeds and the poorly developed seed marketing systems also impose further limitations to forage seed production and forage development. Different recommendations on the way forward to improve the

overall forage seed system in the country have been provided in the workshop proceedings and all interested readers are advised to refer the proceeding for further detail information.

- **Free livestock grazing systems**–most forage species are perennials which once established can persist and provide continuous feed supply for more than five years with good management. However, the prevailing free livestock grazing systems limit the development and utilization of these forages by smallholder farmers. Prolonged dry season and the lack of irrigation setups also impose further limitations to the development and proper management of perennial forage crops.

4. CONCLUSION AND RECOMMENDATIONS

Feed scarcity in terms of both quantity and quality has remained to be the main limiting factor hampering productivity of the Ethiopian livestock sector. Provision of adequate feed supply is essential to ensure economically viable and environmental friendly livestock production. This requires complementing the traditionally available low quality feed resources with other alternative feed resources. One potential option is the sound application of improved forage technologies generated over a long period of time in the country. Different promising forage species with their corresponding agronomic management practices have been identified for the different agro-ecological zones of the country. However, the potential of these forage species as livestock feed resources has been yet untapped, and their contribution to the annual livestock feed budget remains insignificant. Some of the major reasons for low adoption of improved forage crops include lack of adequate demonstrations on comparative advantages of improved forage crops, lack of specialization in livestock production and the underdeveloped market-oriented livestock enterprises, lack of reliable forage seed sources, the overall low attention given to forage development by the extension service, and the consequent low public awareness. Historically, forage development efforts in Ethiopia have been associated with different short-term projects of external sources and lacked strategic and sustainable development approaches. Therefore, the following issues should be emphasized as a way forward to ensure proper promotion, development and utilization of improved forage crops as potential remedies to fill the feed shortage gap livestock producers are facing in different farming system of the country:

- Further extensive demonstrations of the comparative advantages of the already recommended forage species with their production, management and utilization strategies including animal response studies involving strategically selected farmers. The farmers engaged in market-oriented livestock production such as improved dairying using crossbreds and/or cattle fattening could serve as potential target groups and entry points for improved forage demonstration and promotion activities.
- Available policies and strategies related to livestock production in general and forage development in particular should be supported by adequate institutional commitments in terms of overall focus, input supply and service delivery systems. The establishment of livestock state ministry in recent times could serve as a golden opportunity to take livestock development a step forward via focused and targeted extension services to develop market oriented intensive livestock enterprises which in turn trigger adoption of improved forage crops. In order to materialize this, there is a need to device and follow context specific extension approaches than the existing blanket extension approach (e.g. more livestock focused extension approach in areas with comparative advantage for livestock production than cropping).
- The extensively launched NRM programs with increasing closure of large area of land from livestock in the country can serve as another potential niche for conservation based forage development. Growing forages on the enclosures not only helps to provide a better ground cover to protect the soil, but also provide better quality livestock feed for cut and carry feeding systems.
- The suggested forage promotion and development strategies should be supported by reliable supply of forage seeds and planting materials. The Ethiopian Seed Enterprise (ESE) which is mandated to produce the required agricultural seeds in the country is mainly devoted to the production of food crop seeds with no or very limited involvement in forage seed production. Therefore, there is a need to establish a special unit responsible for forage seed production, processing, quality control, packaging, storage and distribution either under ESE or livestock state ministry. This should be accompanied with strategic planning taking into account estimated national demand for forage seeds, target agro-ecology and production system, and reliability of the seed marketing system.

- Strong coordination and institutional linkages should be established among the different actors (research, extension, seed enterprises and concerned private sectors).

Conflict of interest

There is no conflict of interest, according to the authors.

REFERENCES

Abera O (2006). Indigenous Common Grazing Land Management in Chencha Wereda, South Ethiopia. M.Sc Thesis, School of Graduate Studies, Addis Ababa University, Ethiopia 97 pp.

Alemayehu M, and Getnet A (2012). The Evolution of Forage Seed Production in Ethiopia. In: Getnet Assefa *et al.*, (eds). 2012. Forage Seed Research and Development in Ethiopia. Proceedings of a workshop organized by EIAR-ASARECA Cooperation, Ethiopian Institute of Agricultural Research, Addis Ababa.

Alemayehu M (2002a). Lesson Learned From Implementation of the Ethiopian Fourth Livestock Development Project: Experience and Results, Ethiopian Journal of Animal Production. 2(1): 25-47.

Alemayehu M (2002b). Forage Production in Ethiopia. A Case Study in the Implication for Livestock Production. Ethiopian society of Animal Production. Publication No. 3, Addis Ababa Ethiopia.

Aschalew T, Beyene C, Derrick T, and Asnake W (1996). Effect of frequency of clipping and N application on dry matter yield, and nutritional quality of four improved grasses under irrigation. In: Proceedings of 4th annual conference of the Ethiopia Society of Animal Production (ESAP) held from 18-19 April 1996, Addis Ababa, Ethiopia, 1996. Pp. 216-222.

Ayele S, Assegid W, Jabbar MA, Ahmed MM, and Belachew H (2002). Livestock marketing in Ethiopia. A review of structure, performance and development initiatives. Socio-economics and Policy Research Working Paper 52. ILRI, Nairobi, Kenya.

Azage T, Berhanu G, and Dirk H (2010). Livestock input supply and service provision in Ethiopia: Challenges and opportunities for market-oriented development. Working Paper No.20. Improving Productivity and Market Success (IPMS) of Ethiopian Farmers Project, ILRI, Addis Ababa, Ethiopia.

Diriba G, Diriba D, and Jemal D (2005). Forage Productivity and Compatibility of Mixtures of *Chloris gayana* and *Panicum Coloratum* with *Desmodium unicenatum* at Bako, Western Ethiopia. In: Proceedings of the 12th annual conference of the Ethiopian Society of Animal Production (ESAP), August 12 – 14, 2004, Addis Ababa, Ethiopia.

Diriba G, and Lemma G (2002). Forage yield performance and the residual effect of undersown forage crops on maize grain and residue yields. In: Proceedings of 9th annual conference of the Ethiopia Society of Animal Production (ESAP), Addis Ababa, Ethiopia, Pp. 213-223.

EARO (Ethiopian Agriculture Research Organization) (2000). Livestock Research Strategy Document, EARO, Addis Ababa, Ethiopia.

Fekede F (2009). Variation in maturity among oats varieties and its implications for integration into the highland farming systems. *Livestock Research for Rural Development. 2009. Volume 21, Article #173. Available online* http://www.lrrd.org/lrrd21/10/feyi21173.htm.

Fekede F, Adugna T, and Solomon M (2008). Nutritive value of different varieties and morphological fractions of oats harvested at the soft dough stage. *Trop. Sci. 2008, 47(4), 188-196.* Published online 13 November 2008 in Wiley InterScience (www.interscience.wiley.com) DOI: 10.1002/ts.213

Fekede F, Adugna T, and Solomon M (2008). Proportions of morphological fractions of oats (*Avena sativa* L.) as affected by variety and growth stage. *Journal of Livestock Research for Rural Development.* 2008. *Volume 20, Article #89. Available online http://www.lrrd.org/lrrd20/6/feyi20089.htm*

Fekede F, Getnet A, Lulseged G, Muluneh M, and Tadesse T (2004). Evaluation of Napier grass-vetch mixture to improve total herbage yield in the central highlands. In: Proceedings of the 13th annual conference of the Ethiopian Society of Animal Production (ESAP), August 25 – 26, 2004, Addis Ababa, Ethiopia.

Getnet A (2012). Retrospects and Prospects of Forage and Pasture Crops Research in Ethiopia. In: Getnet Assefa *et al.*, (eds). 2012. Forage Seed Research and Development in Ethiopia. Proceedings of a workshop organized by EIAR-ASARECA Cooperation, Ethiopian Institute of Agricultural Research, Addis Ababa.

Getnet A, Abreham G, Fekede F, and Tadesse T (2005). Effect of Methods and Dates of Clearing Regrowths of Rhodes (*Chloris gayana*) and Colored Guinea Grasses (*Panicum coloratum*) on Seed Productivity. In: Proceedings of the 12th annual conference of the Ethiopian Society of Animal Production (ESAP), August 12 – 14, 2004, Addis Ababa, Ethiopia. 2005.

Getnet A, Fekede F, and Abreham G (2003). Effect of manure and nitrogen fertilization on establishment, herbage yield and seed productivity of perennial grasses. In: Proceedings of 10th annual conference of the Ethiopia Society of Animal Production (ESAP), in Addis Ababa, Ethiopia, 22-24 August 2002. ESAP, Addis Ababa, Pp. 245-255.

Getnet A, Abreham G, Fekede F, and Berhane L (2003). Methods of Perennial Grass Establishment, Forage Productivity on Fallow Lands and Their Effect on the Subsequent Barley Crop. In: Proceedings of 10th annual conference of the Ethiopia Society of Animal Production (ESAP), in Addis Ababa, Ethiopia, 22-24 August 2002. ESAP, Addis Ababa, Pp. 257-263.

Getnet A (1998). Observation on Potential of Various Treatment Options to Overcome the Inhibition of Germination in Tagasaste (*Chamaecytisus palmensis*). In: Proceedings of 5th annual conference of the Ethiopia Society of Animal Production (ESAP), Addis Ababa, Ethiopia, Pp. 220-227.

Getnet A, and Tadesse T (1996). Effect of harvesting stage on yield and quality of perennial grass seeds in the highlands. In: Proceedings of 4th annual conference of the Ethiopia Society of Animal Production (ESAP) held from 18-19 April 1996, Addis Ababa, Ethiopia, Pp. 208-215.

Getnet A, and Tadesse T (1996). Effect of cutting frequency on forage yield and quality of Tagasaste (*Chamaecytisus palmensis*) in the highlands. In: Proceedings of 4th annual conference of the Ethiopia Society of Animal Production (ESAP) held from 18-19 April 1996, Addis Ababa, Ethiopia, Pp. 196-202.

Getnet A, Lulseged G, and Tadesse T (1996). Effect of forage legumes on the yield of subsequent cereal crops. In: Proceedings of 4th national livestock improvement conference (NLIC) held from 13-15 November 1993, IAR, Addis Ababa, Ethiopia, Pp. 188-192.

Halderman, M (2005). The Political Economy of Pro-Poor Livestock Policy Making in Ethiopia. Pro-Poor Livestock Policy Initiative (PPLPI) Working Paper No. 19. FAO (Food and Agriculture Organization), Rome, Italy.

Halima H (2005). Effect of cutting frequency on forage yield of Napier grass accessions (*Pennisetum purpureum*) under rain fed condition, Northwest Ethiopia. In: Proceedings of the 12th annual conference of the Ethiopian Society of Animal Production (ESAP), August 12 – 14, 2004, Addis Ababa, Ethiopia.

Lemma G (1998). A Note on Cost of Seed Production of Vicia atropurpurea as Influenced by Different Supporting Structures. In: Proceedings of 5th annual conference of the Ethiopia Society of Animal Production (ESAP), Addis Ababa, Ethiopia, Pp. 237-240.

Lulseged G, and Alemu T (1985). Pasture Research and Development in Ethiopia. In: Kategile, J.A. (ed.) 1985. Pasture Improvement Research in Eastern and Southern Africa, Proceedings of a workshop held in Harare, Zimbabwe, 17-21 September, 1984. IDRC, Ottawa, Canada.

MANR (Ministry of agriculture and natural resources). (2016). Crop variety register issue no. 19 (2016) Plant variety release, protection and seed quality control directorate, June, 2016, Addis Ababa, Ethiopia. 2016.

Samuel M, and Mesfin D (2002). Evaluation of the effect of cutting height on DM forage yield and quality of Napier grass (*Pennisetum purpureum*) in northeastern part of Wello. In: Proceedings of 9th annual conference of the Ethiopia Society of Animal Production (ESAP), Addis Ababa, Ethiopia, Pp. 199-211.

Seyoum B, Zinash S, Tadesse T, and Liyusew A (1998). Evaluation of Napier grass (*P.purpureum*) and Pennisetum hybrids (*P.purpureum* x *P.typhides*) in the Central Highlands of Ethiopia. In: Proceedings of 5th annual conference of the Ethiopia Society of Animal Production (ESAP), Addis Ababa, Ethiopia, Pp. 194-202.

Tekleyohannes B and Worku J (2000). The effect of undersowing baley with forage legumes on grain and straw yields of barley and herbage yield of forage legumes in the Highlands of Bale. In:

Proceedings of 7th annual conference of the Ethiopia Society of Animal Production (ESAP) held from 26-27 May 1999, Addis Ababa, Ethiopia, Pp. 241-246.

Tekleyohannes B, and Daniel S (1998). The Effect of Wheat-clover Seeding Pattern on Wheat and Clover Yield in the Highlands of Bale. In: Proceedings of 5th annual conference of the Ethiopia Society of Animal Production (ESAP), Addis Ababa, Ethiopia, Pp. 233-236.

Tesfaye LT, Puskur R, Hoekstra D, and Azage T (2010). Commercialization of dairy and forage systems in Ethiopia: An Innovation Systems Perspective. Working paper 17. ILRI, Nairobi, Kenya.

Tessema Z, Robert B and Alemu Y (2002). Effect of plant height at cutting, sources and levels of fertiliser on yield, chemical composition and in vitro dry matter digestibility of Napier grass (*Pennisetum purpureum* schumach). In: Proceedings of the 9th annual conference of the Ethiopian Society of Animal Production (ESAP), August 30 – 31, 2001, Addis Ababa, Ethiopia. Pp. 165-179.

Tessema Z (1996). Forage yield performance of different perennial grass/legume mixtures in Northwestern Ethiopia. In: Proceedings of 4th annual conference of the Ethiopia Society of Animal Production (ESAP) held from 18-19 April 1996, Addis Ababa, Ethiopia, Pp. 203-207.

Tsige-Yohannes (2000). Livestock feed security and associated impacts on sustainable agricultural development. Proceedings of the Seventh Annual Conference of Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia, 26-27 May 1999. 2000. pp. 51-61.